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Development of an Evidence-Based Toolkit

to Support Safe Design for Children

by

Suzanne M. O'Connor

A Doctoral Thesis

Submitted in partial fulfilment of the requirements

for the award of

Doctor of Philosophy of Loughborough University

January 2018

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Abstract

This thesis contributes to developing an evidence-based toolkit for designers when designing products based on theoretical inputs from human-factors study. Theoretical and developmental knowledge, relevant to the design of warning and risk communications and the area of design for child safety, is translated into support for reflections to practitioners. The risk management framework derived from this study aims to increase awareness of the implications of the aspects involved and as a reference point for groups involved in design for child safety. The thesis covers a shift from risk communications with children to information about children (including physical dimensions etc.) for designers. The final output is a collation of this knowledge base and some conceptual tools that can be applied to a specific design context—whether that context be in risk communications or the area of general safety design considerations. Designers with little experience in managing design for children can benefit from this study when deciding on their design strategies.

This reflective support is the result of a study of risk communication as a complex and unique activity in which various groups and domains are involved. The process of building an understanding started with an analysis of the literature in the field and with the direct experience of the researcher, who worked directly within ergonomics as part of a design-innovation team.

The framework presented in this thesis follows a more structured approach to risk communications. It is conceived as an aid to help practitioners reflect on the implications each stage of the development process has on the experience of developing appropriate risk communications and appropriate products. In this way, it is thought of as a dynamic and flexible reference that can be adapted by design researchers when planning and coordinating design to suit different design situations. The use of this tool in the child-safety, design, and study communities would provide validation of the effectiveness of the framework and its continuous improvement.

The purpose of this study is twofold: to contribute to study and practice with the aim of providing fundamental guidance to designers. The research detailed in this thesis brings readers up-to-date with the current literature on theories of risk communications. It then highlights methodologies, tools, guidelines and requirements for risk-communication advances in study and practice. A framework for risk communication for young children has been developed out of a resource review based on previous work in

the area by McLaughlin and Mayhorn, (2014). The information accumulated in this study has been used to develop initial prototype tools for designers who are considering young children. The developed platform supports practitioners from two different angles: theoretical and practical.

Designers engaged in the core activity of design for child safety need methods that support the consideration of ergonomics and other product requirements, such as risk communications. This study contributes to developing methods and tools that can be used by designers and other relevant groups when designing risk communications for young children. Available knowledge is collated and integrated into the framework with the intention that it will be developed further throughout the thesis to consider effective use within the design cycle. This study aims to contribute to child safety by providing the first development of tools/decision supports aimed at designers who are designing for young children and are accordingly evaluating human-factors methods in design for child safety. The aim of this study is to gather the requirements of a collaborative design tool for use by industrial designers, engineers and other groups involved in design for child safety. This thesis aims to address these needs. When considering the needs, limitations and capabilities, ('mental model') of the intended users (i.e., children), important aspects such as safety have been considered. The general need for support methods are addressed through a review of the safety, design and ergonomics literature. After this, empirical study through interviews and observations is used to outline some problem areas: the development and implementation of human-factors methods in design, lack of available resources and inaccessibility of data.

Three empirical studies were conducted to meet the requirements of this study: Study 1 in Chapter 4 involves documentary analysis of existing models and methods, Study 2 in Chapter 5 involves formal interviews with designers (N = 30), and Study 3 in Chapter 7 involves an online survey for initial feedback about the prototype-persona (N = 50) respondents. The first section outlines the study questions. It discusses the outputs of the three main studies contained within this thesis.

Acknowledgements

There are many people who supported me in this journey and I would like to thank them all. Thank you first of all to each of the participants who gave their valuable time to the data within this thesis, without you there would have been no thesis to write.

To Patrick Waterson and Thomas Jun And to Andrew May for their continued support and belief throughout this PhD. With your inspiration and guidance, you have given me the opportunity to pursue the exciting career I have built within ergonomics.

A special thanks to the examiners, including Roger Haslam, for the interesting discussion during the viva and the valuable comments that allowed me to improve the thesis.

To my daughter, Erin O'Connor who was my sole inspiration for embarking on my PhD journey – who is now about to embark on her journey through university! To the rest of my family for their continuous support, my parents Thomas and Mary and my brothers Mark, Martin, Steven and my sister Katrina, thank you for trusting in my ability and supporting me in all that I have ever wanted to achieve. For their continuous love, support and belief they have provided throughout.

A big thank you to my fiancée Marcus Seaton who was there to encourage me to keep going through the most vital moments – including my viva!

"Childhood is measured out by sounds and smells and sights, before the dark hour of reason grows" John Betjeman – Summoned by Bells (1960)

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Definitions & acronyms

Table 1.1 Definitions and Acronyms

Term	Definition
Injury	The term injury refers to the physical damage that results when a human body is suddenly subjected to energy in amounts that exceed the threshold of physiological tolerance, or damage resulting from a lack of one or more vital elements, such as oxygen (1).
Acceptable Risk	Risk evaluated as "acceptable" based on the manufacturer's policy for determining acceptable risk.
Characteristics related to safety	Qualitative and quantitative characteristics that could affect safety of the product.
Product	Defined by the International Standards Association as a good, service, structure, building, instillation or a combination of any of these. Note in the case of consumer goods, packaging intended or likely to be retained as part of the product is considered as an integral part of the product. (ISO, Guide 50).
Harm	Physical injury or damage to the health of people, or damage to property or the environment.
Hazard	Potential source of harm.
Context of use	Users, tasks equipment (hardware, software and materials), and the physical and social environments in which a product is used (British Standards Institution, 2010).
Reasonably foreseeable misuse	Incorrect or improper use of the product based upon categories of foreseeable user action, including use error during intended and unintended use.
Risk	Combination of the probability of occurrence of harm and the severity of harm.
Risk analysis	Systematic use of available information to identify hazards and to estimate risk.
Risk assessment	Overall process comprising a risk analysis and a risk evaluation
Risk control	Process in which decisions are made and measures implemented by which risks are reduced to, or maintained within, specified levels.
Risk evaluation	Process of comparing the estimated risk against given risk criteria to determine the acceptability of risk.
Safety	Freedom from unacceptable risk.
Severity	Measure of possible consequence of a hazard.

Use scenario	Specified sequence of events and tasks as performed by a specific User in a specified environment.
Usability	Characteristic of the user Interface that establishes effectiveness, efficiency, ease of User learning and User satisfaction. Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [SOURCE: ISO 9241-11:1998]
Usability engineering	Application of knowledge about human behaviour, abilities, limitations, and other characteristics related to the design of tools, devices, systems, tasks, jobs, and environments to achieve adequate usability.
Child Appealing	Attracting children to unsafe situations.
Every day product	A consumer product or walk-up-and-use product designed for use by the general public (British Standards Institution, 2006).
Channel	The channel represents the medium (e.g., visual or auditory) used to deliver the message.
Cognition	Information processing.
Receiver	The *receiver* is the decision maker.
Receiver Characteristics	Aspects such as age, gender, ethnicity, and socioeconomic status.
(RAPEX)	The source or sender is the originator of the information.
Human- centred Design process	An approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques.
Environmental context of use	The physical and social environments in which a product is used.

Abbreviations

Table 1.2 Abbreviations

Term	Definition
BSI	British Standards Institution.
CAPT	Child Accident Prevention Trust.
ROSPA	Royal Society for the Prevention of Accidents
HF/E	Human Factors and Ergonomics.
IEHF	The Institution of Human Factors and Ergonomics Society.
(RAPEX)	EU Rapid Information System. A market surveillance cooperation and coordination, including the functioning of the EU Rapid Information System (RAPEX) and online distribution channels
ISO/COPOLCO	The ISO Committee on consumer policy (ISO/COPOLCO) is ISO's forum for promoting consumers' interests in standardization. Its purpose is to focus input of consumers' views into ISO's policies, procedures, standards and service, and to help consumers around the world benefit from standardization.

Chapter 1: Thesis overview

1.1 Problem statement

Research into risk communications aimed at young children is relatively new. "Young children" are referred to throughout the thesis, and by this is meant children aged between 5 and 11 years of age. Recent empirical study and reports have suggested that guidelines or tools that can help designers design warnings for children may prevent children from having future accidents (Pederson et al., 2008; Waterson et al., 2010). Empirical study regarding their design and evaluation are limited (Wogalter and Laugherty, 2008; Waterson and Monk, 2014; Wogalter et al., 2014).

Children are not always aware of the hazards around them or know what action to take to avoid harm to themselves and others. Visits to the accident and emergency department in hospitals due to unintentional injuries to children cost the NHS approximately £146 million per year (Party 2007 p.4). The scope of childhood injuries is further addressed in Section 2.3.1. The main motivation for this study is to understand children's characteristics—, including their perception of risk—to develop resources that will help designers better understand and consider the safety needs of children when developing risk communications. Overall, the study looks towards the development of a resource or "visual aid" in the form of booklets, cards, infographic materials and animations. Infographics are "graphic visual representations intended to present complex information quickly and clearly" (Smiciklas, 2012). The information and data in the tools will help to outline children's development, explaining how this leads to approaches to promoting safety which differ from those used to meet the needs of adults. Furthermore, it will facilitate better understanding and awareness among designers of the specific safety needs and requirements of young children and their carers. Study is required for inputs into the design requirements to determine how evidence can best be turned into practice to improve safety for young children.

In summary, the study detailed within this thesis was undertaken in response to, 1) the high number of unintentional child injuries; 2) previous work pertaining to guidelines for design for child safety (Waterson, 2012; Waterson and Monk, 2014b) and the need for an evidence base created by a lack of empirical data on the design of risk communications for young children; and 3) the unavailability, inaccessibility, or

inapplicability of data (Wilson and Norris, 1993 p. 677). Consequently, there is a need to provide stakeholders with alternative resources and usable guidance to support safe design for children, thereby potentially reducing the number of unintentional childhood injuries.

The researcher has a deep understanding of designing risk communications and products from two perspectives, both design and ergonomics, having worked in ergonomics in various environments and working closely with a design-innovation team. The researcher has knowledge in design and creative processes, hence the way in which designers consider safety in designing for children and how this is applied to risk communication and product development is of interest.

When working on medical devices with instructions for use and accompanying warning information, the researcher's attention shifted to consider how to transfer these concepts to the context of young children's risk communications. In this study setting, there were more variables to be considered and more assumptions to be avoided than are present in adults' contexts.

Analysis of a multitude of studies reported in the literature together with my own experience in the field has created the basis for reflecting on the practice of design with children, its different applications and interpretations. These reflections led to the proposal of a framework that organises all the elements implied in risk communication design with children. The overarching goal is to facilitate appreciation and employment of the practice—especially for researchers who are not expert in this practice and want to embark on it. For the purposes of this study, *product* refers to the output of design activity, examples of which include consumer products, designer graphics (Clarkston et al., 2007) and risk communications via various platforms.

1.1.1 Study context: from human factors to user experience

The study presented in this thesis follows the principles of user-centred design (UCD): an approach to design that puts the needs of users at the centre of the design process as advocated in other research by Norman and Draper, 1986. The practice of developing support tools for design practitioners in considering children is based on this approach. Norman and Draper (1986) claim that, "While HCI expanded from work to everyday activities, the range of target user groups increased by addressing different abilities, cultures and ages" and this is also true of the risk communication research. There is a

need to better understand and build an evidence base if we are to further translate human factors and ergonomics methods to "promote child safety through design" (Waterson et al., 2014; Wilson and Norris., 1993 p. 677). Waterson (op. cit., 2014, p. 605) acknowledges the role played by a "range of trade-offs in the practical use of human factors and ergonomics methods and at the same time, to avoid exclusively scientific criteria when assessing the success or failure of a specific method". The term *human factors*, which appears throughout this thesis, refers to how a person interacts with the system or interface surrounding them. This includes the products and technology they use as well as less complex interfaces such as signage or labelling. Human-factors research takes the environment, the user population and potential competing distractions into account. The thesis covers a shift from risk communications with children to information about children (including physical dimensions etc.) for designers. The final output is a collation of this knowledge base and some conceptual tools that can be applied to a specific design context—whether that context be in risk communications or the area of general safety design considerations.

This study approached the problem from a holistic viewpoint in considering the design tools and organisation as well as the individual values, attitudes, perceptions, and patterns of behaviour taken in implementing safety solutions to reduce the number of unintentional injuries to children. Human-factors interventions to prevent injury are important for keeping young children safe; thus, the practical development and use of such methods is invaluable in the field of child safety.

1.2 Research aims

This thesis aims to introduce knowledge about design for child safety into design practitioners' decision-making processes. Bridging the evidence/practice gap assumes that practical knowledge derives from study knowledge (Hammersley, 2013), but this translational work requires an iterative approach to developing, introducing and evaluating the tools/decision aids. It appears that many of the problems of information and knowledge transfer outlined here are caused by a lack of communication between potential users and producers of information.

The overall study seeks to systematically review psychological theories of child development including cognitive development, adult and children's interactions with risk communication, and risk communications for adults. This study proposes a useful, integrated framework to guide the design and evaluation of risk communications aimed

at children. This study addresses children aged 5–11 years: i.e., school-aged children, in line with Piaget's stages of child development.

1.3 Study questions

To meet the requirements of the study contained within this thesis, a number of study questions are addressed:

1. *What models, methods and resources are available in theories and practices to support designers when designing for young children?*
2. *What do designers actually need?*
3. *Which theoretical perspectives are useful for enhancing user-focused design when designing for children aged 5–11 years?*
4. *How can various relevant theories be formalised (modelled) to help designers' practices, and how can these be used to support designers of risk communications aimed at young children and their carers?*

1.4 Scope of study

The scope of this study is limited to the field of human factors in designing risk communications for child safety. It borrows from other fields where appropriate to collate information relevant to keeping children safe from harm. For example, it considers the industrial and engineering design impacts of a wide range of products that are designed for or used around children, such as medical devices and consumer electronics. Risk-communication theory, including its processes and models, is investigated for use in integrating human-factors tools and methods into the design process to help designers understand and communicate how risk-communication processes work. The study is limited to the UK, which has been identified in the literature review.

1.5 Understanding design practice

This thesis does not provide a theory or a prescriptive model about children: The aim of this study is instead to provide a framework that can be used in concrete instances as a

support for reflection—especially for novice design practitioners. This reflective support is a result of research aimed to understand the design of risk communication in study and practice as a complex and unique activity. In this thesis, this understanding is drawn from the analysis of first-hand and reported experiences of design practice as well as theoretical understandings of warning and risk communication study in the context of children. It contributes to the development and improvement of the practice.

1.5.1 Study audience

This study has primarily been conducted to aid designers and other experts who are involved in design processes in considering children. The knowledge created may be of further relevance to individuals from design practice, child-safety organisations and other researchers working in the field.

1.5.2 Thesis structure

Table 1.1 Proposed Outcomes of Chapters

Chapter	Purpose	Outcome
Chapter 1: Thesis Overview	Describes the research background, Introduces the research motivation, research aims, specific objectives and research questions. The thesis structure is also summarised.	Background to the research and identification of gaps aims and objectives and scope of the study. What is the current knowledge base?
Chapter 2: Literature Review	Presents a detailed review of the literature, related to designing risk communications for young children and gaps identified. This is largely guided by warning theory, and other safety research as it relates to keeping children safe from harm. Looks at theoretical perspectives on safety and design for children from psychology & warning theory.	Identification of gaps in the literature and propose research questions. 1st version of a risk management framework describes a system's view integration of multidisciplinary knowledge.
Chapter 3 Research approach	Discusses the overall research approach employed in this research. The methodology discusses the theoretical and empirical focus of the research as well as the methods employed to develop its practical application for use by designers.	Propose and design a research strategy.
Chapter 4: (Study 1) Documentary analysis	A critical review of models, methods and current sources of information. Collation and evaluation of available tools and guidance. (Research Study 1) presents a documentary analysis of the current resources including, tools, models and methods relevant to this research, in relation to risk communication design and child safety. In view of the findings, the model of risk communications for older adults, developed by McLaughlin and Mayhorn (2014), has been adapted into an integrated risk management framework relevant to young children.	2nd version of a proposed risk management framework for young children developed from McLauchlin and Mayhorn (2014).

Chapter	Purpose	Outcome
Chapter 5 (Study 2) Gathering the requirements from designers.	RQ: 3 - How and when do designers use information? What do designers need? (Research study 2) gathers the requirements from designers. This chapter presents the results of n=30 semi-structured interviews with experts and designers.	Gathering designer's requirements for the tool/ decision aid. 3rd version of the risk management framework for young children developed from McLauchlin and Mayhorn (2014).
Chapter 6: Toolkit Development	This chapter outlines the development of the proposed persona tool. It integrates and explores knowledge transfer through the found sources and the fit with designer's requirements for a working tool.	Initial personas and early stage concept of the card tools.
Chapter 7: Online Questionnaire	(Research study 3) presents the findings of an initial online evaluation and suggestions made within the online survey for further development of the tools. RQ. Is the proposed persona useful? What else do designers require?	An online questionnaire gained feedback from experts involved in the previous studies- to gather further insight. Suggestions for further development of the tools.
Chapter 8: Discussion	The discussion concludes the thesis by re-visiting the developed risk management model, addressing the research questions and reviewing the contributions.	Example support tools for designing for young children's safety. Contributions to theory and practice.
Chapter 9: Future work & Conclusions	Discusses research conclusions and future work. The proposed aims and outcomes for each of the chapters can be seen in Table 1.1.	Road map for further development and evaluation of the tools in-vitro with designers. Recommendations for other applications for the tools.

The diagram in Figure **1.1** details the flow of the study mapped onto the thesis" chapters.

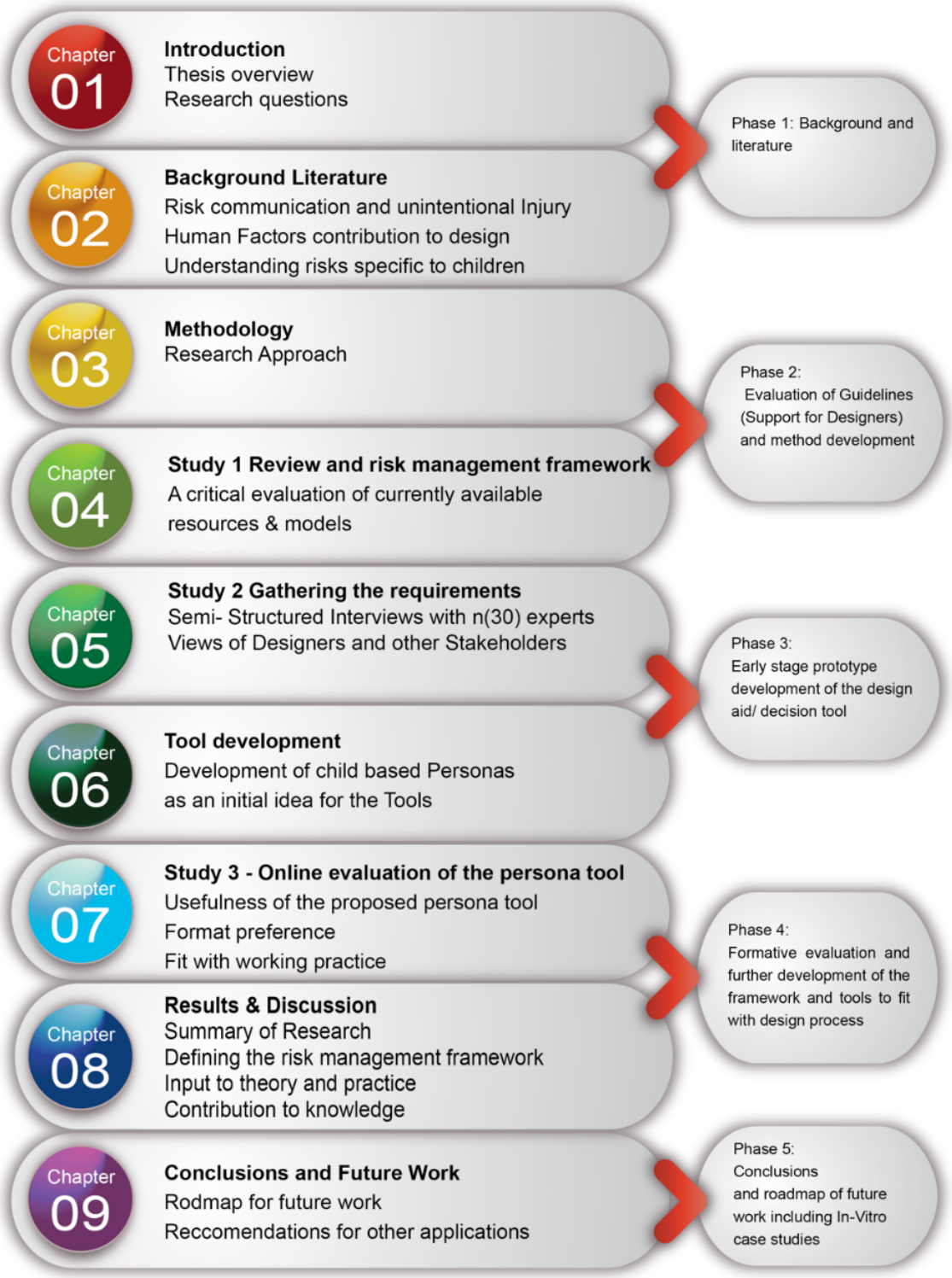


Figure 1.1 Outline of thesis

1.5.3 Summary

This chapter has presented the study topic and study questions. This thesis aims to contribute to the discussion around designing risk communications for children, by providing insights for reflection and practice. The next chapter reviews the background literature, relevant to the study topic.

Chapter 2: Background literature

2.1 Introduction

For risk communications to be evidence-based, they must be consistent with scientific knowledge. This literature review explores warning theory, unintentional child injury, guidelines and policy and identifies study gaps. Specifically, this chapter addresses the following four questions:

- *What factors influence the design of risk communications for children aged 5–11 years?*
- *What are the current and previous perspectives on child safety?*
- *What are the gaps in the existing body of work?*
- *How can we consider influential factors and knowledge from the existing body of work on risk communication design in relation to young children?*

2.1.1 Chapter overview

In meeting the study requirements, a review was made of the published human-factors literature concerning the design of pro-active risk communications for young children was completed. This literature concerns the history, theoretical directions of engineering, design and human factors. The review also considers other sources (e.g., grey literature, standards and reports) that may be relevant from both a theoretical and applied perspective. The areas of investigation within this relatively wide scope, were covered in the review of the empirical literature. These highlighted significant gaps in the existing body of work.

A literature review typically consists of an analysis of existing studies that are relevant to the subject matter (Hart 1998); however, as limited empirical study of children has been undertaken in relation to the design of risk communications and warnings, the first step in my literature study is to review accident data relevant to children in the age range of 5–11 years. This review then considers existing guidelines and knowledge not specifically aimed at designs for young children, and finally discusses the applicability of these studies to children within the scope of the limited available literature on children. Various researchers and risk-communication specialists have proposed guidelines (or

principles) for the design (or evaluation) of warnings or risk communications in general, and the models most relevant to this study topic are included in this review. Section 2.3 of the review presents key findings from the literature. Section 2.5.1 discusses a risk communication processing model which was developed from existing literature, namely the communication - human information - processing (C-HIP) model from Wogalter and Laughery (1999). A model developed by McLaughlin & Mayhorn (2014) for the design of warnings for older adults from the safety-science literature is reviewed in Section 2.9.1. The STEP approach to message design and testing (SatMDT)—which is relevant to road-safety advertising and is obtained from the accident analysis and prevention literature—is another model that was found to be relevant to the study topic (Lewis et al., 2014). A user-centric approach of design and evaluation is then described with the ISO procedure for the development of public-information symbols from Zwaga and Easterby (cited in Edworthy and Stanton, 1995 p.2267). A model relevant to evaluating warning signs for children is also included, and guideline formulation for the design and evaluation of children's risk communication from Waterson et al. (2012) and Waterson and Monk (2104) is discussed.

The review aims to find gaps in previous literature and opportunities for further study that can be conducted to help designers apply guidelines in designing for child safety. Overall, this review seeks to systematically review psychological theories of children's development, children's cognitive development, adult and children's interactions with risk communication, and risk communications for adults that may also be relevant to young children. The chapter explores literature which may be relevant to overcoming the difficulties described in reviewing past and present studies and other available knowledge. It reviews this literature with a view to determining the essential components of design and the evaluation of communications in the context of children so as to better describe where the gaps are and where children fit.

2.2 Methods

The review explores unintentional injury interventions for young children in the form of risk communications and warnings. For this review, studies of interest include but are not limited to empirical studies, standards, reports and grey literature relevant to the study topic. Components and characteristics of risk-communication design are highlighted and later discussed in the context of children aged 5–11 years. Only literature published in English is included in this review. Study designs of

relevance to this review include new methods relevant to the study, including qualitative methods and user-centred design (UCD) methods in the development of risk communications.

2.2.1 Literature search strategy

Considering the study questions outlined in Section 1.3, the literature review falls within the bounds of multiple fields and positions, which means that the study is approached primarily from a systems perspective. Consequently, this review is positioned largely in the field of human factors, drawing on other disciplines where they inform the research. Relevant information was selected from journals, reports, conference proceedings and books. Several literature-search strategies were employed to adequately cover the study topic and to thoroughly examine the literature on human factors and ergonomics, accident analysis, medicine, and psychological and paediatric factors, etc. Contacts were made with child-safety organisations and large product-safety companies to identify current and unpublished literature. The literature search involved searching electronic databases (Scopus, ISI Web of Knowledge, Ergonomics Abstracts, Science Direct, the Loughborough University Institutional Repository, and the Loughborough University Library Catalogue) and grey literature from child-safety organisations, browsing physical libraries and following the reference trail provided by the initially identified materials. The researcher was thus exposed to a wide range of the available literature. Combinations of keywords were searched, including all variants of different spellings, grammatical forms and synonyms to include the following terms:

- children AND risk-communication design guidelines;
- children AND visual information OR guidelines; and
- children AND risk perception;
- children AND developmental stages;
- unintentional injuries AND development stages.

Other key words such as *safety* and *warnings* were used to narrow down the results. Identifying the components of warning theory and their interpretation within the human-factors literature to promote a systematic approach was achieved via electronic-database searches, reference and citation tracking and personal knowledge of the relevant literature (Hart, 1998). Additionally, searches were carried out on safety standards to access the safety guidance currently available in the UK. Contact with key

experts and "Google" searches were used to identify grey literature and other relevant documents. The literature gathered via these search methods was examined using an inductive thematic-analysis approach, as described by Braun and Clarke (2006), to identify the core components of warning theory and to determine which of these components might be relevant to children's interactions with a warning. Throughout the study process, literature searches were continually updated to identify new research.

2.3 Key findings

Much of the empirical study was found in warning- and risk-communication theory. Titles and abstracts were reviewed, and any duplicates were deleted. Articles were narrowed down to include papers relevant to the study topic for age ranges of 5–11 years. Research developed for adult groups was included if it was thought to be of relevance to developing the study topic. Abstracts were read, and those considered irrelevant to the study were discarded. A total of 160 titles from the initial search were found to be relevant for the study and were imported into a reference-manager programme. With the results obtained from the systematic review, we can see that much of the literature lies in the fields summarised in Table 2.1 below:

Table 2.1 Breakdown of literature sources

Literature type
Public health and health promotion theory *n* =14
Health persuasion *n* = 11
Human factors and ergonomics *n* = 49
Accident analysis and Prevention *n* = 29
Psychology *n* = 20
Behavioural science *n* = 23
Marketing *n* = 7
Design for children *n* = 15

Much of the relevant empirical study in relation to warning- and risk-communication theory and practice was found on adult groups and was situated within the domain of human factors (*n* = 49 articles). These articles were narrowed down to those thought to be of most relevance to the study topic. The remaining papers of potential relevance to

the study were examined in more detail, and nine papers were retained as relevant to young children and risk-communication design. The most up-to-date studies in the area on the design of safety-risk communications for children within the age range of 5–11 years were further reviewed and listed in Table 2.4. Few of these studies include methods for including children in research.

Prior study in the field includes literature about how people interact with, understand and comply with a risk communication or warning. Prior study also explores new methodologies and models that describe the stages of warning processing for adults: namely, the C-HIP model (Wogalter, 1999). Much of the literature describing principles and previously tested communications is on adult groups or vulnerable groups, such as McLaughlin and Mayhorn's framework (2014) for risk communication. Existing literature has been lacking, and the limitations of the studies found in the review include a limitation on age ranges within the limited literature. Past study with children is limited both because there are few available studies and because there has been little attempt to directly assess children's understanding of sign features (Morongiello et al., 2016). There is also a lack of information on child-development stages and not much information on gender or cultural considerations. One exception is ergonomics for children (Lueder and Berg Rice, 2008) along with a small number of articles that will be discussed in this chapter. Papers relevant to the study topic are discussed in greater detail in the following sections.

2.3.1 Definition of risk communication

The terms *safety or risk communications* and *warnings* (Laughery and Wogalter, 2014) are used interchangeably throughout this thesis to contribute to a communication which will help keep children safe from harm. Warnings are used to communicate hazard and risk information to people as a means of preventing accidents and injury. Warnings like this one are defined in the human-factors literature:

In general, warnings are safety communications designed to decrease harm to people and property (Mayhorn et al., 2014).

Risk communication is the term used when people need useful information to make sound choices. It involves a distinguished commitment to accuracy and avoidance of spin, and it may include alerts and warnings, may describe the existence and location of one or more hazards, and is intended to invoke a specific behaviour on the part of a

person to reduce the likelihood of harm (ISO/IEC Guide 50: 2014). One way of further reducing unintentional injuries is to design effective safety and risk communications and warnings aimed at the target user group (Wogalter et al., 2014; McLuaghlin and Mayhorn 2014). However, as discussed, children tend not to be taken into consideration as a user group when designing safety and risk communications, despite the fact warnings for children need to be designed very differently from those aimed at adult groups (Kalsher and Wogalter 2008; Waterson and Monk, 2014).

2.3.2 Understanding the scope of unintentional injuries

To understand the roles and requirements of risk-communication models in preventing unintentional child injuries, an understanding of the scope of childhood injury occurrence should precede. The World Health Organization identifies unintentional injury as the leading cause of death for children over the age of 5 (Peden et al., 2008). The World Report on Child Injury Prevention, published by the World Health Organization in 2008, is a comprehensive attempt to collate and interpret information from all countries. The report says that preventable injuries and accidents in childhood account for a considerable amount of childhood morbidity and mortality, with causes of all types of injury linked to children's physical and social environments. According to the report, more than 830,000 young people die needlessly each year. Types of injuries include road-traffic crashes, drowning, burns, falls and poisoning.

Perspectives toward child safety and attitudes towards children in today's society have been changing, and this is largely due to current advances in technology, the development of new products and the identification of new and emerging hazards, which add further complexity and new risks to young children. Empirical study suggests that guidelines for designing warnings for children may prevent children from having future accidents (Waterson et al., 2012; Waterson and Monk, 2014). In industrialised countries, injuries are the leading cause of child death. They account for 40% of all child deaths between the ages of one to 14 years (UNICEF, 2001 p2). Injuries at home account for 40% of medically attended injuries in 5–9-year olds and 25% in 10–14-year olds (Morrison & Stone., 1999). An overview of common causes of child accidents is illustrated in Figure 2.1 below:

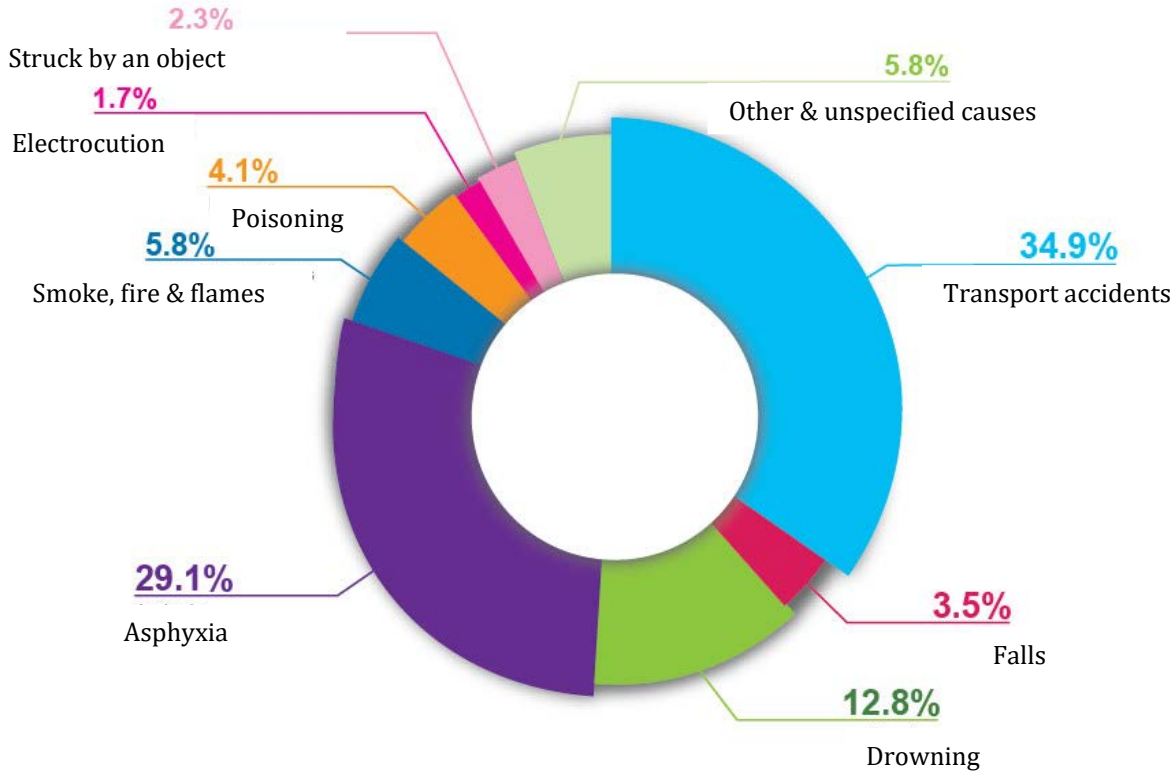


Figure 2.1 Common causes of childhood accidents. Adapted from Making the Link, 2017.

Figure 2.1 presents the most common causes of accidental death for children under the age of 15 years. The common causes outlined are due to transportation accidents via air, rail and sea, as well as crashes, cycling accidents and pedestrian deaths. Most transportation accidents involve land transport, which includes road, rail, pedestrian and cycle. In comparison, the number of accidents in the air and on the sea represent a tiny proportion. Road accidents, which are typically pedestrian-related, are the leading cause of death for children under 15 years of age in most industrialised countries (Malek et al., 1990). Four of the top 15 killers of children aged 5–14 years are road-traffic injuries, drowning, fire-related deaths and falls. Non-fatal road-traffic injuries and falls are two of the top 15 causes of disability-adjusted life years in children from birth to 14 years. The total burden of all injury deaths under the age of 18 years (including both intentional and unintentional) is estimated to be 950,000 per year. The commonest types of injury deaths are those related to road-traffic injuries, drowning, and fire-related burns. Designers and other groups involved in keeping children safe could use the

developed tool to better understand children's capabilities and limitations at various stages of development when designing road-safety campaigns or products. The resources could contain information about common accidents involving young children that derives from accident data at the various stages to better consider the interaction of young children with their environment at varying stages of development.

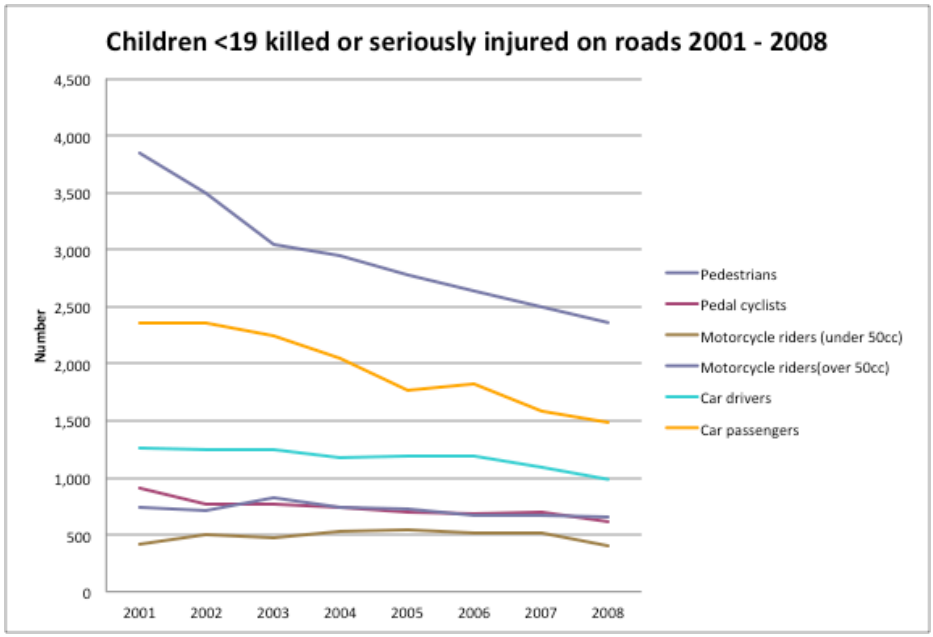


Figure 2.2 Children <19 Killed or seriously injured on the Roads from 2001 - 2008. From http://www.makingthelink.net/node/186

As Figure 2.2 illustrates, the number of children killed and seriously injured on the roads each year decreased between 2001 and 2008. This data from the department shows that the number of deaths and serious injuries was 21% lower in 2011 than the average for 2005-09. Despite this data, traffic accidents still remain the leading cause of accidental death for children and can cause life-changing injuries, as illustrated in the following table.

Table 2.2 Type of road accident and number of serious and "slight" injuries for GB in 2008. From Making the Link, 2008.

	Deaths	Serious injury	Slight injury	Total	Deaths as % of total
Pedestrians	33	1, 569	6, 205	7,807	0.42

	Deaths	Serious injury	Slight injury	Total	Deaths as % of total
0-15 years					
Pedal cyclists 0-15 years	6	392	2, 483	2,881	0.21
Car occupants 0-15 years	21	315	7, 235	7, 571	0.28
All road users 0-15 years	60	2, 352	17, 062	19, 474	0.31

Knowledge of children's abilities and limitations in understanding risks, in other words more information on characteristics of children, such as physical and psychological development and characteristics of the types of injuries that they face at certain stages of their development would aid in developing better risk communications that are targeted at the appropriate risk and at the appropriate age- range.

2.3.3 Perspectives of child safety

Various approaches to child safety are reviewed in this section to give a clearer understanding of the context of this study.

2.3.4 The balance between risk and play

Children are born with a natural urge to play, and most parents would agree that their children should take challenges and accept some level of risk while growing up. This is supported by the European standard for fixed play equipment, which promotes balancing risks and benefits. However, the lives of children have become much more restricted and controlled over the past 30 years or so because of cultural, social and economic factors. Hence, children's opportunities to play and explore their neighbourhoods on their own have decreased noticeably, and they spend more time under adult supervision (Ball et al., 2008). Children need to encounter risk as part of their healthy development, as they must develop the appropriate knowledge and skills

required to assess the dangers and risks that face them accurately, so they will be equipped the knowledge and experience and ability needed to take appropriate action. On the other hand, adults are responsible for children and have a moral, social and economic responsibility to keep children safe. Play England has developed guidelines (Shackell et al., 2008), and there has been much debate surrounding this balance. The Royal Society for the Prevention of Accidents (RoSPA) advocates this balance in "not warping children in cotton wool" (RoSPA, 2017).

2.3.5 Public-health interventions

The public-health approach (Figure 2.3) is a model that comprehensively addresses health or social problems. It considers the human-factors characteristics of the source of harm and the environment, and it identifies causes and suggests possible interventions. The first steps in intervention are surveillance (01), recognising and monitoring the extent of the problem, and understanding demographic information about the age groups it affects. In the second step, risk factors are identified (02) to understand the reasons behind why that select group is being affected. The third step is the development and evaluation of interventions (03) before the broader implementation of more evidence-based strategies (04) in step four.

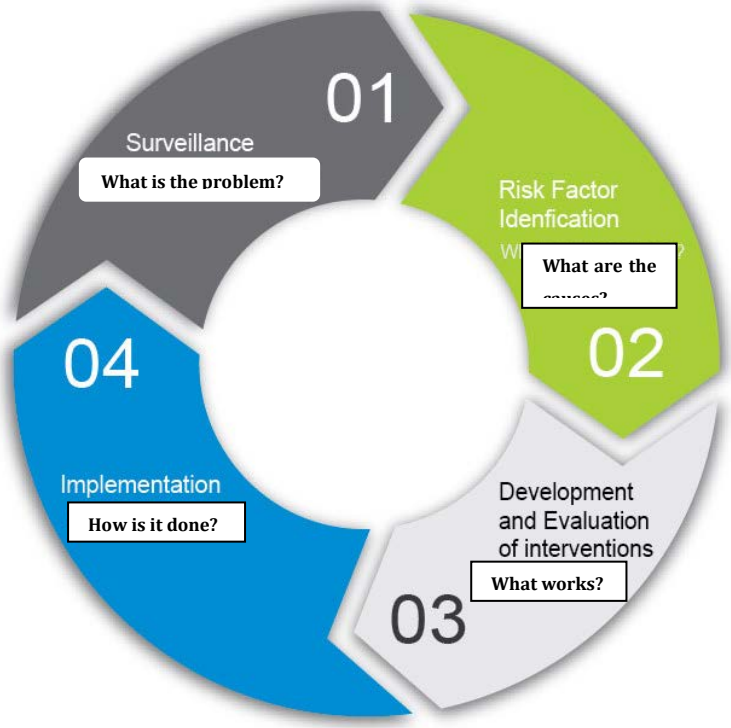


Figure 2.3 Public-health approach to preventing Injuries (European Report on Child Injury Prevention, 2008) Adapted from: World Health Organization, 2008.

Unintentional injury is a major public-health problem, and the magnitude of this problem varies considerably according to the various risk factors, socioeconomic group, age, gender, cultural and ethnic group, country and neighbourhood. There are also considerable variations in injury rates between these groups. This is relevant to targeting specific demographics in developing risk communications; however, some of the factors described are currently out of the scope of the research.

2.3.5.1 Development and evaluation of interventions

During the late 1980s, a very different perspective prevailed concerning childhood injury. Childhood injury was not a well-respected area for study, as childhood injuries were just something that happened. People tended to label them “accidents”, with the perception that they were “random” and “unavoidable” events rather than “injuries” which could be “preventable”. Thus, very few people in the public-health field were working in child safety at this time. There is, however, a lack of empirical evidence to

support the public understanding of the word *accident* (Girasek, 1999). In a telephone survey involving 943 adults in America, conclusions from the study indicated that promoting the advantages of passive intervention, for example, might be more productive than omitting the word *accident*.

There was an attempt by the department of health in the UK to bring together a large group of people involved in this field to develop a national injury prevention strategy from a public-health point of view. Historically, Americans have been the leaders in this area, and they were the first to set this up across states. However, the body of research on risk communication in public health has grown steadily since the 1990s (Barry et al. 2013 p.5). Major safety organisations note that even today many believe that an accident may occur due to fate or bad luck (RoSPA., 2017) Regularities in accident patterns are identified in the statistics. The fact that they replicate themselves in the same way year after year suggests that there must be constant factors at work that are not merely a matter of "fate". A systems approach to accident prevention—for example, the analysis of accident patterns—is a major preoccupation in the field of accident epidemiology. On a global level, international organisations are working towards child safety and health. Randomized controlled trials are considered the gold standard for assessing the effectiveness of injury interventions; however, trials concerning child injuries are relatively rare, as these would be impractical or unethical (Norton et al., 2006). Currently available information that may contribute to appropriate safety interventions includes analysis of reports of accidents involving children, hospital accident data, and anthropometric and biomechanics data.

2.3.5.2 Overview of standards, legislation and enforcement

As Norris and Wilson point out, various measures have been taken to achieve consumer safety in the UK. These include regulations (national and European), voluntary standards, voluntary-agreement codes of practice and consumer safety-awareness initiatives (Norris and Wilson, 1997). Standards and regulations have a significant bearing on the extent to which child injury can be prevented; however, these are not always efficiently implemented, and Van Weperen (1993) has discussed the shortcomings of safety standards for consumer products which may serve as obstacles to protecting consumers to the appropriate level, (Van Weperen 1993). This is crucial to take into account when it comes to protecting young children. Many countries have specific standards or regulations, some mandatory, for a wide range of goods and

services relevant to child safety (Peden et al., 2008). There is much discussion of global toy standards which is not aligned. Differences which exist between standards across the world create various issues for manufacturers, who may not always be well educated with respect to varying markets. Childcare articles, playground equipment and protective equipment such as helmets are all covered within these. Standards are particularly important for designers when it comes to keeping children safe from harm. The Word Report on Child Injury Prevention discusses the fact that, "Vertical standards based on hazards compile this information so that manufacturers and regulators can identify known hazards in products and reduce them to acceptable levels" (Penden et al., 2008). This approach has been adopted in *ISO/IEC Guide 50: Safety Aspects: Guidelines for Child Safety*. Risk reduction is meant to cover how people use a product throughout the product lifecycle, and the guide discusses the characteristics of children with respect to safety. A further problem exists in which standards do not cover the development of new products and the identification of new and emerging hazards relative to them. This adds further complexity and new risks to young children. For many new products, standards do not exist, and the introduction of standards for individual products can be a slow process.

2.3.5.3 Design and engineering

Design and engineering play an essential part in accident prevention in children's environments, for instance, at home, play spaces or schools. These might include, for example, on-and-off switches on electrical sockets and child-restraint containers for medicines and household poisons. In engineering, there is an existing process for adhering to a hazard-control hierarchy: to design out or eliminate the hazard, to guard against the hazard, and finally to warn (Wogalter, 2006 p.4). According to the international standards organisation, when reducing risks, the order of priority should be as indicated in Figure 2.4 (adapted from ISO/IEC Guide 51).

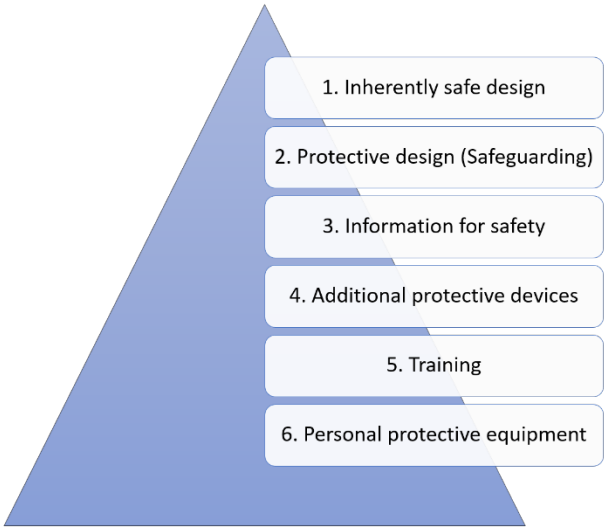


Figure 2.4 Prioritising the reduction of risks. Adapted from ISO/IEC Guide 51

2.3.6 Human-factors contributions to design

Waterson and Kolose (2010) conducted study exploring the social and organisational aspects of human-factors integration within the defence industry, and concluded that individuals in the industry were not entirely convinced of the value of human factors and educated about, and lacked training in the use of HF tools and methods (Waterson and Kolose, 2010). This is often the case and barriers exist in all areas of human-factors integration, particularly in the field of design. There is, however, a more fundamental means of improving product safety, which is sometimes overlooked. Human factors support ensures that potential users may be involved continuously in the design process, despite this it is not always readily used. Ergonomics evaluation of the safety of the product throughout the design process involves the designer understanding the characteristics of potential user groups, including their abilities and limitations, throughout the entire process of designing, developing and marketing products (Norris and Wilson., 1997). This is fundamental to improving the outcomes of a product, system or service and in relation to the research, the design of effective risk communications.

2.3.7 Human-centred design process

2.3.7.1 General guidelines (usability and design principles and heuristics)

Universal design and usability encompasses the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities/ disabilities (Story et al., 1998). Usability is defined in the ISO 9241-11 (1998) standard as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context or environment of use.

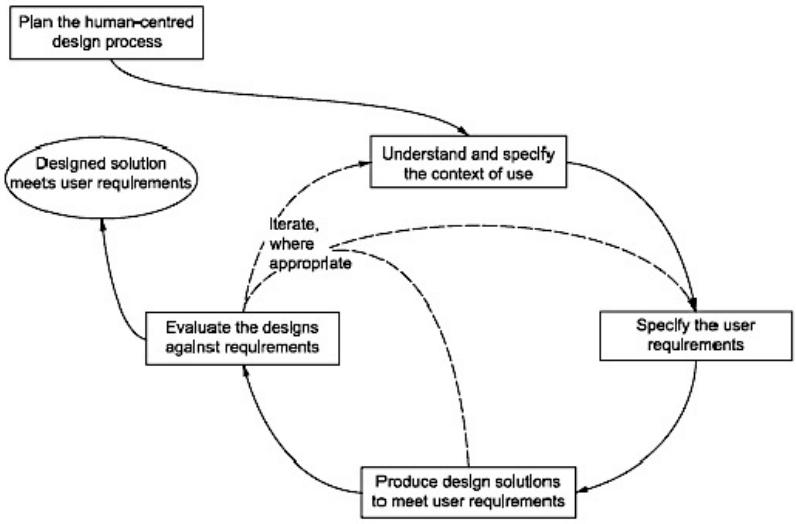


Figure 2.5 ISO 19240-210 design lifecycle (ISO, 2010)

What is common to iterative models described in this literature review, including the design lifecycle illustrated above is that the outcome of each activity is the premise for the following one. The results of the analysis of the context of use and user requirements, for example with regards to a risk communication, must be reflected in the design decision, and the analysis of the findings from the evaluation of design ideas against the requirements gathered need to drive the changes and improvements for the following design cycle. One criticism of these models is that they tend to focus on only one idea for the whole process instead of considering many possible ideas, as is suggested in the so-called “funnel” models as discussed by Acklin, 2010 (Cited in Mazonne., 2012).

2.3.7.2 A user-centred method for designing and evaluating warnings

Edworthy and Stanton's study of auditory warning signals describes a user-centred method of design and evaluation (Edworthy and Stanton, 2005). The procedure outlined in Figure **2.6** is a standardised procedure primarily developed for evaluating public-information symbols (Zwaga and Easterby, cited in Edworthy and Stanton, 1995).

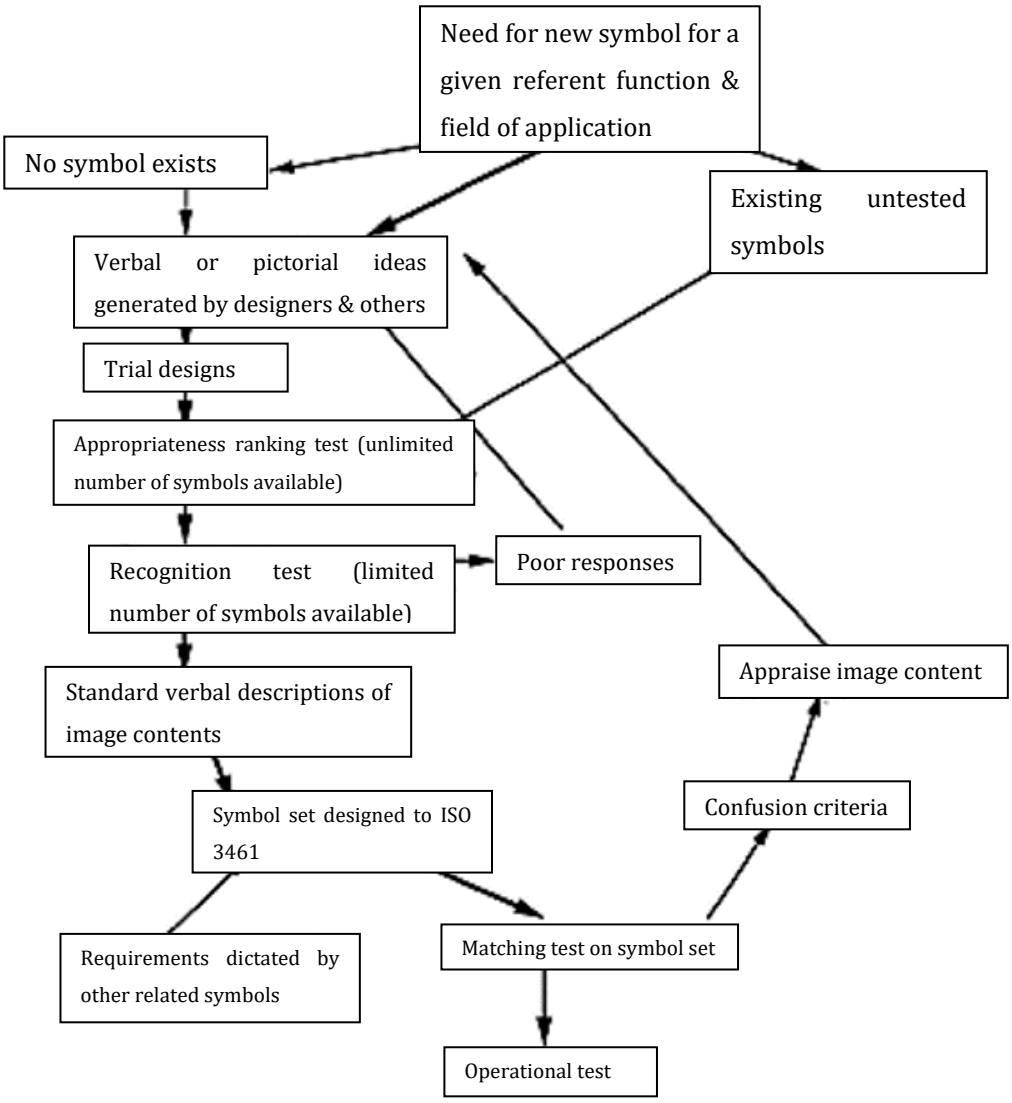


Figure 2.6: ISO procedure for the development of public-information symbols (Zwaga and Easterby, 1984)

The procedure outlined above is used in visual symbol design to allow for a user-centred approach to involving users in the process. It has considered input from the user in incorporating comprehension testing with the user. Currently, no method exists for assessing auditory warnings, and the authors recognise that the components of this procedure might be useful for application to audible warnings due to parallels between

modes. Thus, it is clear that the procedure needs to be adapted considerably for use in designing and evaluating risk communications aimed at young children, as it is difficult to test risk communications with young children (Waterson and monk, 2014). A user-centred approach has been advocated in previous research in designing for children. As part of this, designers need to understand the user's cognitive and behavioural characteristics (Poltrock and Grudin, 1994) so they can apply appropriate risk communications that the user group can understand and comply with. The study discusses the fact that, by taking into consideration individual aspects of theories of learning, it may establish a useful understanding of a child's cognitive development during school. Child characteristics should aid in gaining a perspective on how children perceive and identify signs and other forms of risk communications, which can, in turn, inform practical design guidance. The relevant theories of learning that may be influential will be discussed in more depth in the resource review in Chapter 4.

2.4 Method development in human factors

Despite the vast literature and tremendous growth on warning effectiveness, there is a lack of empirical evidence that can provide insight into what types of communication may be helpful in designing effective safety and risk communications and warnings for young children. The majority of this study has been aimed at adults. Various theoretical models about risk communication and warnings have been developed to explain these interactions, which are discussed in the following sections. Individuals are influenced by risk and safety information in complex ways; therefore, children need to be considered in these processes. Design and engineering play an essential part in accident prevention. Developments have occurred in risk communication research within the field of human factors, since warning study has undergone advancements in methodologies and research into defining the factors that determine whether a warning will or will not be adequate. Laughery and Wogalter (2014 p. 3) point out that,

a communication, a warning is intended to provide information for the audience to whom it is directed.

This is difficult to achieve in practice, because there is very limited guidance in the area in the context of young children (Waterson et al., 2012). Kalsher and Wogalther (2007) indicate that warnings designed for children should differ from those for adults. They note that practical study regarding the needs of children is lacking. There is a wide range of guidance for the design of visual information for adults. However, there may be

aspects of guidance for adults that can be applied to young children. This is further discussed in Section 2.5.

2.5 Human-factors literature

This section presents an overview of the warning-study literature with the intent to focus on the most crucial factors in designing useful visual warnings aimed at children in the included age range. Findings from the human-factors literature include various tools, methods and models which are grounded in both warning study and theory. This information concerning adult groups can be used as a starting point for the research to develop empirically grounded guidelines to encompass the needs of children aged 7–11 years in the UK. Waterson and Monk (2014) used qualitative methods to expand upon the previously developed guidelines of Waterson et al. (2012) to develop guidelines aimed at designers and manufacturers who are developing risk communications for children in this age range. Studies carried out to date on risk communications and factors may determine that their effectiveness is situated within the field of human factors. However, there is a lack of study into children within the age range examined in the warnings research. Kashler and Wogalter (2008) suggest that some aspects of the guidelines aimed at adult populations can be adapted for use with young children. This study intends to expand currently available sources for integrating perspectives from cognitive psychology and other grey literature to include the needs of young children. For the scope of this literature review, however, the emphasis is on the human-factors literature with some information on child-development stages.

2.5.1 The warning process

From the perspective of human factors, warning study and warning theory play a considerable role in viewing safety from a systems perspective. They can accordingly provide information relevant to developing empirically grounded guidelines. The literature is vast and diverse with a wide range of applications, and it includes results from many disciplines including psychology, decision science, sociology and communications. We all want children to be safe. However, injury prevention is a complex area with multi-agency interests and needs. As a discipline, human factors are concerned with understanding interactions between people and other elements of complex systems (understanding interactions between humans and interfaces). This

knowledge has informed the development of accident-prevention programs and campaigns by third-sector organisations (RoSPA, 2009). The researcher found a considerable amount of study covering multiple theoretical perspectives on warnings, as this is a large and growing body of human-factors literature. The included study is relevant to enhancing the design for child safety by considering factors that are internal to the user, such as beliefs, perceptions of risk and stress. In general, the term *target audience* is used to identify a sub-group or sub-groups of the overall population that represent the primary users of a product or process for which the warning is designed (Wogalter et al., 2006). These internal factors are sometimes termed "referent characteristics". Prior study in the field explains how adults interact with, understand and comply with a risk communication or warning. Models have been developed that describe warning processing such as the communication-human information processing (C-HIP) model (Wogalter et al., 1999). More recent study within the field considers different abilities and sub-groups of the population (McLaughlin & Mayhorn., 2014; Reis et al., 2013; Riley, 2014). As discussed, surprisingly little has been published about child-warning interactions and processes (Kalsher and Wogalter, 2008). Thus, defining the parameters of active safety and warning information for young children and positioning this within warning theory is a challenge, as there is a lack of input from theoretical study concerning young children. At the final stage of the hazard-control hierarchy, it is necessary to warn. Wogalter et al. (1999) stress the fact that the warning may become insufficient due to specific variables. Variables encompass aspects pertaining to the unique characteristics of products, environments and people. Aspects could pertain to the characteristics of the target audience or perhaps to the location of the information itself. These variations are further discussed and addressed within the scope of this review. A theoretical stance facilitates an increased understanding of the warning processes and variables affecting the processes at different stages expressed through previously tested communications. In the theoretical understanding, the warning process is interpreted within human-communication models or mental models, such as the C-HIP model in Figure 2.7 (Wogalter and Laughery, 1996).

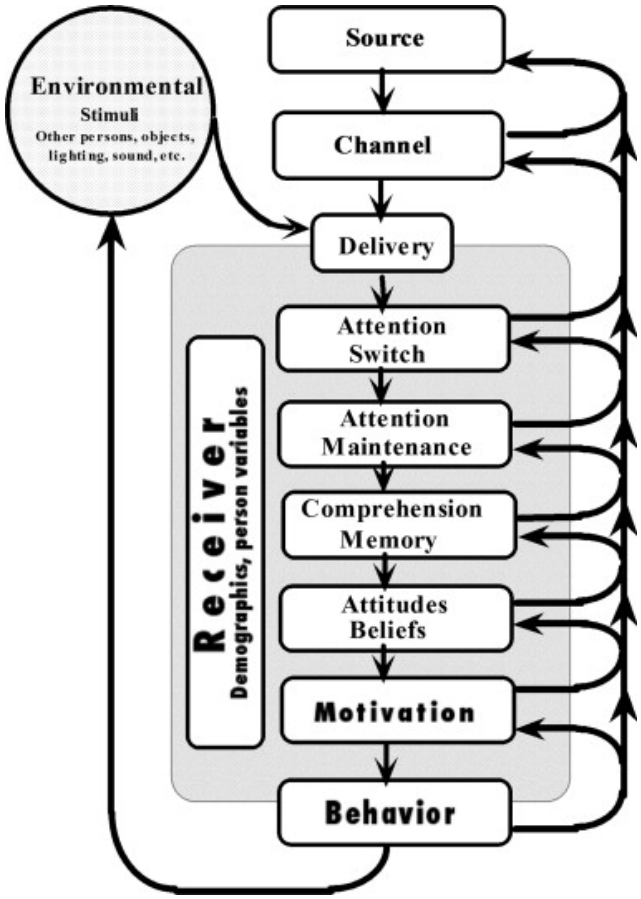


Figure 2.7 Communication-human information-processing model (C- HIP) (Wogalter et al., 1999)

The model considers previous literature in the area and, although there is a considerable diversity of methods and findings, warning study generally fits within the C-HIP model. Location aspects of warnings must also be considered, as hazards occur in a variety of conditions corresponding to where the user can locate the information (Wogalter, 2006:8). The location also encompasses the channel of the information (or format), for example, whether the information is provided within accompanying leaflets, embossed on the product or applied within the built environment (e.g.., on a wall or on play equipment). It further highlights the issues involved and what needs to be taken into consideration in applying guidelines to the design of warning information. Study into warnings and warning theory stems from prior research. Previously tested communications, models and principles are also important to developing resources further.

2.5.2 Human-factors principles

Human-factors principles are employed by many companies in design for customer loyalty and marketing proposals. Human-factors information is useful for providing information about complex user interfaces such as products and basic interfaces, such as signs or information. The International Ergonomics Association defines human factors as follows:

The profession that applies theory, principles, data and methods to design to optimise human well-being and overall system performance.

Designers may find it difficult to apply such theories to everyday practice. In the case of developing warnings or risk communications for children, theories have not been designed intentionally for the explicit purpose of informing their development. This is also true of message content in health advertising (see Slater, 1999). There are numerous theories; however, the developed knowledge is difficult to navigate, and there is a gap in the knowledge concerning which theory is the most appropriate one to apply in a given context (Slater, 1999). The theoretical nature of much warnings and message development study means that, "many of the available theories not having been designed intentionally for the explicit purpose of informing the development of message content" (see Slater, 1999). This may lead to confusion, particularly for a design practitioner, concerning how to apply such information to design practice. There are attempts to address these suggested limitations documented in the literature, and various models have been devised. One example is shown in Figure 2.9: the step approach to message development and testing, or SatMDT, (Lewis et al., 2009). Many of these attempts have not been modified to address the specific needs of sub-groups such as children.

2.5.3 Systems approach to message design and testing

One way of pulling together existing information and findings is to adopt a systems approach as demonstrated in the recent warning and risk communications literature (Wogalter, 1999; McLaughlin and Mayhorn 2014). The illustration of the systems approach adapted to risk communication from McLaughlin and Mayhorn's study on designing and evaluating communications for older adults is displayed in Figure 2.8.

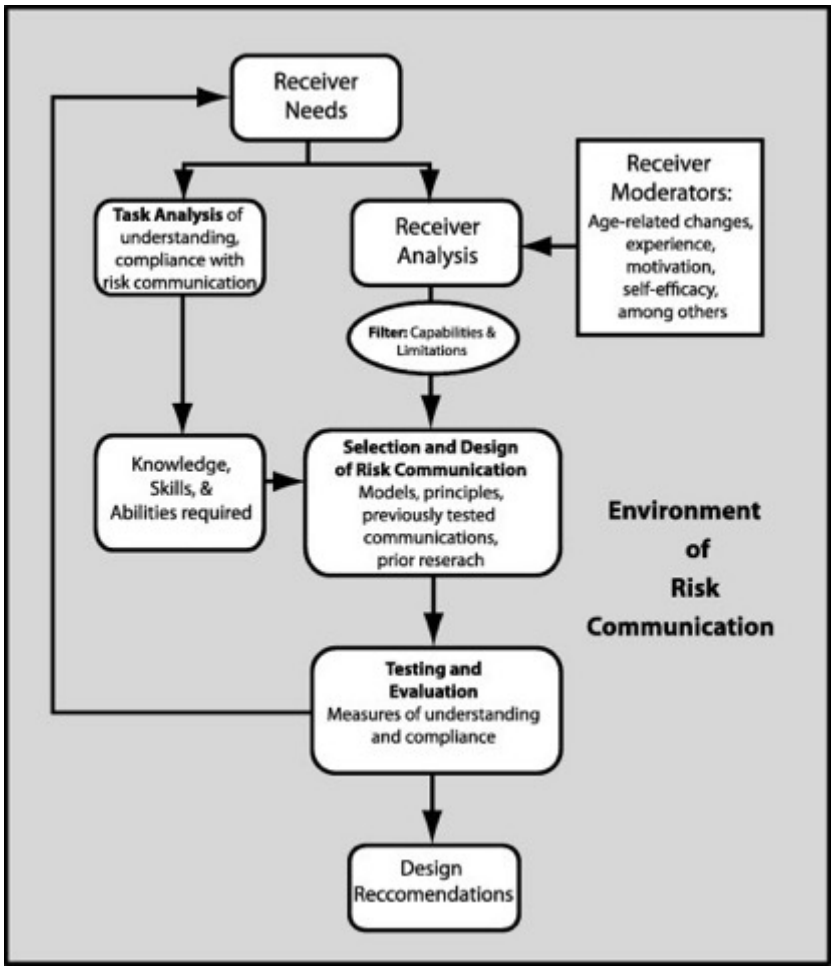


Figure 2.8 Illustration of the systems approach adapted to risk communication. From: McLaughlin and Mayhorn, 2014

Study with adults reveals several factors that affect viewers' understanding of the message communicated by a warning sign, include the language expressed (e.g., word choice, explicitness) and pictorial images shown. There is a danger that designers assume that overcoming safety issues in design relies on the user's ability to follow the warning information and often-unclear instructions. This issue stems from the fact that designers may lack specific knowledge of the consequences of hazards to the specific user groups or individual. The previously described C-HIP model (Wogalter, 1999) in Figure 2.7 as well as other research, developed models and frameworks within the recent safety-science literature, suggest that individual differences are an essential consideration when warning messages are being produced (Wogalter, 1999; Mclaughlin and Mayhorn, 2014; Riley et al., 2014:11). It thus seemed appropriate to look at this important area from a holistic view adopting a systems approach to design for child safety. The design of visual information for children is not well accounted for; therefore, a systems approach aims to be more holistic and hence, comprehensive. In

fact, the potential to apply "systems thinking" is realised within recent studies (McLaughlin and Mayhorn, 2014). As a group, older adults are similar to young children, as they have changing physiological, psychological and physical abilities.

As illustrated above, McLaughlin takes a systems approach to investigating the environment of risk for older adults and looks at age-related changes—specifically discussing sensory changes such reduced cognitive processing or physical changes. He describes these changes in relation to possible interactions with risk communication (McLaughlin and Mayhorn, 2014). The study considers moderators derived from previous research and the demands imposed by a risk communication on older adults. As children are also moving targets with quickly changing abilities, the systems model developed for customising risk communications for the needs of older adults (McLaughlin and Mayhorn, 2014) is adapted to include examples and recommendations for the design of risk communications aimed at young children and their carers. Adopting this approach provides a technique for collating existing research in bringing together existing information and findings. The model can be easily adapted to consider the key moderators of comprehension and compliance for young children through an analysis of the receiver population where the risk is communicated.

McLaughlin and Mayhorn (2014) suggest that previous models of risk communications have concentrated on communication elements. Wogalter (1999) claims that future models of warning processing will likely integrate aspects of other outside sources and include the environmental context of warning information to gain a holistic or system-based view. The author claims that this approach should ideally be combined with model validation and revision and be based on evaluation within the context of use (Wogalter et al., 2002). Consequently, McLaughlin and Mayhorn (2014) stress the importance of considering other aspects to include both the environment and the receiver during the design and testing of designs, viewing the model "as one integrated whole" through a systems-integration process. McLaughlin adopts a systems approach to centre on the needs and abilities of the intended receivers. Thus, for risk communications to be designed and tailored to the needs of the intended audience of young children, all elements of the total system must efficiently integrate. Inside the environment, designers must consider the characteristics of the receiver (which include moderators derived from previous research) and the demands imposed by the risk communication (McLaughlin & Mayhorn., 2014). Moderators, as illustrated in the model, include, age-related changes, experience, motivation and self-efficacy, among others. The process also advocates the use of theoretically underpinned, systems-based methods, including task

analysis and receiver analysis (of understanding and compliance with risk communication). Task analysis is a conventional technique used by human-factors professionals to discover the tasks incurred by a task or a set of tasks when interacting with a product or system (Hackos and Redish, 1998). As task analysis mainly focuses on the interaction, it is a relevant method to use in developing and improving upon risk communications. Observing, describing and decomposing a task can be used to analyse the user interaction with a risk communication. The behaviour of the user, the knowledge of the user and the environmental (contextual) variables have an impact on user perceptions and decisions during the interaction with a warning, for example in processing the risk communication. Therefore, task analysis requires both declarative and procedural knowledge (Clark & Estes 1996). According to the results of qualitative task analysis, current products can be maintained or improved and design guidelines for a new product can be identified; hence, qualitative task analysis is a useful human-factors technique for understanding and improving upon the function of risk communications for young children. Indeed, Riley discusses "mental models" in warning-message design. The author emphasizes prioritising risk information cases to illustrate the importance of designing or customising risk communication in ways that are specific to the audience regarding both beliefs and behaviour (Riley., 2014).

Traditionally, risk has been related to the expected losses that can be caused by an event in association with the probability of occurrence of the event (ISO/IEC Guide 50, 2002). Accordingly, the analysis of risk environments is based on statistics of children's injuries in different environments in combination with the clinical impact of such injuries. The lack of an evidence base for young children, particularly in evaluating risk communications, is due primarily to the barriers involved in the evaluation of young children. Evaluating risk communications is challenging for adult groups, and many variables may influence their effectiveness; this becomes yet more challenging in the context of young children.

Section 2.3.2 describes the scope of unintentional injuries. Data shows that accidental injury takes a heavy toll on society—particularly on children and older adults. Children are not small adults, and there is a need to provide designers with a usable set of information resources that will better inform them of the unique characteristics of children and differences in design data in comparison with adults. Recognised critical difficulties in applying ergonomic data and information include the following: Current resources are often piecemeal and lack an accessible format when used by designers and manufacturers, and cognition and capabilities vary significantly at an assumed stage of

development. *Safety aspects—guidelines for child safety* is a guide for standards developer which provides guidelines for child safety and describes the importance of taking the developmental stage of a child into consideration for products, systems and services (ISOIEC Guide 50, 2002). Depending upon the product, system or service, the guide highlights aspects such as the fact that children interact in ways that reflect their developmental stage; therefore, as discussed in CEN Guide 14, it might be necessary to protect children of different ages from varying hazards by using very different means. Their lack of awareness and susceptibility to injury puts them at risk of harm in ways different from adults. Social networks and British safety standards are facilitators of child-safety awareness. Further inhibitors of adherence to safety advice include the birth order and personality of the child, infant development, costs associated with safety products, and the use of alternative safety strategies.

Warning information is an essential part of the reduction of unintentional injuries to young children. Despite this, and given the implications of unintentional injuries, children still tend not to be taken into consideration as a user group when designing risk communications. Warning information developed for older groups does not meet the same requirements as that specifically aimed at a young child, which may, in turn, lead to unsuccessful warnings. This is borne out by study in which Waterson (2012) used qualitative methods, which included sets of classroom discussions with young children and semi-structured interviews with carers and other groups to assess the warning needs of young children (aged 5–11 years) on trains. Their lack of study in the area suggests the need to develop further methodological and design guidelines for the testing and evaluation of warning signs and other types of visual information aimed at young children. The source and the channel of the communication plays a vital role in communication. Multimedia could be used on a cognitive level to satisfy more groups with different learning styles.

2.5.4 The STEP approach to message design and testing (SatMDT)

The literature to date indicates that a more comprehensive approach is needed for the design of effective risk communications to promote the prevention of childhood injuries. Although there is a lack of information regarding the development of suitable risk communications for children, the theoretical knowledge base could be applied to

develop the grounds for a study of children. The theoretical understanding underpinning warning information and risk communications is well-developed, but its application to practice is perhaps not so well understood by practitioners and other groups. A conceptual framework used to guide the development and evaluation of persuasive health communications is presented below from Lewis et al. (2009). The accident analysis and human-factors literature point to the centrality of understanding users' risk perception or hazard perception in designing effective communications and in preventing or reducing the number of unintentional injuries (Riley, 2014:11). Furthermore, it has been determined that, for compliance with the safety information or warning to occur and to be effective, the communication cannot be studied without context (Montagne, 2013). Within previous research studies from the found literature, various models, agendas and frameworks for risk communications for other groups, including older adults have been developed. There are however other considerations, stemming from other research areas, which are discussed in this review, that need to be taken into consideration for warnings targeted at young children. The SatMDT by Lewis et al. (2009) considers pre-existing characteristics such as the gender, age, behaviour and beliefs (including emotional and cognitive responses) of the user. The SatMDT approach describes 4 distinct methodological steps for the process of message development and evaluation, as shown in Figure 2.9.

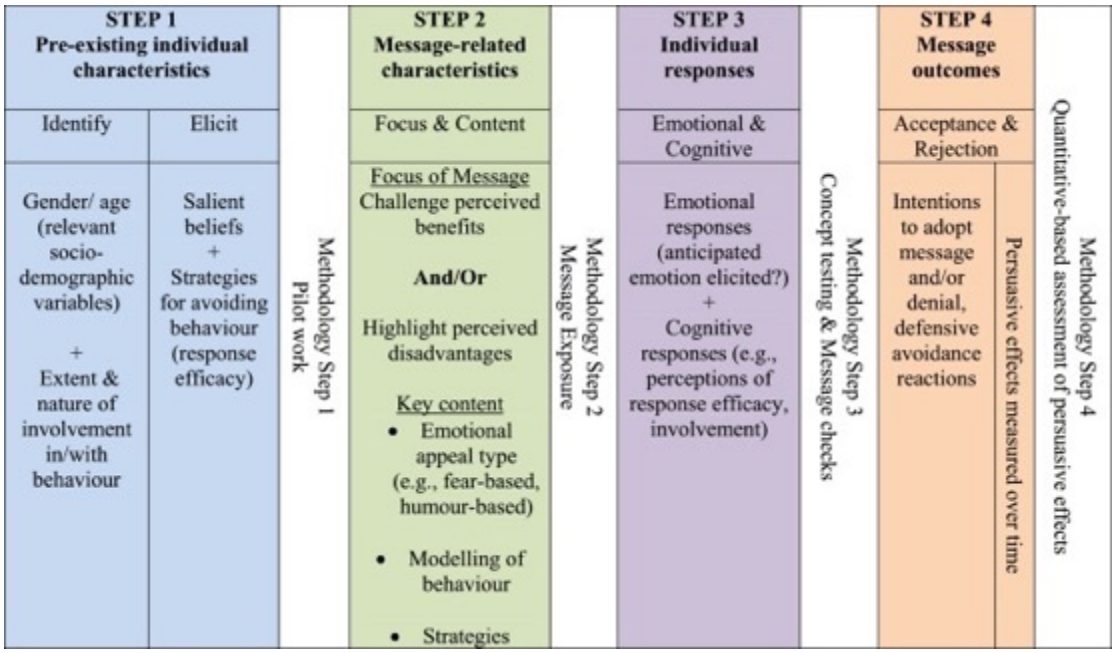


Figure 2.9 The STEP approach to message design and testing (SatMDT) by Lewis et al. (2009)

Methodological step one is the pilot work. The second step consideration is given to the characteristics or focus of the message and message exposure. The authors suggested evaluation of the message with the methodology in step 3 consisting of concept testing and message checks through message exposure with the people whom the message is intended for, to gather the individual emotional and cognitive responses to the message. In Step 4 the authors suggest a quantitative-based assessment with the effects of the message being measured over a longer period of time.

2.6 User population

One of the essential considerations in human-centred design is the user population. In risk-communication research, the question of who will be interacting with the information also needs to be addressed. Individual factors relating to the user population are significant because they are a crucial driver in the overall design and evaluation of risk communications. It is especially important to determine the range of critical dimensions, the message content, and the channel of communication used, or values that are significant to the overall layout and design of the risk communication or product. In the literature, users interacting with the communication are typically defined in terms of age, gender, ethnicity, and other special considerations, for example situational or environmental factors.

2.6.1 Developing risk communications for children

Using a previously established framework to evaluate guidance in design (McLaughlin and Mayhorn, 2014), the studies reviewed (most of which are theoretical in nature) were analysed for themes pertaining to: (1) design culture (existing risk-communication process and user considerations); and (2) use of evidence (processes and variables that may affect or enhance user interaction with a risk-communication). Previous work has identified several factors to consider regarding safety in design for young children. These factors include anthropometric measurements and the physical and psychological abilities at various stages of development. Certain methods involve applying theories from other disciplines such as psychology to concepts that can be used within the design field (Antle, 2008). As discussed, the characteristics of the target user group of young children are rarely considered when formulating warning information. Certain child characteristics (e.g. verbalisation skills, concentration span) may affect design sessions.

Therefore, it is not always possible to include children in the process of testing warnings and risk communications. Waterson & Monk, 2014 propose a cycle that designers should follow which incorporates the authors' guidelines (Appendix A) for testing and evaluation in producing risk communications appropriate for young children. The waterfall model of the cycle allows for an iterative process with several stages of design and evaluation at each stage of the process.

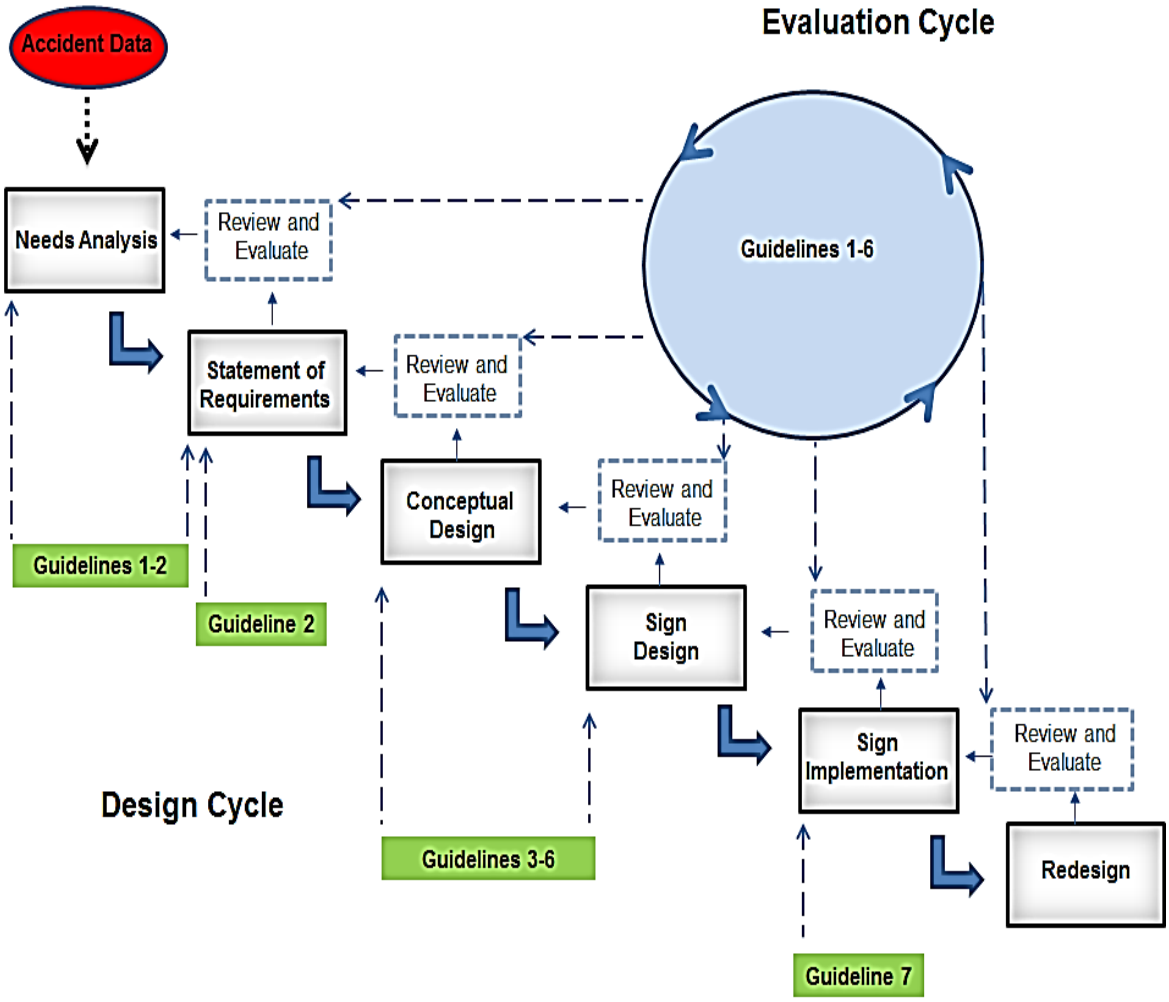


Figure 2.10 Flowchart of design and evaluation activities (based partly on Keates and Clarkson, 2004, p. 154). From: Waterson & Monk, 2014

Waterson and Monk recommend the compilation of a more comprehensive guide for design and evaluation. Amongst other aspects, they stress the need for behavioral evaluation of children's warning signs. For example, as these authors discuss in recent research (Waterson and Monk, 2014), an important consideration is that comprehension and interpretation are likely to be shared processes involving interactions with responsible adults or caregivers. In general, perceptual literacy depends on experience

and types of knowledge that children lack (Schneider, 1996). Children aged 7 to 11 years increasingly receive less direct supervision from their caregivers, as they are at a stage where they are more able to make autonomous decisions about their activities.

Previous research on warnings has established that it is essential to identify who the target audience for the risk communication is. For this reason, this section of the research examines the receiver characteristics of young children. The second section of Wogalter's C-HIP model describes the characteristics of the receiver that relate to information processing, which may affect how they understand and comply with a risk communication. McLaughlin and Mayhorn's (2014) model presents a holistic consideration of the essential stages in the process of designing a risk communication customised to the needs of the intended user or receiver. Adopting a similar model will more accurately determine children's capabilities and limitations. Emphasis will be placed on the need to understand aspects such as demographic and other factors that might affect the processing of risk-related information by the target audience of young children, rather than the adult population. This part of the model is essential in showing people's involvement in understanding or processing the message, which could further explain young children's involvement when a warning is encountered. Part of the model also suggests that environmental influences contribute to the context in which the warning is processed. Mayhorn and Wogalter (2010) state that 'contextual influences also include the co-occurring internal aspects of the individual who is processing the warning.' In developing their guidelines, Waterson and Monk suggest taking into account research regarding children with visual impairments and dyslexia.

The processing stages described in Wogalter's C-HIP model (Chapter 2) pose more of a challenge for young children than for the adult population, as children's development involves complex changes in cognitive, physical, and psychological traits (e.g. emotional and social development). In Walsh's view (2005), 'changes can be a function of 'p*hysical maturation*', environmental influences, or person-environment interactions'.

2.6.2 Children's information processing

The McLaughlin model does not account for fundamental developmental changes in children. For example, it does not consider changes in children's cognitive development, such as language development or the progression from thinking in "concrete" terms to more abstract logical or social thinking. Information-processing models in the literature focus on internal cognitive processes with little attention paid to environmental

influences. Environmental factors, or the nature of the external stimuli to which the individual are exposed, are essential in childhood injury prevention and are discussed in much of the public-health literature (Sethi., 2008). The impact of children's interaction within the process is not considered in the information-processing model; for instance, the model neglects to consider aspects or variables that may affect interpretation that are unique to young children's needs, emotions and individual behaviour in cognitive processing or interpretation. For example, the model does not consider that a child may process a stimulus differently if they are under pressure versus if they are in a calm state. In addition, the information-processing model is described as universal, with little attention being paid to individual or cultural differences. The strategies children use to encode and remember information are of interest to information-processing researchers (e.g., task analysis research).

2.6.3 Encoding and transfer of information

The process of encoding and transferring information is complicated. There are differences in the way that children encode information before transferring it to memory that have not yet been taken into account in the warning literature. Chi points out that substantial evidence exists showing that the processing strategies used by adults are unavailable or deficient in children (Chi., 1976). In order to remember events and facts for an extended period, individuals encode and subsequently transfer them from short-term to long-term storage. Chi., 1997 found that the children have a deficit in processing strategies as well as in processing speed. The author argues that these deficiencies result from limited long-term memory semantic and recognition knowledge. Encoding, storage, and retrieval are typically seen as sequential stages, as described below.

Table 2.3 Processes of transferring information.

• **Encoding**	Refers to how you transform a physical, sensory input into a kind of representation that can be placed into memory.
• **Storage**	Refers to how you retain encoded information in memory.
• **Retrieval**	Refers to how you gain access to information stored in memory.

It is important to remember, as described in the C-HIP model with the use of interconnected loops, that the processes described interact with each other and are

interdependent (Wogalter., 1999), which is also relevant to young children's processing of risk communications.

In the discussion of cognitive processes, emphasis is placed on the recall of verbal and pictorial material, as they are most relevant to understanding warning information. Research indicates that we do however have memories of other kinds of stimuli as well, such as odours (Herz & Engen, 1996; Olsson et al., 2009).

2.6.4 Comprehension

In risk communication, the goal of high levels of comprehension of the message is important because the intention is to communicate important safety information so that persons at risk of injury remain unharmed. Evaluations should determine if a warning is noticed, read, and understood. However, this may also be time-consuming and expensive, as several versions may be needed to reach children of differing abilities (Rice, 2013). Children's ability to encode and comprehend warnings differs according to their age and their cognitive abilities. Hence, the effectiveness of a warning will depend on the child's understanding of the message (written or visual) and their ability to conceptualise, apply logic, and associate the warning to their behaviours and the consequences of their actions. Those who design warnings should ideally test them with the product's target audience, such as children from a certain age range. However, as discussed above, this is not always possible.

2.6.5 Attitudes and beliefs

Perceived hazard or risk is a relevant factor identified in the warning literature. It is interrelated with people's beliefs and attitudes. The C-HIP model (See Figure 2.7, Wogalter et al. 1999) is a framework that describes several stages of processing within the receiver that are necessary for a warning to be effective. A mismatch between people's beliefs about the extent of the hazard and the actual extent of the hazard can affect and may prevent compliance behaviours. If the warning message does not concur with the receiver's beliefs, then for a warning to be successful the receiver's beliefs or attitudes need to be altered appropriately by means of salient or persuasive messages to enable further processing that results in behavioural compliance (Wogalter, 2006). Beliefs about hazards are known to differ between individuals and groups (Woglater and Mayhorn., 2017). The most recent research in warning and risk communications

explores novel methodologies, principles, and previously tested communications, including those developed for vulnerable groups. An example is McLaughlin and Mayhorn's (2014) framework for risk communication aimed at older adults. Although applying theories from psychology can improve safety design for children, the research to date acknowledges that there are difficulties in translating theories from psychology to a design environment (Antle, 2008; Norris and Wilson, 1995). The child-based persona is an example, as it may be difficult for a designer to understand the subtleties between areas of psychology and design, i.e. capability change is both physical and cognitive. If a design is to be optimised for children, a thorough knowledge of children's mental and physical capabilities at the various stages of development is required. Individual elements such as cultural differences may impact on the developmental process, but children are expected to follow a similar developmental pattern regardless of their location. Gossen and Nürnberger's model (Gossen and Nürnberger, 2013) describes the key stages of development that are relevant to the design of effective risk communications specifically for children. They also discuss the characteristics of these stages in relation to Piaget's theory (Pagit, 1997). The model has been adapted to the relevant skills, such as fine motor skills. It shows that as a child matures, their information-processing rate increases. Psychologically, as a child matures, and they enter into the formal operational stage, they have a greater fear of failure than younger children do. A child's capacity for logical reasoning also increases as they reach the formal operational stages, meaning that they are more able to make informed decisions about risks and have an improved understanding of the consequences of their actions. Information of this sort helps to build a better understanding of child-risk interactions and the areas of development that are relevant.

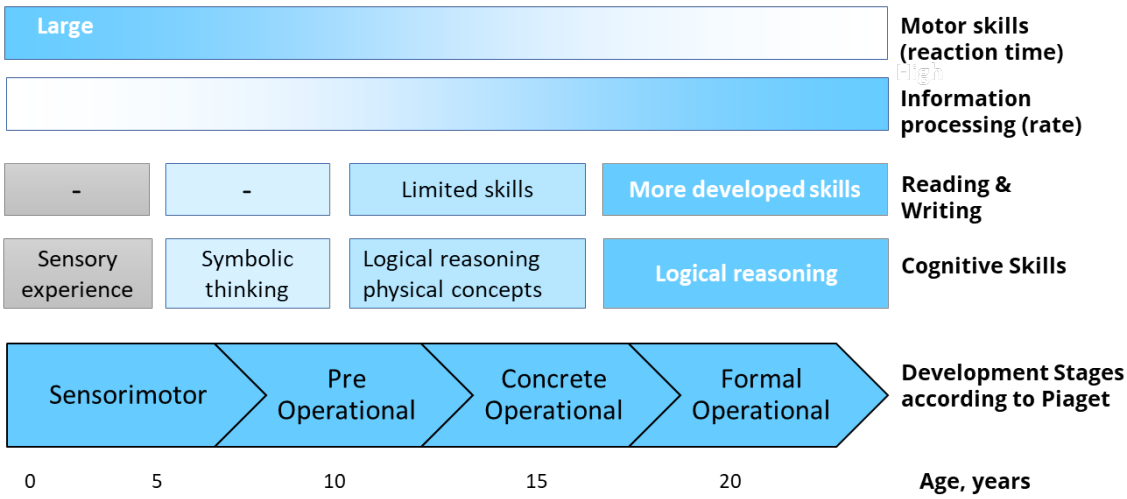


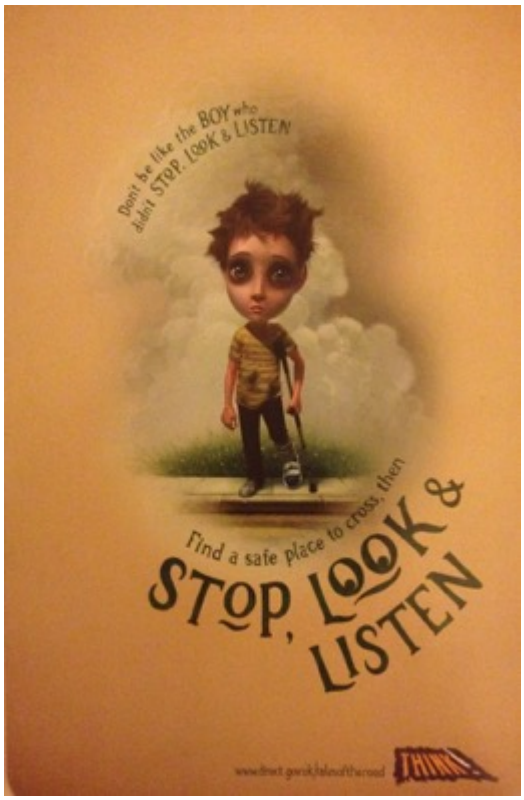
Figure 2.11 Stages of human development and their characteristics. Adapted from Gossen and Nürnberger (2013 p.741)

The concept of developmental stages that is of relevance to this research, which includes pre-operational and concrete operational development, argues that children go through a series of logical stages in their development. During this process, the way they can understand and furthermore identify with objects also develops (Torres et al. 2007; Brouwer-Janse 1997). Therefore, if consideration is given to the child's formal operational stage, for example, it will be possible to develop an understanding of how 11- to 12-year-olds interpret information. This will enable the design of risk communications to be focused on the child's age group. Design targeting a specific age group may simplify the processing stages that the child goes through in understanding a risk communication, as the object used to represent the functionality will be derived from something with which the child is familiar. Understanding risks specific to young children

The research on children is reviewed in this section to understand the gaps in current knowledge regarding the target age group. Table 2.4 outlines various studies and determines gaps in the literature and relevant considerations.

2.6.6 Characterisation of risk communication

Risk-communication campaigns and warnings are one form of intervention aimed at young children that intend to assist in accidental injury prevention. There are different models of fear-based and humour-based campaigns. The Think! Campaign posters for road safety are provided as examples in Figure 2.12. Research indicates that a warning should inform users of what to do or avoid, and these examples show possible consequences, i.e. injuries that may be incurred (see ANSI, 1987, Wogalter, et al., 1987; Goldhaber & deTurck, 1998). Studies analysing road-safety communication campaigns have identified several main types of persuasive approaches used in their message design, including informative, positive, and emotional approaches. Goldhaber & deTurck, 1998 indicated the advantages, limitations, and ethical issues associated with each type of campaign, drawing on behaviour change theories.



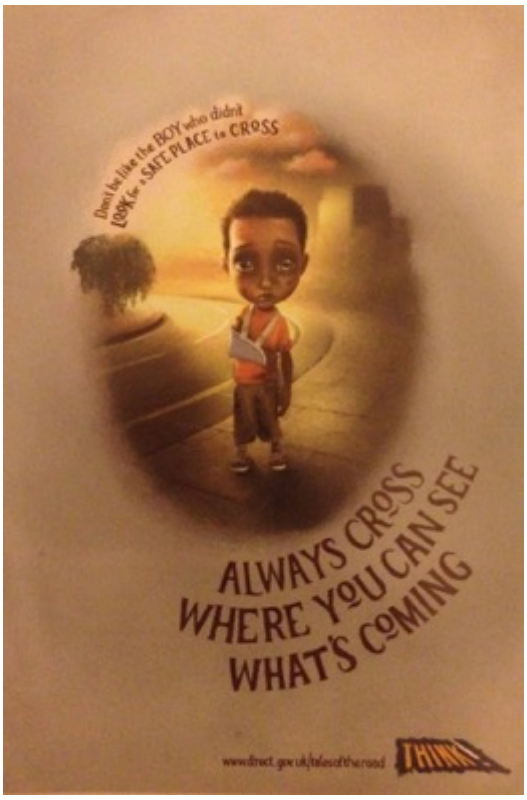


Figure 2.12 Think! Campaign—Tales of the Road

The above examples make use of realism and are an example of a fear-based road-safety campaign aimed at young children. Such campaigns have been found to be effective mainly when they are part of multifaceted interventions and when they utilise explicit theoretical frameworks and a social marketing approach.

2.6.7 Methods used with children

Various methods for developing risk information have been used within the risk communication and warning literature. This review collates the sources that are most relevant to designing risk communications for young children. The table below compares the approaches, groups involved, age ranges, and gender of children included in studies to date. The findings and limitations of each of the studies are discussed in this section to provide a comprehensive overview of the research that has been done and the gaps that exist.

Table 2.4 Age ranges and methods

Literature Source and Keywords	Purpose and Aims	Methods	Participant Numbers and Gender	Age Ranges	Findings and Limitations of Study/Applicability to UK
Boto et al., 2015. (Portugal) Warnings; Children; Safety; Design; Ergonomics	Focus is the design of a warning regarding a poisoning hazard targeting children from 9 to 12 years old. Investigates how children interoperate current warnings and what the principal characteristics are that children search for in a warning to interpret it correctly.	4 focus group sessions (4–5 children per group). Suggests that 4 or 5 participants are probably the ideal number of participants, especially if they are younger children.	(*N* = 20) 11 females and 9 males. 9 boys were divided into 2 sessions, one consisting of 4 and the second of 5 participants. 11 girls were divided into 2 sessions of 5 and 6 individuals.	Children's ages varied between 9 and 12 years old. Average age of 10.60 years (SD = 0.99). Girls: aged between 10 and 12 years old (10.36 years) (SD = 0.67). Boys were aged between 9 and 12 years (10.89 years) (SD = 1.27).	**Findings:** Children had difficulties in correctly expressing the warning's meaning, especially in terms of vocabulary. Some guidelines for designing new poisoning warnings are provided. **Limitations:** It does not specify the duration of the focus groups.
Morrongiello et al., 2016. (Canada) Children; Unintentional Injury; Diving; Warning Signs	Addresses the lack of research on children. The study examines children's understanding of both text and image features on 'No Diving' warning signs.	Structured interviews. Children were asked questions to assess their understanding of text, images, and main messages on 'No Diving' warning signs. Parent filled out questionnaires regarding family demographics, child's history of swim lessons, and experience in diving.	(*N* = 120) children. Equal number of males and females in each group.	One group of normally developing 7–10-year-olds (*N* = 62, 7.0 to 8.5 years, *M* age = 7.52 years, SD = 0.68 years) and an older group (*N* = 58, 8.8 to 10 years, *M* = 9.16 years; SD = 0.64 years).	**Findings:** Children do not routinely consider that permanent injury can result from diving into shallow water. Explicitly outlining consequences that you can "break your neck" may improve effectiveness. Active supervision is particularly important to the safety of children with prior positive diving experiences, as this seems to constitute a "high risk" group.

Literature Source and Keywords	Purpose and Aims	Methods	Participant Numbers and Gender	Age Ranges	Findings and Limitations of Study/Applicability to UK
					Limitations: The sample in the study was mainly Caucasian, middle-income, well-educated families. A diverse sample should be tested in future because exposure to factors that could influence children's understanding of diving risks (e.g., recreational water experiences, news stories/discussion about diving injuries) is expected to vary with income and parent education levels.
Morrongiello et al., 2010. (Canada) Children; Unintentional Injury; Risk Assessment; Questionnaire	The objective of this study was to develop a standardised questionnaire (*BACKIE*) that would assess the Behaviours (B), Attitudes (A), Cognitions (C), Knowledge (K), and Injury Experiences (IE) of elementary school children pertaining to seven types of injuries, including falls, motor vehicle collisions, burns, drowning, choking/suffocation, poisoning, and bicycle/pedestrian injuries.	20–30-minute activities during physical education classes so the children would understand that it was related to health and well-being.	(*N* = 512) children (53% male). All children were fluent in English and none had any physical or mental disability or delay.	7 to 12 years. There was good variation in scores across the ages tested, meaning that the *BACKIE* items were well suited to children 7 through 12 years of age.	**Findings:** Results indicated that this measure provides a reliable and valid indicator of elementary-school-aged children's safety attitudes, cognitions, knowledge, and behaviour relevant to 7 broad types of injuries. It also clarified that it was easy to use: children readily understood the instructions and items, with very few asking clarification questions during administration. The *BACKIE* allows investigators to examine the relative importance of these factors in predicting risk and safety behaviours in children aged 7 through 12 years of age and allows for intervention planning. **Limitations:** The questionnaire lacks evaluation.

Literature Source and Keywords	Purpose and Aims	Methods	Participant Numbers and Gender	Age Ranges	Findings and Limitations of Study/Applicability to UK
Siu et al., 2017 (Hong Kong) Colour Association; Colour; Ergonomics; Safety Signs; Children; Warnings; Reasoning; Participatory Ergonomics; Public; Design	To address a lack of recent research focusing on children and their colour association in the context of safety signs Different combinations of colours were also considered in view of the research gap identified in the literature review.	Analysis of children's drawings and design to understand how children use colour in drawing different safety signs and how they associate colours with different concepts and objects that appear in the signs. Researchers observed and analysed colour in children's drawings to understand children's thoughts about sign design.	(*N* = 32) 16 male and 16 females.	7–11 years old. (The study conforms to Piaget's stages of cognitive development.)	**Findings:** Significant associations were found between red and 'don't', orange and 'hands', and blue and 'water'. The participants could explain the reasons for the use of certain colours based on concrete identification and concrete and abstract associations. The children were unable to distinguish between referents' different levels of hazard or to relate orange and yellow to lower levels of hazard such as warnings, as they also used red in some warning signs. The child participants were only able to identify the reasons for the use of yellow, green, blue, and black through concrete identification and concrete association, and red through abstract association. **Limitations:** The study is applicable to the UK as the children's knowledge of colours was assessed against ISO-registered signs. A small number of children participated in the study,
Waterson and Monk (2014). (UK)	Provides further development and refinement of a set of guidelines (Waterson et al., 2012) for the design and evaluation of warning signs and other visual material for	Set of 11 semi-structured interviews and 6 focus groups involving various experts for the evaluation of guidelines developed by Waterson et al. (2012).	(*N* = 38) parents of young children, teachers, human-factors	N/A	**Findings:** Models of sign comprehension and communication, e.g. the C-HIP model (Wogalter et al. 1999), need to be modified to accommodate adult-child interaction and involvement in the

Literature Source and Keywords	Purpose and Aims	Methods	Participant Numbers and Gender	Age Ranges	Findings and Limitations of Study/Applicability to UK
Warnings; Signs; Children; Safety; Railways	young children (aged 5–11 years).		experts, and other groups.		process of building a negotiated mutual understanding. **Limitations:** Need for a broader application of the guidelines and further behavioural testing with children.
Waterson et al. (2012). (UK) Warnings, Signs, Children, Safety, Railway	To obtain children's opinions on existing and novel safety signs.	The study involved the analysis of industry accident incidence data and a set of classroom discussions which lasted on average between 20–30 minutes with 4–6-year olds. With older children (7–10 years) the workshops lasted longer (45–60 minutes).	(*N* = 210) children across 7 different classes. Males and females.	Younger children (4–6 years) and older children (7–10 years). A small number of children in the reception class were 4 years old and a similar number in the Year 6 class were 11 years old.	**Findings:** A set of guidelines for the design of safety signs for young children. Need for summative assessment. **Limitations:** Conducting research with and extracting comments from children is challenging. Evaluation was carried out on the same group of children due to time constraints.
Liu et al. (2015) (Taiwan) Young Children; injury burns; 5-Factor Accident Sequence; Story Telling	To analyse the within-corpus differences in the narratives of 60 6- and 7-year-old children. Specifically investigated whether illustrations (5-factor accident sequence) were or were not employed to assist children's narration of a home accident in which a child received a burn injury from hot soup.	Storytelling. The researcher built a connection with the children by playing games. In step 2, to make the children focus on the experiment, they were told they would need to retell the story to their parents, who were not present. In step 3, the burn story was told. In step 4, the children were allowed to play games for 15 min after the storytelling. In step 5, the researcher asked the children to	(N = 60) children. Male and females were split evenly into 2 groups.	(Ages 6–7) Normally developing children. (IQ of children was assessed)	**Findings:** Employing the combined oral storytelling and pictures approach can help 6- and 7-year-old children memorize the story and its specific content, such as "the dangerous objects that caused the burn injury", "the reason why the protagonist committed the unsafe act", "the unsafe act committed by the protagonist", "the protagonist's attitude toward the unsafe act that caused the burn", and "feelings about the severity of the burn".

Literature Source and Keywords	Purpose and Aims	Methods	Participant Numbers and Gender	Age Ranges	Findings and Limitations of Study/Applicability to UK
		retell the story to their parents, which was recorded on tape.			This study utilised the "story grammar" approach (Stein and Glenn, 1979). **Limitations:** This study only explored one risk situation. Other injury circumstances need to be assessed. There is a need for further testing with children. The authors recommend behavioural testing to examine the influence of presenting unsafe actions (i.e., critical factors for accident prevention) in warning information to promote behaviour changes.
Ricketts et al., 2010. USA Health communication; Injury prevention; Stories; Anecdotes; Safety Warnings; Accident prevention.	To examine the impact of injury stories on actual safety behaviour in a controlled experiment to assess how safety messages might be redesigned to have a greater impact on risky behaviour.	Using Story-based messages to convey risk communication messages.	Male and Female University students	N/A	**Findings:** Story-based messages resulted in a 19% improvement in safety behaviour compared with non-narrative communications. Importantly, injury stories did not create undue fear of the message object, demonstrating that brief anecdotes about accident victims can convince people to take reasonable precautions without creating unwarranted alarm about risks. **Limitations:** This study involved adults and no children.

2.7 Discussion

This section discusses factors that may influence a child's understanding of the communicated message based on the findings in the literature. The most up-to-date research is presented in the table above. From the review of the above literature sources, it is clear that there is insufficient empirical research on the development of effective risk communications aimed at young children. However, the studies that have been included are relevant to aid the researcher in further developing methods for the design and evaluation of risk communications aimed at 5- to 11-year-old children. The varying nature of these studies assists in gaining a broader understanding of risk communications.

The table above compares the limitations of some of the included studies. It highlights for example the varying age ranges and various countries that have been studied. The limited amount of research that has been conducted in the UK also limits the generalisability of these findings to the UK. The main limitations are summarised below:

- Age ranges vary
- Group sizes vary
- Ratio of male to female participants varies
- Few studies have been carried out in the UK
- Varying methods are used, although these are mainly qualitative rather than quantitative
- Need for further evaluation and behavioural testing

Research with adults has identified several factors that affect viewers' understanding of the message communicated by a warning sign, including the language used (e.g., word choice, explicitness) and images contained within the message (Morrongiello et al., 2016). Boto et al. (2015) found that children's vocabulary may limit their ability to understand and express the meaning of a warning. However, various studies show that storytelling is a method that has been effective in engaging both adults and children in understanding risk and promoting effective ways to communicate risk information to the end user (Ricketts et al., 2010; Liu et al., 2015). Ricketts., 2010 used storytelling

methods with adults, including using brief anecdotes about accident victims, and found that this can convince adults to take reasonable precautions. In addition, findings have shown that story-based safety messages result in a greater improvement in safety behaviour compared with non-narrative communications, suggesting that this method may also be suited for use with children. Liu et al. (2015) used storytelling methods with 60 normally developed children aged 6 to 7 years to research children and burn injuries in the home. The "story grammar" approach described by Stein and Glenn., 1979, was used in the study. The children were told a story involving a burn injury and subsequently asked to imagine that they were narrating the story to their parents, as the parents were not present during the data collection. The aim was to analyse the differences in the way that the children recounted the burns story. The study's limitations include that the research only explored one injury circumstance. Hence, there is a need for a more comprehensive understanding of its applications in a variety of other circumstances relevant to young children. Similar to Waterson and Monk's 2014 research outcomes, one of the outcomes from this research was the identification of a need for further behavioural testing with children.

2.7.1 Methods for including children in design research

As described in Table 2.4 above, previous research has primarily used qualitative methods, including but not limited to classroom discussions and semi-structured interviews, to improve understanding of the requirements of risk communications for young children. Waterson et al., 2012 and Waterson and Monk., 2014 used the qualitative methods of semi-structured interviews with parents and classroom discussions to formulate and validate guidelines for the design of risk communications aimed at children aged 5–11 years.

Children's drawings have been used effectively in research. Drawings can reveal more about children's understanding and perception and color associations. Insufficient recent research has focused on children and their colour associations in the context of safety signs. Colour associations are a crucial consideration in ergonomics concerning sign design. The process is documented in the ISO3864 series, which specifies the design requirements, including shapes and colours, for safety sign design. A recent study carried out by Siu et al., 2017 addresses this gap. These authors analyse children's drawings to better understand how children relate to colour in the design of risk communications. During the study, children used colour in their drawings of different safety signs in order

for the researcher to understand how they associate colours with different concepts and objects that appear in the signs. The children that participated in the study used red to represent all types of prohibition and warning messages; however, the colour association between yellow/orange and prohibition warning signs was found to be weak. The research is not conclusive, as it raised further questions about the conventional ways of using colour in safety sign design and children's colour associations. For example, the children that took part used blue to represent water in their drawings, rather than understanding it as being associated with the colour for a mandatory warning sign. The results from this study have however provided the researcher with a clearer understanding of the influence of colour on children's perception of risks, as the drawings produced by the children suggest that colour did influence the level of hazard conveyed and the compliance behaviour of the children involved. The authors concluded further that children need to be taken seriously as social actors when they are involved in health education research. The authors also query the assumption that drawing enables children to communicate their thoughts better than conversational language does. They suggest that future work in child development research is needed with an underlying evidence base of the social context and the world of the child.

Karazsia and Brown Kirschman. 2013 conducted a literature review to identify methods for assessing injury events and physical risk-taking behaviours. The methods reviewed included self- or parent-report scales, behavioural observations, and participant event monitoring. One form of measurement of children's behaviours, attitudes, cognitions, knowledge and injury experiences is the 'BACKIE' questionnaire. A language-appropriate questionnaire was developed for children at a Grade Two reading level. It was developed to assess how knowledge, attitudes, and cognitions can affect the safety behaviour-related decision-making of young children of different genders and varying development levels (Morrongiello et al., 2009). The BACKIE questionnaire was reviewed against other methods. Based on this comparison, the authors found this method 'promising' (Karazsia and Kirschman., 2013). In this study, 25 to 30 minutes was deemed a suitable length of time to complete the questionnaire, taking into consideration the children's ability to understand the items and the length of time for administration, as children needed no prompting.

Morrongiello et al., 2016. examined children's understanding of 'No Diving' warning signs. Included in the study were normally developing 7–10-year-old children. The methods used in the study to determine the children's understanding included

questioning the children on their understanding of aspects of the text, images, and main messages on the 'No Diving' warning signs. The authors stress that active supervision is essential for all children in drowning and diving-risk situations but is particularly vital to the safety of children with prior positive diving experiences, as these children seem to constitute a "high risk" group. There were no differences in the risk-related behavior of the different gender groups in the study and differences between age groups were negligible. Children's prior experience was shown to influence how they perceived the risk of injury, as did they not realise the consequences of injury and downplayed the risk of harm. The study's findings suggest that 'No Diving' warning signs should make clear the consequence of children's decisions and actions – in this case, the possibility of harm – as this may serve to remind children of the risks.

The present researcher found limited literature on the perceptions that young children bring to an interaction with a warning. Furthermore, information was lacking on how warnings in turn influence children's perception of risk. More extensive literature sources on risk perception and risk communication for adult populations provide a more comprehensive set of findings to answer these questions (Riley, 2014). As discussed throughout this literature review, the warning research is distinctly lacking in relation to young children.

2.7.2 Methodological limitations

A wide range of methodological, analytical, and ethical issues are often raised in research involving children (Backett-Milburn & McKie., 1999; Waterson et al., 2012). Historically, the write and draw technique is a method that has contributed to health education research (Bradding and Horstman., 1999). Backett-Milburn & McKie., 1999 describe it as a method employed within the classroom that increases children's participation. The authors point to the fact that although the write and draw technique has made an essential contribution in qualitative health education research with children, there has been little reflection on and hence a lack of understanding of the processes involved in the "construction and collection of such data." Largely due to the issues mentioned in this section, such as ethical concerns, being raised in the process. This holds for most research involving young children.

2.7.3 Collation of methods for including children in design

In order to assist designers in choosing appropriate methods when involving children of specific age ranges in the design process, Sluis-Thiescheffer (2011) developed a framework that relates the characteristics of children to those of design methods. There was a gap in the design research that was consulted for the framework, specifically relating to how children with different types of skills could relate to design activities. The research found four types of skills that are characteristic of a design activity, including 'linguistic', 'interpersonal', 'spatial-visual', and 'bodily-kinaesthetic' skills (Sluis-Thiescheffer, 2011). These skills are essential for designers to understand when including children in the design process.

The resulting framework should be applied so that designers can optimise design methods when including young children. The framework of the research uses psychological constructs to outline the rationale for choosing a particular design method for children in a particular educational stage. The focus of the framework is on the developmental stages of children and it incorporates theories of multiple intelligences. However, the research points to the fact that it may apply to other user groups as well, for example adults. The study is an example of how to conduct design research with children applying measurements that have not been used with children but are known to work with adults. The research concluded that the framework requires further testing, which would be time-consuming. In addition, access to the end-user groups may be difficult to achieve.

2.7.4 Applicability of usability goals to children's products

Usability research is considered either too difficult to carry out with children or not entirely applicable for children in specific age groups who are easily distracted (Hanna et al., 1999). According to the US Consumer Product Safety Commission for children's products, it is useful to begin with a targeted age range and supply information about children within that range. For example, one common age range for children's products described in consumer safety regulations is 3–6 years old (US Consumer Product Safety Commission and Therell, J.A., 2002).

Hanna et al. (1999) discuss the process of achieving usability goals. They analyse tasks to understand the user activities that a product is intended to support. For instance, the

authors point out that when analysing usage by children, the product goals may not always match the goals of the child who is interacting with the product. Hanna et al. (1999) list usability research techniques considered to be most useful in the design development process. Table **2-5** lists the usability research techniques employed by Microsoft in carrying out research and developing software for young children.

Table 2-5 Techniques for usability research with children. (Hanna et al., 1999)

Research technique	**Applicable stage of product development**
Expert reviews	Throughout
Site visits	Concept; preliminary design
Survey construction	Concept; preliminary design; beta testing
Card-sorting tasks	Concept; preliminary design
Paper-prototype tests	Preliminary design
Iterative laboratory tests	Prototyping; developing
Longitudinal tests	Beta testing; final products

Hanna et al. (1999) state that expert reviews were used at the beginning of the design process to provide quick checks on the design and to identify obvious problems. This process was quite detailed, as it involved the designers looking at design specifications or storyboards. Child-development milestones and common usability guidelines were referred to in order to check for violations. As a result of this process, they could identify that age-appropriateness is essential in making design decisions. For example, a game for four-year-old children that requires reading is not age appropriate. Thus, child-development milestones are an essential aspect of designing for children and in using specific types of methods in the process.

2.7.5 Interaction with caregiver and their role

The presented model in Figure 2.13 was taken from research by Saluja et al., 2004, who outlines approaches to caregiver interactions and discusses their decisions regarding strategies they adopt around injury prevention. The conceptual model details essential caregiver decisions about injury prevention strategies provides holistic insight into the caregiver's role and interaction with the child, within the fast-changing risk environment. The model includes the dynamic determinants of risk perceptions and

therefore suggests that when taking developmental variation into account, we can design more specific and tailored messages that parents may be more likely to heed.

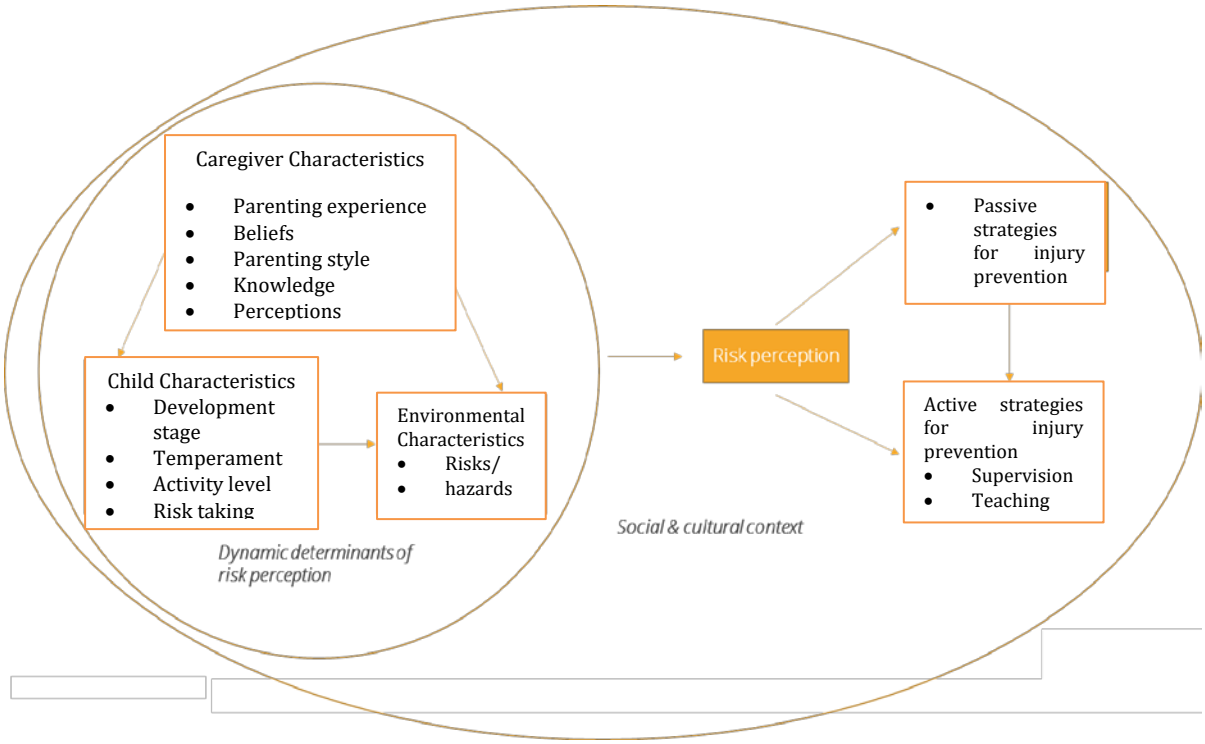


Figure 2.13 Conceptual model for caregiver decisions about injury prevention strategies (Saluja et al., 2004)

It thus deemed appropriate to develop the research from a holistic point of view, in adopting a systems approach to the subject. The model includes child characteristic as a determinant of risk perception for young children. As outlined in the various tables throughout this section, young children are at increased risk for specific types of injuries at different developmental stages, where milestones in motor and physical development occur (Agran et al., 2014). Further included are caregiver's characteristics as they interact with child's perception and children's perception about the hazards present in the environment. Generic messages such as "supervise more closely" are likely to be misunderstood or dismissed as impractical by parents (Morrongiello and Schwebel, 2008). This information may be deemed as being more relevant in line with developmental milestones of the child, and perhaps communicated through a range of sources including social networks, mass media, face-to-face advice from health professionals and other suitably trained mothers.

Some researchers suggest targeting information further to various social contexts. One author discussed that the safe use of home appliances is also an important consideration around children, and the use of child-safety equipment should be explicitly targeted at those who are perhaps less fluent in the language, for example those individuals who have recently migrated to the United Kingdom (Khanom et al., 2013). As we have shown in this paper, cognitive, emotional, linguistic, fine motor abilities of children, as well as their perception and knowledge, are different from those of adult users. In addition to the systems approach being adapted to risk communications, previous research has shown that warnings can work to alter the behaviour of caregivers and children's use of products (Wogalter and Laughery, 2005; Kalsher and Wogalter, 2008). A more holistic understanding needs to be made encompassing physical and social factors as well as cultural and national factors along with the caregiver's role. Risk perception interacts with active and passive strategies for injury prevention. Active strategies include education and supervision. Deciding how closely to supervise children is a complicated process that requires caregivers to simultaneously consider several factors including environmental (hazard level, potential injury severity and injury likelihood) and child variables (age, gender and risky behaviour). Policies and regulations may also be necessary for informing caregiver decisions.

2.7.1 First version of the risk management framework

The included papers (mostly theoretical) have highlighted some central themes of (1) design culture (existing risk-communication process and user considerations); (2) use of evidence (processes and variables that may affect or enhance user interaction with a risk-communication). Themes have been further explored, using the previously established frameworks and models discussed in this chapter, including the framework developed for older adults McLaughlin and Mayhorn, 2014, which has resulted in the researcher producing the first iteration of a risk management model in Figure 2.14.

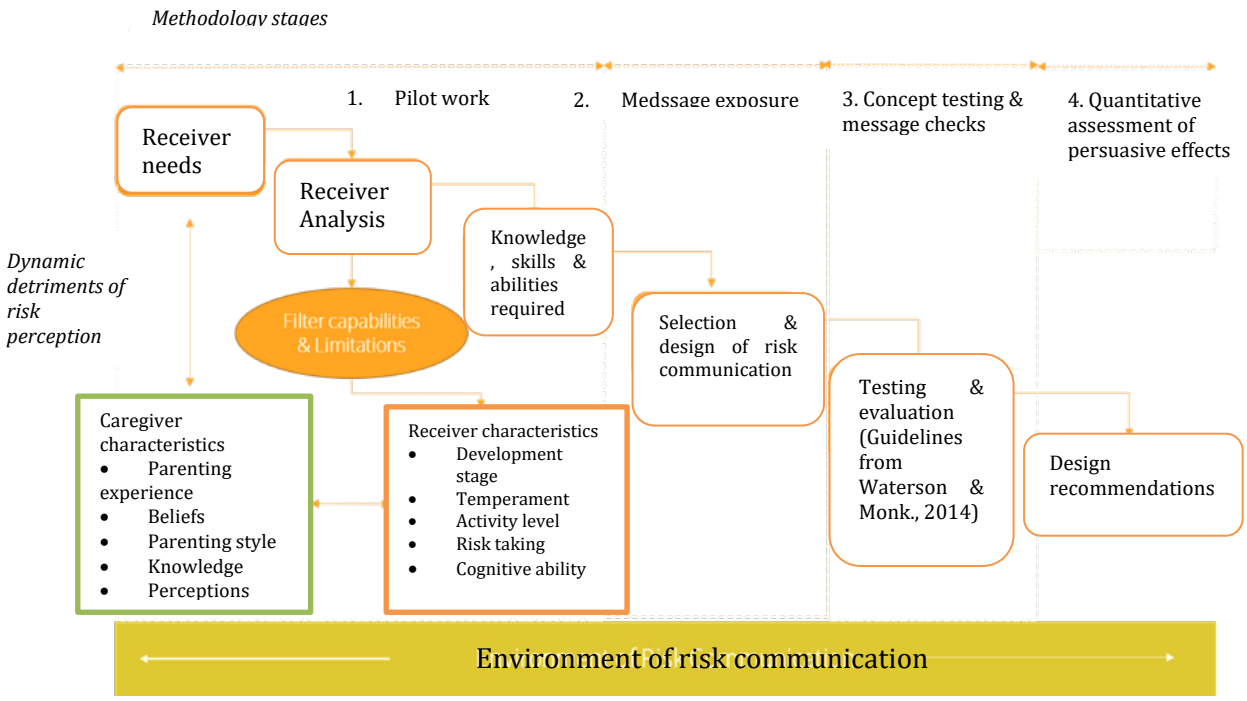


Figure 2.14 First version of the framework relevant to risk communications for young children, developed by the researcher

Ergonomics guidelines can sometimes be too general to apply to a project or else too specific to the application for which they were initially developed. Most of the guidelines do not take into account users' psychological characteristics, such as their previous experience with a product, expectations, perception of risk, and attitude. One exception is the McLaughlin and Mayhorn model (2014), which takes these attributes into account. The adapted McLaughlin and Mayhorn model (2014) considers children's psychological characteristics during the relevant developmental stages: their previous experience with a product, expectations, perception of risk, and attitude. The model has also incorporated the effects of interaction with a caregiver into the process.

2.7.1.1 Challenges with the literature review

The main challenges faced during the literature review were first a distinct lack of research in the area and secondly that available studies suitable to the research varied greatly, making it difficult for the researcher to compare their results. Another potential challenge with the literature review relates to the sample sizes and the ages of the children studied. There were incomplete data on the children's ages, even in the most recent studies of risk communication. The methodologies used in the research reported on include surveys, interviews, experiments, observations, and focus groups. Some observations took place in a controlled laboratory setting, whereas others took place in the child's natural environment, such as a classroom environment. These studies' results are also based on a small number of participants and are therefore difficult to generalise, as they are less likely to be representative of the more significant population of interest.

2.7.2 Conclusions

A literature review has been conducted as part of Phase One of the thesis. This chapter concludes by identifying the research gaps and formulating the research questions as the starting point for further analysis in the subsequent chapters. The overall aim of the literature review was to provide a relevant theoretical perspective that can be used to inform the research process. A first version of a framework has been generated on the basis of the review of the literature and other models (Figure2.14). The review aimed to understand how research that informs risk-communication design is both conducted and used, by looking at literature in the fields of human factors and other areas described throughout. The literature provides background information on the history of this area to better establish the context for the development of a design tool for use by designers when considering relevant safety aspects and interaction in designing risk communications for young children.

2.7.2.1 Knowledge gaps

There is a great deal of relevant research and theory regarding adults and other groups. This review attempted to extract information relevant to the design of risk communications aimed at young children. The first point identified from the research is

the limited amount of information and empirical research in the area concerning the unique user population of young children. To enable the effective design of risk communications, a knowledge base needs to be developed on how children understand and comply with risk communications. However, it is apparent from the review of the literature and the existing models of risk communication that many gaps remain in our knowledge.

The literature review indicates that there are both methodological limitations and gaps in existing knowledge, including the following:

- Disproportionately little has been published on the topic of human factors as it relates to children (see Table 2.4: Age Ranges and Methods).
- There appears to be a lack of evidence-based guidelines for the design of visual warning information, with a predominance of non-evidence-based literature and little that has been conducted in the UK (see Table 2.4: Age Ranges and Methods).
- Much of the research on warning theory and the design and evaluation of risk communications has focused on adults and has not considered young children.
- Many of the findings from prior research point to the need for behavioural testing with the relevant age group of children.
- The results revealed sources and key theoretical inputs in warning design and risk communications situated within the human-factors literature about the adult population that may also be relevant to developing communications for young children's safety.
- One major limitation is that further behavioural testing with children is not easy to conduct. As discussed, when research does involve children, the data collection processes are not well documented.

These gaps have formed the basis for a series of research questions which will inform the empirical data collection approach.

2.7.2.2 Research questions

This chapter presented a literature review regarding the field of human factors as it relates to the research topic. This set the context for further research and provided background information on the history of this area.

Following the literature review and the finding of a lack of empirical research in the area, the following questions are relevant to explore:

- What types of tools and resources are currently available for designers when designing for children?
- What types of information was the researcher able to source from both academics and practitioners?

The resource review presents a critical review of aspects available in various resources, tools, models, grey literature, and reports across other areas, as well as currently available information for design. The resource review in the following chapter will aim to fill the gap in the theoretical knowledge with a detailed description of the systems approach to risk communications, including the development and key components of a framework for the design of risk communications aimed at young children.

Chapter 3: Methodology

3.1 Introduction

This chapter provides an overview of the methods used for data collection and analysis in the different phases of the research.

3.2 Designing a research approach

Despite the availability of research regarding risk communications and warnings, evidence-based communications are rare, as for the most part research is not translated into practice. Thus, there are gaps in how research results apply to real-world situations. Discussions regarding bridging the gap between research and practice tend to rely upon ontological and epistemological considerations (Mohrman and Lawler., 2011). The study of ontology is that which is 'dealing with a priory nature of reality' can be advantageous to producing a quality knowledge-base surrounding the research topic (Guarino., 1995; Saunders et al. 2012). Epistemology of what information that counts as acceptable knowledge (Krauss 2005) can bridge the gap. Since the researcher is external to what is being researched, quantitative methodologies are most commonly used within the objectivist's worldviews. A gap between theory and practice exists where:

"Each community develops its language and frameworks of knowledge, its methodologies for creating and applying knowledge, and its standards of relevance and rigour" (Mohrman and Lawler., 2011).

Therefore, the research contained within this thesis must be capable of considering theoretical knowledge but also the views of the stakeholders who design for children. Design practitioners often develop and refine knowledge as they solve problems and address challenges in order to accomplish their purposes in a particular context. Indeed, the gap between theory and practice might be more accurately described as a gap between academic research and practitioners, i.e. human-factors practitioners and design practitioners. Differences between theory and practice, as described by Mohrman and Lawler, arise partly due to *"different communication systems, ways of knowing*

purposes, and criteria for making decisions in the two communities of practice" (Mohrman and Lawler., 2011).

As part of this research, three empirical studies were carried out to determine appropriate content for the tools. These are study one, the critical review; study two, interviews with designers and other groups; and study three, which involved an online evaluation of the tools. Study one investigated current design tools, risk-communication models in warning and other safety research, and knowledge gaps that had been identified. Study two involved gathering requirements from designers and other experts, and study three's evaluative stage aimed to contribute to the theoretical and conceptual component of the resource and to further develop its practical application for industry.

3.3 Research paradigm

The research uses a middle ground ontology to combine qualitative and quantitative methods/approaches, including ethnographic research using accounts gathered in the research as a source of information to consider, using transcendental (or subtle) realism to monitor assumptions. The underlying concept of realism acknowledges the existence of both the real world that operates independently through natural necessity and the individual with a personal perspective of the world (Bhaskar, 1975). That is that 'the world has an existence independent of our perception of it a common-sense position' (Williams & May., 1996 p.81). Therefore, middle ground ontology used in this study aims to achieve a balance between the post-positivist and constructionist paradigms (Robson, 2002 p. 42–43). The middle ground philosophical position for ergonomics (Hignett 2001a) draws on an ontological position (worldview) of subtle or transcendental realism.

Research can be approached from many different perspectives. These perspectives are the following:

- **Positive and Post-positive** – The view that social research exists externally; that the researcher and participant are 'independent' (and that) 'reality is discovered using experimentation through quasi-experiments and surveys'. Methods like interview and observation are supplementary in the positive paradigm.
- **Constructivism/ interpretivism** – The view that participants help the researcher construct a view of 'reality' using naturalistic methods such as case studies, interviews, and observations (Golafshani N, 2003 p.600)

- **A critical approach** – The view that the researcher is an expert researching powerless participants, trying to overcome an imbalance in power.

3.4 Qualitative research

Robson (2002) divides research methodologies into two types, traditional fixed and flexible design, which are also referred to as quantitative and qualitative. Qualitative methods were considered appropriate for this research due to the lack of empirical research in the area (see below for the Interconnection of Worldviews and Research Methods in (Figure 3.1). Qualitative methods offer the opportunity to ask questions such as 'how' and 'why' (Hakim, 1997). They differ from quantitative methods as Emphasis on numbers, measurement, experimental design, and statistical analysis (Palomba & Banta 1999). Qualitative methods also rely on opinions, behaviours and experiences of the participants to be investigated (Fink., 2010). Thus, qualitative research lends itself to developing a thorough understanding of individuals' opinions and feelings, their attitudes, motivations, and behaviour, providing 'richly descriptive reports of individuals' perceptions, attitudes, beliefs, views and feelings' (Hakim, 1997:26). The qualitative research design is the most suitable choice to understand how designers understand and approach the complexities of design for child safety. In the few studies that have been conducted to date, qualitative methods have been used to investigate risk-communication design specifically for young children within the specified age ranges. The lack of available knowledge and the investigation's aim of seeking new insights means that the research will be exploratory.

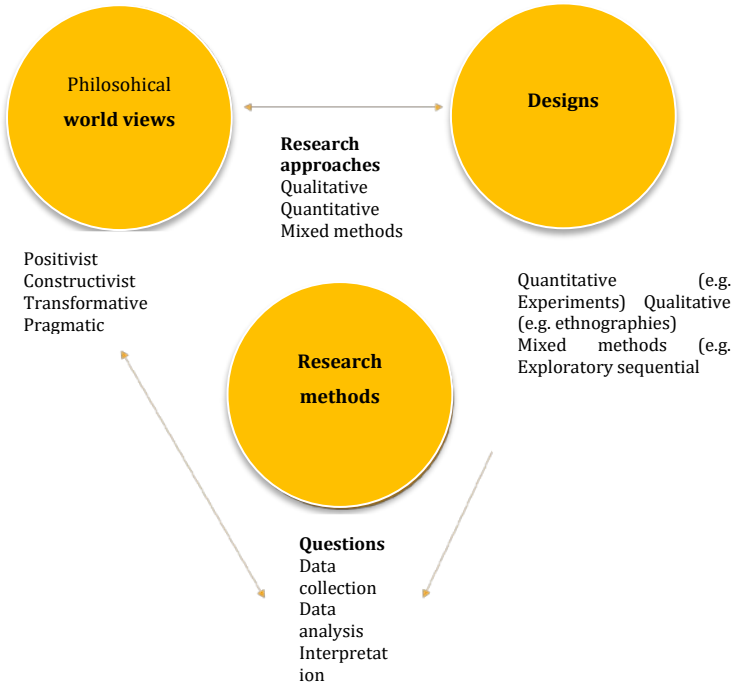


Figure 3.1 A framework for design (Interconnection of Worldviews and Research Methods). From: Creswell

Qualitative methods are used to test, support or question the data gathered in order to explore and understand the meaning individuals or groups ascribe to a social or human problem. Qualitative methods, in this research, are used in order to obtain an in-depth understanding of designers' attitudes and of designing for child safety. It is difficult to predict what these may be. There are numerous inherent strengths and weaknesses that should be acknowledged when carrying out qualitative research. A primary advantage is the increased depth and detail obtained in qualitative analysis, which allows for greater insight (Robson., 2002). Despite fewer participants being involved in the research, the findings aim to gain further knowledge and detail regarding a topic, rather than quantifying the contribution of specific issues to an outcome.

3.4.1 Scope of research

The research is approached from a human factor engineering ergonomics or human factors/ ergonomics (HF/E) perspective, as this is a field that conducts research into human psychological, social, physical, and biological needs, which can include the capabilities and limitations of young children. The systems approach is the foundation of HFE, and it provides a flexible method to gather information from many sources in order to develop a comprehensive understanding of an issue from an overall systems

perspective. Evidence-based design is a growing multidisciplinary field that applies rigorous quantitative and qualitative research methods. This research is primarily being carried out with the aim of turning guidelines into working tools, which will aid designers and other groups in the development of materials that are well-informed and evidence-based. The 'working tools' could explore the need for an industry-academic partnership as a way of catalysing future collaborative work within the wider area of 'evidence-based design'. This can be achieved by translating the work into a suitable form that will support the implementation of inclusive design within the industry and promote knowledge transfer about design for child safety. The findings from this thesis aim to make several contributions to the area of risk communications for young children and design from the viewpoint of child safety.

3.4.2 Research structure

Robson (2011) describes careful and systematic research as one of the best tools available to understand an issue and find ways to deal with a problem. The research methodology employed here involved qualitative methods using the principles of ethnography. The methods employed include document analysis, questionnaires, semi-structured stakeholder interviews, and observations. The research phases are documented in the table below. Each of these will be explained further in the following sections. This is followed by an explanation of the alternative methods considered within this thesis. A risk management framework was built incrementally during the research presented in this thesis. The table below show how the stages of research contributed to it.

Table 3.1 Methods Overview

Research phases	**General purposes**	**Studies conducted, and methods applied**	**Results**
Phase 1	Exploratory studies to review research questions.	Literature review.	Research questions formulated and **1st version of the Risk Management Framework** derived from the review of the literature
Phase 2	Gathering the requirements for the design tool/ decision aid and method development.	Critical evaluation of resources and models. Exploratory studies:	**2nd version of the Risk Management Framework** presented at the end of Chapter 4, where factor

Research phases	General purposes	Studies conducted, and methods applied	Results
		(interview, observation, documentary analysis) Collect evidence for potential applicability/ feasibility.	lists were derived from standards and other design guidance resources.
Phase 3	Early stage prototype development of the design aid/ decision tool:	Concept Creation: Identification of lead concepts based on insights into children's development; Practical development of lead concepts to deliver small quantities of test materials for designer's evaluation.	Concept tools persona developed to be evaluated in the next study. New content developed from the research around communication theory and children's perception of risk and other psychological characteristics have been implemented into a child-based persona.
Phase 4	Formative evaluation and further development of the framework and tools to fit with the design process.	Evaluation of persona (design intervention aimed at child safety) (Early prototype of concept persona tools, online survey, integration of research)	Research questions answered and supporting evidence obtained Future work identified **Final version of the framework** presented in the discussion chapter with a description of how a designer (or other professional in the target community) would be expected to use it.
Phase 5	Map out future study to evaluate the tools in-situ with designers working on a live project.	Review theoretical and practical implications, and limitations.	A roadmap for future research and recommendations for further application.

The literature review (Chapter 2) examined research on methods, including user-centred design (UCD), and investigated specific applications of risk communication and its advantages and challenges. This analysis was followed by a review of the resources and models and the initial stages of development of a risk management model.

The knowledge gained in this exploratory phase was analysed to identify best practices and caveats of the application of risk communication and design with children in design

research. The resulting information was then used to define an initial structure of a risk management framework (Chapter 4) to organise the elements practitioners need to consider in risk management in designing for children. This arrangement was used in the requirements-gathering study (Chapter 5) to gain a deeper understanding of the practitioners' perception of the experience of the risk management framework and designing for children. These studies included interviews and observation sessions, each involving novice and experienced design practitioners and targeting others involved in considering safety for children. The data collected from the surveys came from interviews, observations, and notes taken by the researcher. The results of this evaluation were analysed qualitatively to identify categories of crucial aspects related to child safety in design. The elements that influenced these points were then mapped onto the structure of the persona tools to make sure their relevance was reflected. This research process resulted in the definition of structured dimensions for the framework, each with a set of essential elements to consider in designing appropriate risk communications. The relevance of this framework is analysed and discussed (Chapter 8).

3.4.3 Data collection techniques

The primary disadvantage associated with the use of data collection techniques such as interviews, observations, and questionnaires are undoubtedly the large amount of resources that is required. A considerable amount of initial effort and resources is often required to design the data collection procedure. The design of interviews and questionnaires is a lengthy process, involving numerous pilot runs and re-designs. Large amounts of data are typically collected, which commonly leads to a lengthy data analysis processes. Collecting data from designers often requires access to the design team, which is typically difficult to obtain. In addition, many of the projects that would be useful to the researcher are confidential. For this reason, design teams do not readily allow their personnel to be observed while at work. Getting stakeholders to participate in interviews is difficult, and questionnaires often have meagre return rates (typically as low as 10% for a postal questionnaire).

3.4.4 Overall sampling strategy

Given that the aim of this research project focuses on the requirements of designers when designing for young children, designers were chosen as the core-sampling panel to be used for the majority of the project. Having said this, the sampling panels were delimited too, as the research plan and the evolution of the project itself required it. To develop a toolkit, it was essential to understand the need for multiple inputs form the various experts involved. More specifically, sampling was concerned with the role of the design team and the nature of its relationships with caregivers and other professionals involved. This was examined from the perspectives of all these groups. For example, findings from the initial exploratory phases of the research pointed to the need for diverse and multidisciplinary teams of people when designing for complex problems; henceforth, the research aimed to include a variety of disciplines, ages, cultural backgrounds, and experience levels in the sampling group. Sampling was done on a structured-convenience basis with participants from the chosen sample groups selected based on their qualifications, experience, and availability, i.e. those most likely to be able to provide useful insights into the problem under investigation. Interviewees were drawn from relevant stakeholder groups to achieve a structured purposive sample (Bryman, 2004). Wilson and Corlett (205, p. 121) describe 'stratified purposeful sampling' as 'illustrating characteristics of a particular group'. Therefore, safety experts were included to form a stratified purposeful sampling strategy. From the outset, stratified purposeful sampling formed the overall strategy, with secondary strategies having a role at various stages of the process. Opportunistic sampling, was then carried out, which Wilson and Corlett (2005, p. 121) to follow new leads.

3.4.5 Units of analysis

The aim of understanding the development of risk communications in relation to young children can be achieved through an in-depth study of the existing literature. Literature relevant to the investigation includes empirical research on young children's acquisition of skills, such as their cognitive development and other developmental characteristics relevant to risk communication design. The methods employed within this thesis aim further to construct a knowledge base regarding aspects related to designing risk communications for children. The research outputs contribute to developing access to knowledge through tools and resources that will be primarily aimed at designers in

considering design for child safety. In Phase 1, the existing literature constitutes the units of analysis. The essential works in the relevant categories will be identified through a systematic analysis of guidance and tools aimed at supporting designers in designing for the safety of children aged 5 to 11. The potential guidelines and other design-related factors identified in Phases 1 and 2 will be the units of analysis in Phase 3. Through careful synthesis, analysis, and coding, the data gathered during the literature review will be integrated and reformulated and then organised into a logical framework. The research takes an iterative approach to the development and evaluation of the tools, thus in Phases 2 and 4 the final framework will be developed and tested.

3.4.6 Assumptions

The first step of the study was the exploration of the context of risk communications and design with children, which comprised studying existing research within the literature, interacting with researchers in the field, and gathering the requirements from designers. The assumptions associated with risk perception and children were considered within the broader context of the research and are listed in Table 3.2.

Table 3.2 Assumptions associated with the literature analysis and Resource Review (phases 1, 2 and 3)

Ontological assumptions	Children from five to eleven have specific characteristics that distinguish them from other children and I can learn about them through other people's (i.e. theorists and researchers) writings about their behaviour, ideas and thoughts. This research assumes that through understanding children and their experiences with risk communications the researcher can better determine support tools on how to design risk communications that will be relevant to their needs
Epistemological assumptions	This research acknowledges the role of different contexts that may influence the knowledge gained (that of the authors of the texts under study as well as that of the researcher). The research expands on knowledge of children's behaviour with questions in mind related to the theories of risk communication
Methodological assumptions	The research methods included in this study were chosen in order to develop the required knowledge, for example the qualitative analysis of psychological theories and resources, research reports attentive reading and re-reading of these texts, looking for themes, tensions, contradictions, et cetera.

3.5 Elements that contributed to exploring the context of this research

The elements that contributed to exploring the context of this research are discussed in the following sections.

3.5.1 Literature and resource review

The literature review positioned the research in the field of ergonomics, described the theoretical context and identified the gaps in the area. Study 1 differs from a standard literature review as the researcher was gathering and collating evidence from empirical research of other experts within various domains, who are involved in child safety and design, to evaluate evidence from empirical research (real-world sources). As discussed in section 3.4.5 Phase 1, the existing literature constitutes the units of analysis. The essential works in the relevant categories will be identified through a systematic analysis of guidance and tools aimed at supporting designers in designing for the safety of children aged 5 to 11.

3.5.2 Stakeholder interviews: Phase 1 (study 2)

Interviews are used for different purposes. Typically, participants are interviewed on a one-to-one basis, and the interviewer uses pre-determined probe questions to elicit the required information from the participant. There are three types of interview, namely structured, semi-structured, and unstructured or open interviews. In this study, semi-structured techniques were used to elicit data regarding decision-making among design practitioners. Semi-structured interviews were carried out with various experts. The interviews had two main aims of the interviews: to obtain an overview of design for young children's safety and to understand designers' information needs when designing risk communications aimed at young children. Interviews were carried out with experts based in the United Kingdom, Europe, and America. The data captured were used to help define the design and evaluation specifications of the risk communications toolkit.

Along with observational techniques, interviews are probably the most commonly used human-factors technique for information gathering. Interviews have been used in human-factors research to gather specific information in many different areas, including

system design, system usability, attitudes, job analysis, and task analysis. In terms of application times, a typical interview takes between 10 and 60 minutes. Kirwan and Ainsworth (1992) suggest that an interview should be a minimum of 20 minutes and a maximum of 40 minutes in length. In this study, data were collected through a series of 30 individual stakeholder interviews. Semi-structured interviews were conducted to gather in-depth information from individual participants (Robson, 2002). Although the analysis process associated with interviews is time-consuming, interviews were deemed appropriate for this research in order to gain better insight and understanding into designers' requirements and perspectives regarding safety aspects in designing for children.

External experts in the field of child safety were identified through the Child Accident and Prevention Trust's (CAPT's) network of contacts, and this provided a framework from which to base the rationale for stakeholder recruitment.

Data were collected through interviews with three groups of people associated with design: (1) safety experts such as ergonomists and standards experts; (2) staff working as part of a design team without experience in children's products; and (3) design professionals involved in some degree of collaborative work in design for children.

Template analysis can manage datasets of different sizes, ranging from a single case study to extensive datasets such as that used in this research, and was therefore considered appropriate for the analysis. This study involved a large number of participants in comparison to many research projects utilising qualitative methods. Finally, its use of *a priori* themes means that template analysis may be particularly well suited to this research, which has applied or theoretical concerns that need to be incorporated into the analysis. Interviews were chosen, as a series of interactive interviews with practitioners helps to articulate the key components involved in their learning design processes. The interviews helped to identify the areas where further support might be required. These discussions and the detailed analysis informed the initial requirements analysis for the toolkit.

3.5.3 Ethnographic research

Observations further consolidated the data obtained from the interviews, as observations provided the opportunity to identify how design tools and evaluation

methods function for the individual and the group and to explore what terminology is used and how support is applied in working practice.

3.5.4 Formative evaluation: Phase 2 (study 3)

Evaluation research seeks to answer questions about target audiences of designers. Background information can be collected before the implementation and assessment of the tools developed.

3.5.5 Questionnaire survey

Questionnaires can cover a multitude of aspects and they may be quantitative, qualitative, or a mixture of both. Questionnaires may comprise a combination of both open and closed questions, depending on whether participants' answers can only come from a list of possible responses (Brace 2013). Questionnaires have been used in many forms to collect data regarding numerous issues within ergonomics and design. The research questions of this study are concerned with how designers select materials and why they do so. With such an open topic, a fixed design approach (Robson, 2002) would constrain the types of answers that the respondents could give thus this research did not use a fixed design. The measurement approaches used for the questionnaire design were an itemised rating scale and a Likert scale. Table 3.4 below shows the process of planning a questionnaire survey.

Questionnaires offer a very flexible way of quickly collecting large amounts of data from large amounts of subjects. Questionnaires have been used in many forms to collect data regarding numerous issues within ergonomics and design.

3.5.6 Survey design and rationale

Table 3.3 Process of planning a questionnaire survey (adapted from Cohen)

Stage 1	Define the Objectives.
Stage 2	Decide the type of Survey Required- cross sectional.
Stage 3	Formulate research, questions/hypothesis.
Stage 4	Decide the issues on which to focus.

Stage 5	Decide the information that is needed to address these issues.
Stage 6	Decide the sampling required
Stage 7	Decide the instrumentation and the metrics required.
Stage 8	Generate data collection instruments.
Stage 9	Decide how the data will be collected- online questionnaire survey.
Stage 10	Pilot the instruments and refine them.
Stage 11	Data collection.
Stage 12	Data analysis.
Stage 13	Report the results.

3.5.7 Limitations of interview and questionnaire data

Table 3.4 Summary of data collection techniques

Method	**App time**	**Advantages**	**Disadvantages**
Interviews	High	1) Flexible technique that can be used to assess anything from usability to error. 2) Interviewer can direct the analysis. 3) Can be used to elicit data regarding cognitive components of a task. **Advantages** Interviews can be used to gather data regarding anything e.g. usability of existing systems, potential design flaws, errors etc. Interviews can be used at any stage in the design process. The use of SME's as interviewee's gives interviews the potential to be very powerful. The interviewer has full control over the interview and can direct the interview in way. This allows the collection of specific data. Response data can be treated statistically. Interviews are a very flexible technique. Interviews have been used extensively in the past for a number of different types of analysis. Specific, structured human factors interview already exist, such as ACTA and the Critical Decision Method.	1) Data analysis is time consuming and laborious 2) Reliability is difficult to assess. 3) Subject to various source of bias. The construction and data analysis process ensure that the interview technique is a very time consuming one. The reliability and validity of the technique is difficult to address. Interviews are susceptible to both interviewer and interviewee bias. Transcribing the data is a laborious, time consuming process. Conducting an interview correctly is a difficult thing to do.
Questionnaires	High	Flexible technique that can be used to assess anything from usability to error. 2) Several established HF questionnaire techniques already exist, such as SUMI	1) Data analysis is time consuming and laborious 2) Subject to various source of bias. 3) Questionnaire development is

Method	App time	Advantages	Disadvantages
		and SUS. 3) Easy to use, requiring minimal training.	time consuming and requires a large amount of effort on behalf of the analyst(s)
Observation	High	1) Can be used to elicit specific information regarding decision-making in complex environments. 2) Acts as the input to numerous HF techniques such as HTA. 3) Suited to the analysis of C4i activity.	1) Data analysis procedure is very time consuming. 2) Coding data is also laborious. 3) Subject to bias.

The aim of qualitative research is not to obtain a representative sample via random selection (as in quantitative sampling), but to seek information from specific groups and sub-groups within a population (Hancock, 1998).

3.6 Mixed methods approach

The author found limited literature regarding young children within the warning literature. However, Riley (2014) presents an overview of multi-method approaches to warning design that customise risk communication for target audiences. These approaches use quantitative models to determine exposure endpoints and combine these with both psychological and ethnographic approaches to understand users' mental models of exposure (Riley, 2014). Mixed methods research is an approach to inquiry involving the collection and integration of both quantitative and qualitative data. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone.

It was therefore desirable to collect both qualitative and quantitative data. A multiple methods approach was adopted for data collection (Robson, 2002). The advantage of using multiple methods is that it allows triangulation (Robson, 2002). In this study, there is data triangulation (interviews, group interviews, and surveys) and methodological triangulation (qualitative and quantitative data collected). Quantitative data were used to support or contest the findings in the current literature, and qualitative data were used to provide the specific details necessary to aid in the development of an evidence-based toolkit to support safe design for children.

3.7 Concept detailing and initial prototyping

A key element of concept detailing and initial prototyping is applying the theoretical understanding of the underlying factors controlling design for child safety to identify concepts that the researcher believes have the potential to add value to research and design practice aimed at child safety.

3.8 A system's approach

This section described method's relevant to the design and evaluation of risk communications. Design for child safety encompasses a wide range of professions and disciplines. This is indicated by the distribution of the literature across multiple domains. One means of improving the uptake and integration of guidance within the designer's everyday working environment is to adopt a systems approach. Policy-makers and design practitioners are typically not familiar with systems approaches. To understand why systems theory concepts are not being applied by policy-makers and design practitioners, it is necessary to examine how information is transferred from research to practice. To achieve this, a conceptual framework was developed to provide a structure for the analysis of knowledge transfer within the systems approach.

Chapter 4: 'Study 1' a review and risk management framework

4.1 Introduction

It is necessary to understand existing resources, models and methods currently used in design practice when designing for children to develop a useful design aid or tool. Under these premises, this thesis aims to propose a deeper understanding of the practice of risk-communication design with children and suggest critical factors to refer to when preparing for it. This chapter addresses RQ1, which was presented in Section 1.3:

- RQ1. What models, methods and resources are available in theories and practices to support designers when designing for young children aged 5–11 years?

Sub-questions of RQ1 are covered in this chapter:

- *RQ. What are the gaps between theories and practices and how can the gaps be narrowed?*
- *RQ. What is the set of requirements for a new toolkit (resource review consolidation)?*

The question refers to specific design methods for children both published in the resources and applied in practice. The question also refers to the various kinds of information and resources available in academia and in practice. In particular, this chapter aims to answer the following research questions resulting from the review of the literature:

- *What types of standards and other design guidance resources are currently available for designers to support them in designing for young children?*
- *What types of information is the researcher able to source from academics and practitioners?*

Findings from the literature revealed a gap in developing communications aimed at children aged 5–11 years. The human-factors models presented in the literature review, including the model developed by McLaughlin and Mayhorn (2014) as shown in Figure 2.8, have generally not considered young children in the process. Areas to be explored in relation to young children in developing risk communication include, for example,

developmental stages, capabilities and limitations. Outcomes also emerged from the prior research that point towards the need for behavioural testing (Waterson & Monk, 2014). Furthermore, based on previous work, a framework has been developed and presented at the end of Chapter 2, as shown in Figure 2.14, for the design of risk communication aimed at young children. Chapter 3 discussed the range of methods to be employed in the research.

4.1.1 Overview

Interventions to prevent accident occurrence are essential in keeping young children safer from the potential risks of unintentional injury. This chapter presents a critical review of the currently available resources and models to better understand existing processes, procedures and guidelines in and between disciplines, with the goal of identifying potential areas for enhancement of guidance relevant to those involved in design for children. The study documented in this chapter differs from a standard literature review, as the primary purpose of conducting the critical review of the resources was to explore the resources that are currently available to designers and other groups that are relevant to understanding risks and developing risk information aimed at young children. This can be described as empirical research, as the researcher was gathering and collating evidence from empirical research of other people and found materials to evaluate evidence from real-world sources. Knowledge regarding cognitive skills, capabilities and limitations in the reviewed resources that relate to the interaction of children are to be integrated into the framework, including aspects of developmental psychology, i.e. cognitive development for the 5–11-year age group. This knowledge may be relevant when designing risk communications as well as in a broader context to provide general tools on aspects of children that may be applicable in providing further support for other products and services.

4.1.2 Study design and rational

As discussed, current human-factors methods, resources, guidelines and standards that apply to design for children are presented in this resource review. The findings are integrated into the developing model to fill gaps in knowledge. The first version of this model was developed by the researcher, and presented in Chapter 2, using the information from the models and frameworks gathered from the background literature.

It is proposed that all the relevant information be drawn from this resource review and that guidelines be organised into a flexible framework, which maintains the relationship between these guidelines and the underlying theory regarding system interaction. In this way, it is much clearer which existing guidelines can be used, where they need to be made more specific for this type of product and user group and where possible gaps exist. For designers, this method also provides an easy overview of all guidelines. The unifying framework that has been proposed is based upon McLaughlin's model of risk communication, which is primarily aimed at older adults. The model is used for the evaluation of risk communication for adults but will be used in a novel way to help design and evaluate risk communication for children and structure the design guidelines. The study seeks to examine the range of available materials or tools, their content and where a designer can access the information. The study outcomes are added to the developing evidence base by collating available information on caregiver interaction, e.g. the level of supervision expected during certain development stages and information on the capabilities and limitations of children. The results of this study help to highlight the importance of continued development of resources, fill the gaps in the research and educate design practitioners and other groups involved on aspects relevant to developing appropriate communications.

Further support is needed to understand in what stages guidelines are applicable or how guidelines can be refined to meet user task requirements for a specific set of users and a specific type of application. Methods: Resources and reports recommended by experts were found through initial email contact with experts, who then provided various guidelines and reports to the researcher.

4.1.3 Research method

It was decided that document analysis and collation of available information sources were appropriate means to gather the requirements for designers and aid in further development of the risk management model and guidelines. The study seeks to examine the range of available design aids or tools, the content of them and where a designer can access the information.

1. First, this study includes documentary analysis of found resources and those recommended by experts along with those used by designers in practice. Resources and reports were both recommended by experts, and online searches were carried out by the researcher.

2. Second, this study includes a collation of existing information for safety guidelines for design and evaluation from found sources (Waterson & Monk, 2014; Waterson et al., 2012; CEN/CENELEC Guide 14, 2009) in to the framework to further develop an evidence base.

The resource review aims to follow a strategy of comprehensive sampling, as there are a limited number of respected sets of guidelines for the design of risk communication and few explicitly aimed at risk communications for children. External experts in the field of child safety were identified through the CAPT's network of contacts, and this provided a framework from which to base the rationale for stakeholder recruitment.

In this chapter, relevant information from resources and models provided by experts and found by the researcher have been integrated. The guidelines produced from Waterson and Monk (2014) and Waterson et al. (2012) have been used as a reference and implemented into the framework at the design and evaluation stages.

4.1.3.1 Inclusion criteria

Examples of design resources and standards specific for young children have been reviewed. Academic texts written by leaders in the field of human factors and other sources relevant to designing for children, including design tools such as grey literature, are gathered and used as the guide in identifying the resources, models or guidelines incorporated in this study. As with the theories of cognitive development, the study is restricted to prominent and respected work in the field of human factors that are referred to often in both theory and practice and is currently regarded as important to designers, credible and influential. To determine whether an adequate quantity of material had been covered, the researcher observed when no new categories or themes emerged, when the relationships between existing themes were clear and when the theoretical discussion was complete. Sources include safety guidelines for design and evaluation (Waterson & Monk, 2013; Waterson et al., 2012), information from the CAPT, anthropometric data (Norris, 1998) and other sources, which are all discussed within the chapter. Information from studies on the design of risk communication for vulnerable groups is also provided (McLaughlin and Mayhorn, 2014).

4.1.3.2 Exclusion criteria

The critical analysis of the resources and models in this chapter explicitly reviews the development and behavioural characteristics of young children aged 5–11 years, e.g. physical and cognitive capabilities and limitations on designing for young children's safety. The study has generated further data that describe the population of children likely to be in contact with the risk communication, as the abilities and skills of children quickly change as children develop and are different from adults.

4.1.4 Individual factors in relation to the design of warnings for children

Most of the guidelines do not consider users' psychological characteristics, such as their previous experience with a product, expectations, perception of risk and attitude. One exception is the McLaughlin and Mayhorn model (2014), which studies these attributes and their relevance to older adults. The adapted McLaughlin and Mayhorn model (2104) looks towards better consideration of children's psychological characteristics, their previous experience with a product, expectations, perception of risk and attitude. Individual factors regarding the design of warnings for children were recognised as being relevant to the design of warnings for adults and other groups. This section aims to review what information is available on the individual factors that may affect children's interaction with a warning or risk communication. Guidelines on individual factors (receiver or audience analysis) from Waterson and Monk (2014) in the context of risk communication aimed at young children may be useful for design practitioners in developing risk communication and are outlined in Table 4-1 below. The wider set of guidelines are included in Appendix A.

Table 4-1 Example section of design guidelines. From: Waterson & Monk (2014).

Target audience	Definition
Age	What age range does target audience fall into? What are their reading levels (very young children (< 7 years) will have low levels of reading comprehension)?

Cultural, national factors	Cultural and national factors may impact the comprehension of signs, e.g. interpretation of characters and symbols; language comprehension (English as a second language).
Special needs and disabilities	Some children may have learnt disabilities; a significant proportion of children are colour blind.
Gender	What is the gender mix of the target group? Gender may influence the degree to which characters, colour and symbols are interpreted and comprehended.

The models discussed within the literature review, including the C-HIP model (Wogalter et al., 1999) have not been primarily developed to facilitate design practitioners in developing warnings or risk communication for children. For example, the models have not considered children's attitudes, behaviour and other needs, such as the concept of adult-child interaction. Findings from Waterson and Monk (2014) presented in the literature review indicated that children are unlikely to be able to interpret visual information on their own, since in this age range, they are more likely to be accompanied by an adult (Waterson & Monk, 2014). The content of the guidelines produced previously from Waterson and Monk (2014) and the model from McLaughlin and Mayhorn (2014) can be further adapted to include guidelines that consider young children's specific needs.

4.2 Resources identified

This section describes the findings from a review of resources used by designers. Knowledge had been gathered on current information sources and formats available to designers to see if these could be improved. Human-factors considerations have been made for user safety and the specific needs and characteristics of young children. This section includes a documentary analysis of sources, introduces the concept of risk-communication design, explains key models with children's characteristics and stages of warning processing in mind and ends with a review of various design methods practiced in industry. Sourced resources and guidelines relevant to the area are collated in Table 4.2 below. The table describes from where the resource or guidelines relevant to the

research were sourced. These were divided into the following three categories. The first are resources recommended by experts; secondly found resources (sourced via online searches by the researcher) and thirdly Resources used by the designer in practice. In some instances, the resources were sourced from two or more of these categories and are listed beside the relevant titles. It is interesting to note that some of the resources recommended by experts are not currently being used in practice. In some instances, the resources were sourced from two or more of these categories and are listed beside the relevant titles. It is interesting to note that some of the resources recommended by experts are not currently being used in practice.

Table 4.2 Sourced resources and guidelines

Sourced from	Title	Age-range covered	Resource overview & intended audience	Evidence base	Format
1. Recommended by product safety expert	ISO/TR 8124-8:2016 (en) Safety of toys-Part 8: Age determination guidelines	Birth to 14 years Guidelines illustrate the age ranges during which a typical child has developed certain abilities.	Reference to determine the appropriateness of toys by earliest age. Audience: manufacturers and agencies (e.g. distributors, institutions, and organisations involved with child play, as well as by paediatric institutions, teachers, other professionals that use toys in their routine activities, and consumers)	Developed based on the advice of experts and traditional play patterns of children	Technical Report containing guidelines for different age groups of children.
1. Recommended by product safety expert	Therrel et al., CPSC, 2002	Birth to 12 years Covers children's basic abilities and preferences for distinguishing typical differences between age groups of children for assessing toy appropriateness.	Covers the four domains of children's physical and cognitive development, also their emotional and social development. Audience: distributors, institutions, and organisations involved with child play those involved in labelling, age-appropriate products	Based on literature and empirical research study	Guidelines organised into 4 levels each representing an increased level of detail; play categories toy subcategories; age groups; toy characteristics.
2. Found resource (sourced via online searches by the researcher)	Guide, ISO, 51. Safety Aspects-Guidelines for their inclusion in standards. 1999.	N/A	Guidelines for their inclusion in standards, which presents the overarching principles of risk assessment	N/A	Provides an informative assessment checklist for standards developers verify that aspects of safety have been considered.

1. Recommended by child safety expert 3. used by the designer in practice	ISO/IEC Guide 50:2014 Safety aspects-Guidelines for child safety.	Developmental stage broadly encompasses children's size, shape, physiology, physical and cognitive ability, emotional development and behaviour.	Provides guidelines for child safety. This guide provides a general approach to child safety, including the principles for a systematic way to address hazards and details of developmental characteristics of children that place them at risk of injury. Specific hazards to which children might be exposed during their interaction with a product, such as mechanical, thermal, and chemical hazards, are also identified, along with specific suggestions for addressing them.	Builds on the risk management approach described in Guide 51	Gide Text format with tables and lists of information.
1. Recommended by child safety expert	CEN/CENELEC Guide 14 (2009),	Of value are the examples of what children can do at different stages of development, the resulting hazardous behaviours and characteristics and potentially effective preventative measures.	A European document on the inclusion of child safety in standards. Audience: Aimed at standards developers as an memory aid to assist them in taking children's safety into account when writing standards and can be used by designers to help consider the needs of children when designing everyday consumer products	Builds on the ISO/IEC guides 50 & 51 offering mechanisms to enable the user of the guide to reach appropriate solutions in a structured way	Guide Text format with tables and lists of information.
2. Found resource (sourced via online searches by the researcher)	The Makaton Charity (2012), How Makaton Works. Online resource available at: http://www.makaton.org/aboutMakaton/howMakatonWorks (last accessed 31st October 2016).	N/A	Makaton, a method of communication using signs (gestures) and symbols (pictures) and is used to help people communicate	Even been proven to increase literacy and numeracy skills and encourages development of visual, recognition and identification skills	Booklet
1. Recommended by	The international language of ISO graphical symbols (ISO): 2010	N/A Teaches the understanding of safety	A booklet to help people to understand internationally harmonized ISO graphical symbols. Many of the symbols relate to safety/ injury prevention issues. The idea of the	Developed based on information from the ISO standards and regulatory requirements for warning sign design. A story – based pictorial booklet that	Booklet

standards expert	Available at: www.iso.org/iso/graphical-symbols_booklet.pdf	messages and public information regardless can be achieved of language barriers or illiteracy.	booklet is to raise public awareness of ISO graphical symbols, which transmit safety messages and other important information without creating language barriers.	describes this process aimed at being accessible to all users.	
3. used by the designer in practice	Peebles, L. and Norris, B., (1998). Child Data: The Handbook of Child Measurements and Capabilities – Data for Design Safety. UK: Department of Trade and Industry.	Birth to 18 years	Contains the most up-to-date anthropometric and physical strength data for countries around the world	Highlights important 'gaps' in the data available for direct use in product design	Tables & charts Data on 187 measurements of children's characteristics
2. Found resource (sourced via online searches by the researcher)	DTI, 2000 Strength Data	5–10 years	Finger push strength Pinch-pull strength Hand grip strength Wrist twisting strength Opening strength Push and pull strength	Research within the varying age ranges. To provide designers with a comparable set of design-applicable data for all age groups, children through to older adults were measured in the study. Around 150 subjects from the UK aged from 2 to 90 years have been measured for each strength measurement. Subjects were grouped into 5 or 10-year age bands, with around 15 individuals in each band, although this varied slightly between each measurement.	Data sheets
1. Recommended by academic in the field 2. Found resource (sourced via previous research)	Waterson and Monk. 2014	5–11 years. UK school-aged children	Additions and amendments to the previously developed guidelines for a developed set of guidelines for design and evaluation of safety signs aimed at young children aged 5-11 years.	Evaluation of the set of previously developed pilot guidelines (Waterson et al., 2012) using interviews and focus groups with parents, teachers, human-factors experts and other groups ($N = 38$)	Empirical research with groups relevant to research and developing risk communications aimed at young children.

1.Recommended by academic in the field 2. Found resource (sourced via previous research)	Waterson et al., (2012)	5–11 years. UK school-aged children	First development of guidelines for safety signs on board trains. The research involved running a set of workshops with young school children (aged 4-10, n=210) and showing them examples of existing train signs and gathering the requirements for new designs	Guidelines were developed based on the outcomes of classroom discussions with children in the classroom.	Empirical Research with children.
1.Recommended by expert and author	Shackell, A., Butler, N., Doyle, P. and Ball, D.J., 2008. Design for play: a guide to creating successful play spaces. The Department for Children, Schools and Families (DCSF) and the Department for Culture, Media and Sport (DCMS).	N.A.	Guidelines for play: This guidance strikes the right balance between providing safe play and allowing children to learn about managing risk.		Booklet
1.Recommended by expert and author	Ergonomics for children Lueder & Rice (2008)	Children aged 3–mid-teens	Guidelines on designing products and environments understanding of how children develop and how these developmental changes can influence the design of products and places for children Covers a broad range of topics including children and injuries, warnings for children of different ages	Various standards and other sources	Book Contains guidelines for warnings illustrated with photos and other images lists the information in compact forms the 1,000 pages is in tables, charts and graphics.

4.2.1 Resources and reports recommended by experts

Contact with experts provided various guidelines and reports. In this instance, Guide 50 (ISO/IEC: Guide 50) was supplied by a safety expert at the *Child Accident and Prevention Trust (*CAPT) along with other tables detailing children's perceptions of risk. Other booklets on child development were provided by a design group that works alongside nursery children to develop and research their products.

4.2.1.1 Resources relating to graphical symbols

There are several relevant harmonized standards and internationally recognised symbols that improve usability in their ability to convey information when written words are not adequate. A discussion of the standards sourced by the researcher is included in the sections below.

4.2.1.2 Included standards

The standards included in this study cover risk communication and design for child safety and are relevant to the universal design of signs, warnings and the safety of products pertinent to young children within the age range of 5–11 years. The guides included were also crucial to the study, as they cover much information relevant to keeping young children safe from harm. International standards developed by ISO (International Organization for Standardization) provide a coherent set of graphical symbols to help overcome language and other barriers.

A standards expert recommended some work that they were involved with that encouraged the teaching of safety signs conventions to all groups of people. A leaflet by *ISO/COPOLCO* was developed to raise public awareness of ISO graphical symbols that transmit safety messages and other necessary information without creating language barriers.

Figure 4.1 Example Resource: ISO graphical symbols: 2014

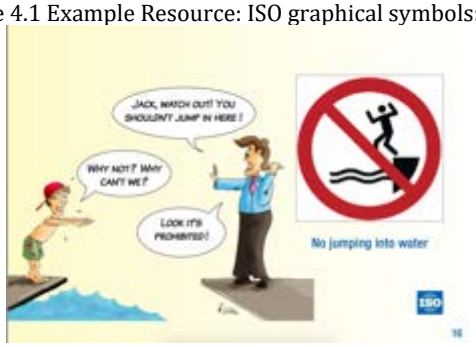


Figure 4.2 Example Resource: ISO graphical symbols: 2014

A technical committee has defined internationally accepted requirements for designs, colours, content and shapes of graphical symbols (*ISO/TC 145, graphical symbols*). These symbols convey essential messages about product features, directions and other aspects of daily life—whether at work, at home or for leisure. Critical areas include health and safety-related warnings, prohibitions and mandatory actions. Further recourses in the form of international standards are listed in the findings below.

Table 4.3 Available standards for safety sign design and implementation

Name of Standard	Description
ISO3864 and series	Specify design requirements, including shapes and colours, for safety sign design
The international standard ISO 3864-1 (2011). ANSI Z535.3 (2011a).	Provides design rules for the shapes and colours of this and other safety-related symbol signs.

4.2.1.3 Standard requirements for safety sign design

The grammar, graphical symbols and signs and the specifications for geometric shapes as wells as colours and layout are presented as requirements for safety sign design in *BS 5499-1:2002*. Examples of safety signs may be taken from those standardised in *BS 5499N-5*, such as graphical symbols and signs, safety signs, including fire safety signs, and signs with specific safety meanings.

4.2.2 Resources used by the designer in practice

There were a limited range of resources used by the designer in design practice. Design safety child data (Norris & Wilson, 1995) was one source and the other was *ISO Guide 50.* These resources are difficult to access online and are not freely available. Some design practices utilise online resources from the CAPT regarding childhood injuries.

4.2.3 Found design resources and available accident data

Resources that are currently available (sourced via online searches by the researcher) and are appropriate in assisting with the design of risk communication for young children include the following: *European Home and Leisure* (EHLASS); Accidents reports (1990–1995); the *European Comparison of Home and Leisure Accidents* (1992); include the *CHILDDATA-Child Ergonomics Databank* (1995); *Strength Data* (DTI, 2000); *national data on child injuries; design safety child data* (Norris & Wilson, 1995).

4.2.3.1 Online toolkits

The *Inclusive Design Toolkit* by Clarkson et al. (2007) is presented in the form of a book and a website. The tools were intended for use by designers to better empathise with the end user. Using the empathy tools, such as the personas, video designers can better understand the needs of a diverse range of people, e.g. older users. The website has various sections introducing the inclusive design process, knowledge and tools, which explain in detail methods such as task analysis, personas and user capabilities. The online toolkit gives the user detailed recommendations, suggestions and examples for design and the ability to interact with various tools to better consider specific sensory, cognitive and physical user capabilities when designing. It also provides interactive

content such as an 'exclusion calculator' that provides an understanding of the level of inclusivity within a design. The online format allows for the straightforward use of the toolkit in a flexible and non-linear form and chooses sections as appropriate.

4.3 Child characteristics

A knowledge base to be consolidated from the findings to enable further knowledge on the practical design of risk communications and on how children understand and comply with risk communications aims to fill the gaps in researchers' and designers understanding. Ergonomic aspects to be considered in supporting safe and suitable design for children, which are apparent from some of the prominent resources and standards, include anthropometrical, biomechanical, physiological and psychological aspects of supporting unique features of young children in terms of body size and mind of a child (Kroemer, 2006). These elements, including available sources and models, are discussed further in this section.

4.3.1 Anthropometrics

Statistical information on child body dimensions can be used in supporting safer design for young children. Anthropometric measurements are used for standards, regulation and product sizing. Overall, encouraging more reliable design for children in the included age range requires knowledge of children's unique physical measurements. These measurements are both anthropometric static (weight, height, et cetera) and dynamic (reach, stretch and grip) measures. Anthropometric data tables were sourced containing data on body size, strength and shape; however, in comparison to adult populations, anthropometric data for children appear to be less detailed. More up-to-date ergonomic information related to young children is needed for design purposes, since children provide a challenge to design teams with their body size and shape changing so quickly (Leuder & Berg Rice, 2008). Physical changes may put a child at higher risk when interacting with their surroundings; it is essential that designers understand where risk communication should be targeted due to, for instance, lack of ability to grip an object or lack of physical strength. There are many sources of anthropometric data for national populations that are available in papers in scientific journals. In other types of resources, anthropometric data has been presented in various tables, such as *CHILDATA* (Norris & Wilson, 1995) and electronic formats in the anthropometric database PeopleSize 2000

(Open Ergonomics Ltd, Leicestershire, United Kingdom). Recent collections of measured and of estimated anthropometry sources for children include the following references: Steenbekkers and Molenbroek (1990), Kroemer (2006) and the book *Ergonomics for Children* by Lueder and Rice (2008).

At present, the sources used in design for child safety, for example, anthropometric *CHILDATA* (Norris & Wilson, 1995), contain the most up-to-date anthropometric and physical strength data for countries around the world. The issue with most sources of anthropometric data is that they are either difficult with which to engage or are based on older outdated sources (Dong et al., 2013; McGinley et al., 2011). Anthropometry data tables are usually 'static', meaning that the data have been collected from people holding themselves in a fixed standard posture. The following tables present some of the published data on children. If the target population includes children, age will take first place. Considering the context of use will consist of where the risk communication is placed, e.g. the height or location of the risk information and any competing information that may be surrounding it. In supporting safe design for young children, it is essential to ensure that the communication is the correct height for children aged 5–10 years and consider additionally that an adult may also need to be able to interact with the information. Anthropometric data provide guidelines on body measurements and indicate the height the communication should be positioned (Pheasant, 1996). In considering children, sources of variability include

- gender (differences in body measurements between males and females),
- age (body measurements differ between age groups),
- culture (body measurements of children across cultures) and
- disabilities (anthropometric data tends not to include children with physical or psychological disabilities) (Norris & Smith, 2008).

Measures for various populations are typically presented as percentiles (e.g. Pheasant's 'Bodyspace', 1996). Table 4.4 presents the stature of children aged between 5 to 10 years in addition to adults in Britain. The 50th percentile measurements suggest that '*50% of the population are shorter than average and 50% are taller*' (Pheasant, 1996). All dimensions are in millimetres.

Table 4.4 50th percentile stature measurements. Adapted from (Pheasant, 1996)

Age	50th Percentile Males	50th Percentile Females
5 years old	1110	1100
6 years old	1170	1160
7 years old	1230	1220
8 years old	1280	1280
9 years old	1330	1330
10 years old	1390	1390
19-65 years old	1740	1610

Table 4.5 below, shows the anthropometric estimates of the eye level height of British children aged between 5 to 10 years in addition to those of a typical adult. All dimensions are in millimetres.

Table 4.5 The 50th percentile eye level heights. Adapted from (Pheasant, 1996)

Age	50th Percentile Males	50th Percentile Females
5 years old	995	990
6 years old	1050	1045
7 years old	1115	1105
8 years old	1165	1165
9 years old	1110	1215
10 years old	1275	1275
19 - 65 years old	1630	1505

Secular trends are apparent in children in the 21st century (Norris & Smith, 2008). The literature indicates that the stature of the adult population is increasing (Peebles & Norris, 1998). It is suggested that this growth is also present in the child population but may be slowing (Roebuck, 1995; Pheasant, 1996). Up-to-date anthropometric data need to be used in considering information that will be of relevance in supporting safe design for children. The information from CEN/CENELEC Guide 14 in Table 4.6 describes general information on growth, form and structure of children from early childhood to later childhood with relevance to safety.

Table 4.6 Growth, form and structure characteristics. From: CEN/CENELEC Guide 14 (2009)

	Early Childhood 3–4 to 7–8 years	Later Childhood 8–9 to 11–12 years
Growth	Growth slows down compared with infancy. Weight gain slows more that height.	Increase in height is mainly due to elongation of the lower limbs.
Form & structure	Trunk cylindrical in shape, the abdomen bulges out over the thorax; the pelvis is still small. Limbs still relatively short and muscles not developed. Fatty envelope diminishes. Body becomes longer and thinner.	Experience growth spurts, mainly in the limbs.

While data can still be useful in this form, a designer needs to be aware that static arm length is not the same as dynamic anthropometry. What is of more value to designers may be dynamic measurements, such as measuring how far someone can reach (Erbug,1999). Dynamic measurements for children are not as well documented. The Department of Trade and Industry (DTI) has developed data around this. However, the strength data is also presented in a table format (see below example) and is not easy to follow.

Table 4.7 Example Data Sheet: Push and pull on a cylindrical bar - one handed strength. From: Peebles & Norris (2003)

			Push (N)				Pull (N)			
Age (Years)	Sex	Orientation	No.	Mean	SD	Range	No.	Mean	SD	Range
6 – 10	M	Vertical	4	170.18	99.45	86.30 - 304.17	4	146.16	84.14	69.39 - 261.84
		Horizontal		188.7	141.71	60.15 - 378.25		191.2	144.78	48.91 - 380.58
	F	Vertical	9	187.49	107.9	86.30 - 452.33	9	147.64	63.45	77.58 - 294.60
		Horizontal		177.81	124.78	81.94 - 500.26		150.83	84.97	57.10 - 364.21

4.3.2 Cognitive abilities

Young children have a limited ability to recognise hazards due to their developing cognitive skills. In the first stages of life, a child's cognitive development relies on direct sensory stimulation and perceptions of the world. Cognition, also known as thinking, is the ability to respond to sensory perceptions of the world, process them and choose responses. The ability to communicate is also covered under cognition and the ability to understand or express simple sentences in speech or text for a summary of the language development in young children (Brown & Beran, 2008). As a result, children do not consistently and reliably anticipate or respond to harmful consequences of hazardous conditions (ISO/IEC Guide 50). Aspects of cognitive, social, emotional and language development for children aged 4-11 years are collated in the following table. A summary of the language development in young children is presented in Table 4.8.

Table 4.8 A summary of the language development in young children (Brown & Beran, 2008)

Age	Cognitive	Social/Emotional	Language
4-5 years	Recognises and knows primary colours Can categorise information Often believe in fantasy Can only focus on one aspect of a situation	Can understand and obey simple rules Curious nature Tend to be more interested in children than adults Has a basic understanding of what is right and what is wrong	Can recognise some letters Can recognise familiar words in books and signs Understands before and after Can follow three-step commands
6-7 years	Find it difficult to understand things from other people's point of view Cannot consistently understand the consequences of their actions	Desire to do things right and show the right behaviour Interested in rules	May have an interest in reading
7-8 years	Longer attention span They may still not be able to consider all the outcomes of their actions Understands concrete concepts	Views things as right/wrong Can see things from the point of view of someone else	Can communicate ideas and thoughts

Age	Cognitive	Social/Emotional	Language
9-11 years	May still have difficulty considering all the consequences of their action. Plans for future action.	Begins to see parents and authority figures as imperfect human beings. Can understand other perspectives more.	Often has rules and rituals Likes to read fictional stories and visual information

Much information within found resources describes aspects that designers would need to base a risk communication around if it were to be effective in targeting the audience of young children. In relevance to cognitive abilities, the table describes the limited knowledge and attention span of a 4–5-years old, which improves at the age of 7–8 years when a child begins to understand more concrete concepts. Younger children's social and emotional development varies greatly. A young child aged 5 years, for example, is curious in nature; however, as children become older, they begin to develop rules and understand differences between right and wrong. By the age of 9 years, children can better understand other people's perspectives. In language development, recognition of some letters begins at the age of 4–5 years, and by 7–8 years, children can communicate ideas and thoughts more accurately. At 9–11 years, children's reading is much more advanced, and they also enjoy more visual information.

Table 4.9 Cognitive, communication and language development according to age 5–7 years. From Meggitt (2012); Minett et al., 1992 & (Dempster, 1981)

SOURCE	AGE 5	AGE 6	Age 7
Cognitive Development (Ma et al., 2013:) (Meggitt, 2012:104	Are well-practiced pretenders, nearing the end of the "high season" of pretend play, but they are still developing their ability to judge pretence.C12	Begin to think in a more coordinated way, and can hold more than one point of view at a time.	Express themselves in speech and writing Enjoy the challenge of experimenting with new materials Perform simple calculations in their head
(Meggitt,2012:95; Minett et al., 1992:159)	Can produce drawings with good detail e.g. a house with a chimney and windows Draws people and houses. (Meggitt,2012:9) Knows most colour.	Begin to develop concepts of quantity: length, measurement, distance, area, time, volume, capacity and weight. (Meggitt, 2012:104)	Begin to understand how to tell the time May be interested in design and working models Can arrive at logical conclusions and to understand cause and effect Are now as proficient at judging pretense as adults (Meggitt, 2012:111)
(Minett et al., 1992)	Able to ask about abstract words (for instance "what does "beyond" mean?') Can give their full name, age and address and often their birthday Are interested in reading and writing. Recognise their name and attempt to write it	Can pronounce most sounds in their own of time. Talk fluently and with confidence	Begin to understand book language and that stories have the narrative. Communicate their thought about a book they have read or a TV programme they have seen. Enjoy word games and riddles.
Communication and Language Development (Meggitt, 2012)	Understands the needs for rules and fair play. Talk about the past, present and future, with a good sense of language Fluent in speech and mostly grammatically correct		

SOURCE	AGE 5	AGE 6	Age 7
	Love to be read stories and acting them out		
Age differences in the capacity of the short-term- store. (STS) (Dempster, 1981)	Love to be read stories and acting them out Can remember and repeat nursery rhymes Enjoy jokes and riddles Able to remember about 4 items (refers to the amount of information that people can attend to at a single time or the number of items that people can keep in mind at any one time (Schneider 202:240)	Able to remember about 4 items	Able to remember about 6 items

Table 4.10 Examples of the effectiveness of prevention strategies: The provision of information. From (Hayes, 2012)

	AGE 3-4 YEARS	AGE 7-8 YEARS	AGE 8-9 YEARS TO 11-12 YEARS
Information to carers Verbal keyword	Child not able to read information on their own Understand danger words e.g. “hot”, sharp	Child unable to read and/ or understand information Understand some abstract concepts, e.g. “dangerous”, “careful”, but can only act appropriately in familiar situations	Child unable to read and/ or understand information Unlikely to recognize more technical words describing hazards

Table 4.11 Cognitive, Communication & Language Development Age 8 -11 years. From Meggitt (2012).

SOURCE	AGE 8 & 9 YEARS	AGE 10 & 11 Years
Cognition (Meggitt, 2012)	Have an increased ability to remember and pay attention, and to speak and express their ideas Are learning to plan and evaluate what they do Have an increased ability to think and reason Can deal with abstract ideas	Begin to understand motives behind the actions of another Can concentrate on tasks for increasing periods Can write fairly lengthy essays Begin to devise memory strategies
Communication and Language Development (Meggitt, 2012)	Use and understand complex sentences Are highly verbal and enjoy making up and telling jokes Like to express and communicate their thoughts Can read stories with increasing fluency	

4.3.3 Other physical and psychological traits

Morrongiello (2008) highlighted the theoretical gap within the injury prevention literature, which indicated a lack of focus on psychological determinants of behaviour, such as attitudes or beliefs, and suggested that this has limited researchers' understanding of risk processes that lead to childhood injury. This theoretical gap is also reflected in the predominant emphasis on environmental change in the injury prevention literature (Morrongiello et al., 2008). *CHILDADTA* includes several studies on psychological aspects in both perceptual and cognitive abilities; however, much of this is incomplete, as it is difficult to apply such information to design and is outside the scope of the general design guide (Norris, 2005). Psychological determinants of behaviour are essential, and as discussed in this section, behavioural responses to risk communication are often influenced by receiver characteristics of age, gender, ethnicity and socioeconomic status. These features influence each response's pre-existing beliefs about the seriousness of the hazard and the credibility of the source of hazard information (Wogalter & Laugherty, 2006). Psychological and psychomotor aspects are detailed in the following tables.

Table 4.12 Psychological characteristics of young children. From: CEN/CENELEC Guide 14 (2009)

Early Childhood (3-4 to 7-8 years)	Later Childhood (8-11 Years)
• Occasional outbursts of psychomotor instability and of restlessness; excitement, mischievousness; loss of attention due to distractions from all the external stimulations.	• Confused thinking is diminishing and being replaced by a more analytical and logical approach
• Have "black and white" rules	• Growing child begins to have more interests. Shows an interest in school and extra-curricular activities

Table 4.13 Psychomotor development of children. From: CEN/CENELEC Guide 14 (2009)

Early Childhood (3-4 to 7-8 years)	Later Childhood (8-11 Years)
• Initially use trial and error to determine how to cope with a situation and then move to more adaptive behaviour. • Later, movements become more controlled. • Spontaneous movement becomes more coordinated. • Need to be active. • Appear to be "always on the move." • Acquire skills by imitating adults.	• Overall motor skills acquired. • Coordination improves. • Movements become accurate. • Posture and balance improve. • Control of the shoulder and pelvic girdles and of the spine not fully developed.

Fine motor skills involve the coordination of visual perception and finger and hand movements. Regarding information-processing skills, research from the found literature sources have discussed that limitations in visual skills may affect information processing. Williams. 1967 discussed that visual skills are not fully mature until 6 or 7 years of age. This is due to 'imprecise eye movements, relative farsightedness and incomplete central nervous system development of vision centres can all cause difficulty in tracking moving objects and judging their velocity' (Williams, 1967).

Table 4.14 Physical development according to ages 5–7 years

Sources:	5 Years	6 Years	7 Years
Gross Motor Skills (Meggitt, 2012) (Consumer Product - safety Commission,1980) (Steenbekkers, 1993)	Have increased agility – they can run, dodge, run lightly on their toes, climb and skip Show good balance - they can stand on one foot for about ten seconds, and some may ride a bike without stabilisers. Show good coordination playing ball games and dancing arithmetically to music. Can bend at the waist and touch their toes without bending at the knees Can hop 2-3 meters forward on each foot separately	Are gaining in both strength and agility; they can jump off apparatus at school with confidence Can run and jump, and can kick a football up to 6 m Can hop easily, with good balance Can catch and throw balls with accuracy Can ride a two - wheeled bike, possibly without stabilisers	Can hop on either leg and walk along a thin line with arms outstretched for balance May be expert at riding a two - wheeled bike or using roller skates Can climb on play apparatus with skill, some managing to climb ropes

Table 4.15 Physical development according to ages 8–11 years.

Sources:	8 & 9 Years	10 & 11 years
Gross Motor Skills (Meggitt, 2012) (Zuckerman, 1985)	Have increased body strength and co- ordination and a quicker reaction time Can ride a two-wheeled bicycle easily Can skip freely Often enjoy participating in competitive sports	Differ in physical maturity; because girls experience puberty earlier they are generally as much as two years ahead of boys Have body proportions that are becoming similar to those of adults
Fine Motor Skills (Meggitt, 2012)	Have more control over small muscles and therefore write with greater skill and dexterity Draw people with details and facial features Draw in a more naturalistic way; techniques of showing depth, shading, three dimensions and movement begin to develop	Tackle more detailed tasks such as needlework or woodwork Have an established writing style, usually joined up letters

4.4 Risk perception and young children

This section reviews the currently available information that will guide designers towards a better understanding of how young children perceive risk at various development milestones. Children have limited perception of their environment pertaining to either lack of experience or developmental stage; they are therefore not fully aware of the consequences of the many new situations that they encounter in their daily lives (RoSPA, 2014). It would be beneficial for designers to have a more direct understanding of children's risk awareness at various stages of their development to allow them to design risk communications that will be effective. Research has shown that heightened risk or hazard perception makes one more likely to notice a warning, as risk perception influences how warnings are perceived (or designed) and also affects users' behaviour at all stages of interaction with a warning (Riley, 2014). Research findings point to a critical role that a person's beliefs about a hazard plays in his or her information processing and decision making regarding that risk (Riley, 2014). Methodologies for assessing beliefs and behaviours that are key determinants of risk are described along with the difficulties in implementing various research methods with young children.

Table 4.16 Risk perceptions of young children. From CEN/CENELEC Guide 14 (2009).

Children within the 4-7 age groups
Will have some understanding of what is and what is not food or drink, and accidental poisoning in this age group is rare.
May still mistake items like liquid tabs or vitamins for sweets, brightly coloured chemical bottles for soft drinks or poisonous berries for redcurrants or blackberries.
4-7-year old's may be more confident in water just because they have learned to swim, this is no guarantee of safety in water.

4.4.1 Social and emotional development

Sociocultural theory proposes that the social world mediates individual cognitive development. The 'social environment' refers to the culture and the interaction of people that surround the user(s); this includes such factors as the presence of others, their attitudes and beliefs, status, social interactions, interruptions, et cetera (British Standards Institution, 1998). Contributing to receiver analysis, of the moderators within the McLaughlin and Mayhorn model (2014), is the concept of self-efficacy. Riley (2014) discussed that social learning theory approaches to risk communication consider the idea of self-efficacy (Riley, 2014). In other words, the nature and quality of social interactions are important to risk-communication development.

Table 4.17 - Social and emotional development. From CEN/CENELEC Guide 14 (2009).

From 3-4 to 7-8 years
Children challenge parental authority and show a degree of indifference with regards to fitting into the adult world.
They start to mix with children of the same age and in fact focus on their own age group. Later belong to own gender peer groups

4.4.2 The role of the environment

The nature of the environmental considerations of risk communication to children is outlined in the table below. ISO recognises that most of the environment is designed for adults, not for children (ISO, Guide 50).

4.4.2.1 Dependence on caregiver

Developmental trends are rarely considered when designing safety messaging that target parents. Parents and carers, often over or underestimate children's abilities at different stages of development thus exposing them to hazards. The resources show that the level of supervision varies and is dependent upon the environment and the time of

the day, as described in Table 2.18. In the home, for example, children in early childhood have minimum supervision during play and arise unaccompanied during the night, and in public spaces it becomes more difficult for the caregiver to keep track, as the child may not always be within the line of sight of the caregiver.

Table 4.18 Level of supervision. From: CEN/CENELEC Guide 14 (2009).

Adult Supervision	Early Childhood 3-4 to 7-8 Years	Later Childhood 8-11 Years
In the home	Get up unaccompanied during the night. Play with minimum supervision in the home and	Adult supervision starts to diminish
Unaccompanied travel	Walk or cycle within sight of home/ earshot of carer Out alone/ with friends/ within running distance of home	Visit local park/ streets/ woods with friends. Make short familiar journeys on bus/train public transport
Public buildings/areas/crowds	Not always in sight of carer in shop/ park/ public areas	

4.4.3 Human factors and ergonomics guidance

Problems have been identified in the process of designing for children and targeting effective risk communications for young children and their caregivers. Issues highlighted in the literature review findings include lack of access to standards, lack of up-to-date information and resources that are not mainly in a format that is easy to use for a designer in his or her everyday working environment. Adopting the systems view to handle complexities helps to consolidate existing sources as well as organise the current research. There is currently a lack of understanding and empirical research regarding how overall factors interact. The requirement for qualified supervision is not well defined in the literature. It is unclear what these interactions are between child and caregiver to improve safety. However, information has been gathered around

developmental stages and expectation for supervision at certain age ranges. These findings provide researchers with an understanding of how designers might use information, what types of resources are currently available and what information needs to be made more accessible to designers for designing for children.

Ergonomics data on children has been collected, i.e. *CHILDATA* (Norris & Wilson, 1995). However, at present, there is no support in the form of information-based yet simple-to-use human-factors guidance or tools for designers or manufacturers working with young children as their target audience. This stands in contrast to information of this kind that is available for adults and guidance developed for specific user groups of individuals, e.g. visually impaired and other types of disabled users, (Barker and Fraser, 2000; Royal College of Art, 2012). Similar tools, which have been developed for adults and inclusive populations, have proved successful and have made a significant contribution to design safety. The ISO/IEC Guide 50 provides an alternative hazard-based approach that might be more convenient for products, constructions and services intended primarily for young children.

With relevance to the development of HF/E information considered within this section, the challenges and opportunities for risk communication posed are due to increased volumes and sources of information, technological advances and globalization's call for consistency as well as specificity across and within nations and cultures (Riley, 2014). The available information is often complex and challenging to interpret (e.g. anthropometric data) in addition to being difficult to find (e.g. cognitive abilities). Barriers usually include, as described above, the 'unavailability, inaccessibility and inapplicability of data' (Wilson & Norris, 1993). The emphasis is therefore placed on examining the systems approach to warning design, which centres on the needs of the intended users (McLaughlin, 2012). In the context of this research, the focus is on young children.

4.5 Development of a risk management model

Findings from this section are integrated into the second version of the framework, where factor lists have been derived from standards and other design guidance resources described above and are presented in this section. An essential aspect of the ergonomics view is that human behaviour is complex, and the interaction of humans with products is multifactorial, with many elements within the system influencing the nature of the interactions. Much of the past research on children and risk communication

has been limited. This chapter has, however, looked more closely at the system elements that may impact the nature of a child's interaction with risk communication. Furthermore, studies have indicated that unintentional injuries are caused by a complex set of factors including 'intrapersonal and environmental factors' (Schwebel, 2003). For this reason, such factors are considered in this chapter and are integrated into the framework. Standardisation has promoted, targeted and collected the research in child safety to include cognitive psychology and stages of child development. The research and standards can be used as a basis for determining in which areas relevant information is available and in developing the process of risk communications development in general child-safety work. Further work includes caregiver models for injury control and child safety (Saluja et al., 2004; Morrongiello, 2005) and the C-HIP model, which shows essential stages (Wogalter, 2009). However, the existing work has not yet been integrated into a holistic framework that can be used by experts in the design of systems for young children. This issue has been discussed in international, European and national documents as existing standards, guides and catalogues issued by the ISO. For example, the guide for *Child Safety, Guidance for its Inclusion in Standards* by the ISO recently revised *Guide 50: Safety Aspects – Guidelines for Child Safety in Standards and Other Specifications* (CENELEC 2009 p.252; ISO/IEC Guide 50, 2014).

This study has resulted in a risk management model that can be developed and tested within the design environment with designers and other professionals in the target community. The developed model in has been adapted for use in considering children and is based on McLaughlin and Mayhorn (2014). It is a risk management model intended to be used to aid designers in providing systematic steps to develop age-appropriate risk communication for children. The systems approach considers the whole environment in which the interaction with a risk communication takes place.

Relevant models and methods, including previously developed guidelines within the scope of the areas, have contributed to the development of a support framework. Future work will produce this initial structure. Sources of support and input for design aim to be identified in line with the design lifecycle and developed framework. The information gathered in this review is mapped onto the framework behind the caregiver interaction and stages of development. The design and evaluation guidelines from Waterson and Monk (2014) are also included in the design and evaluation stage of the risk management model. The testing and evaluation are where the support for designers is needed, and this is where the data on child characteristics, capabilities and limitations become useful. The output of the toolkit is to provide design recommendations in the field. There is a

growing realisation that effective risk communication must be tailored to match the hazardousness of the situation or to the target audience's characteristics to benefit comprehension. The designer must therefore consider the components of the receiver, including moderators, and develop their understanding of previous research, age-related changes, experience and self-efficacy.

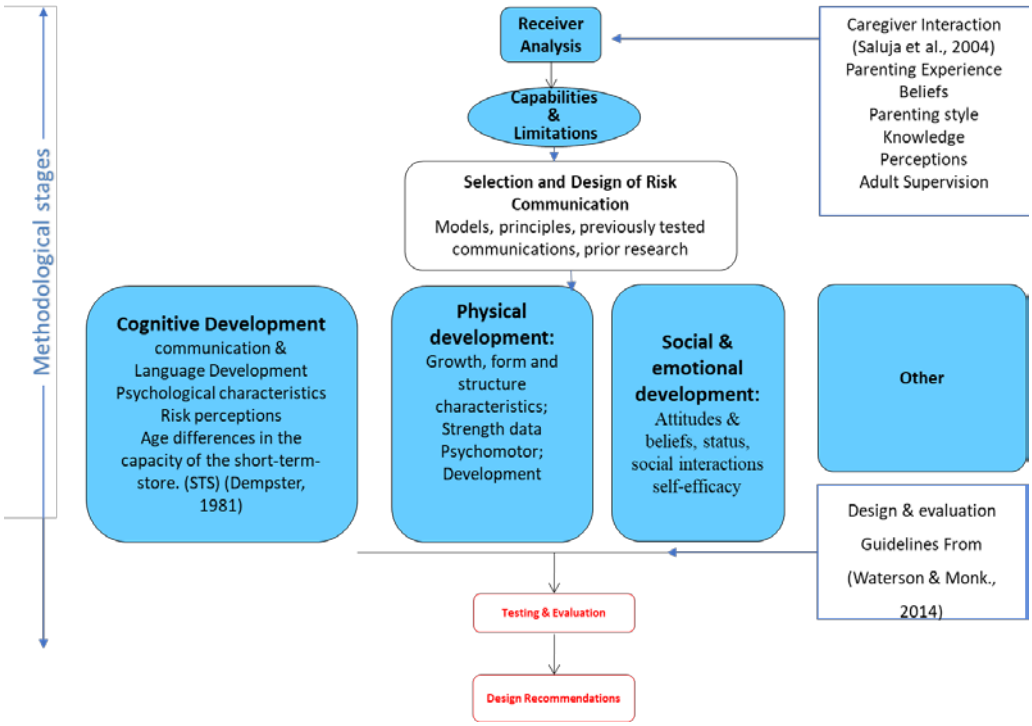


Figure 4.3 An integrated framework for the design of risk communications. Developed by the researcher,

There are not many options for designers in terms of tools to assist them in better understanding children's needs. The findings of the resource review have drawn together the dispersed knowledge into a risk management framework. The framework details components of the relationship between the user, the environmental context and behaviour and other moderators. Designers require systematic methods, tools and data in support, as current findings indicate that the needed ability data is fragmented, outdated and lacking. For these reasons, characteristics appropriate for the development of information have been integrated into a research framework. The outcomes of the research gathered in the exploratory Phase 1 through Phase 3 have been collated into a structured format that explains the differences in the human abilities at the different age ranges. Resources describe young children's cognitive skills, fine motor skills, knowledge, memory, emotional states and their specific safety requirements in how they differ from adults.

This framework was used to scope requirements of the toolkit. The knowledge gathered from the resource review and other literature sources collected in the literature review are to be utilised in the development of the tools. The tools aim to aid the designer and offer easy-to-follow guidance, as currently these resources are fragmented and not easily understood or applied to design. The toolkit components can be combined into a more accessible and integrated format as represented in the risk-communication toolkit depicted in Table 4.8.

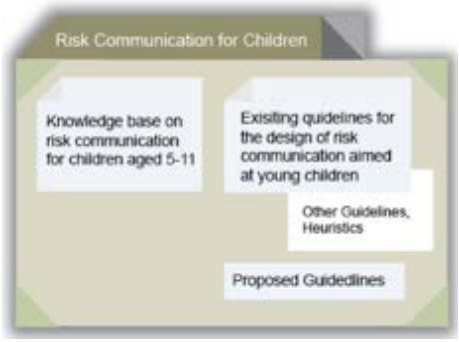


Figure 4.4 Risk-communication toolkit

Findings from reviewing the resources have revealed, for example, that young children have limited understanding of risk and rules about safety, as also confirmed in the literature (Morrongiello, 2005 p.538). Methodologies aimed at establishing these problems need to be demonstrated through a multidisciplinary framework. A context-specific application can predict what information might be relevant and useful to users depending on their task, situation or environment. Aspects that are relevant to better understanding the user group need to be translated across to manufacturers, designers and other experts. An overall combination of factors that need to be considered in the development of the tools are presented in the following list.

- Effective risk communications must (a) target children younger than has been the norm, (b) target strategies to the needs and interests of different ages and environments and (c) provide consistent messages from a variety of sources and over an extended period.
- The purpose of the receiver analysis is to develop a detailed description of the people for whom the message is intended, considering their physical and cognitive capabilities and limitations.

- Variables that are likely to affect the ability of receivers to comprehend and comply with a risk communication have been reviewed, and further information was gathered from the various resources.

The framework can be used to select human factors and ergonomics variables, with an application of scientific knowledge base concerning age-related issues of perception, cognition and movement control. Additional moderators may also be discovered during iterative design and testing, as suggested by McLaughlin and Mayhorn (2014), to include attributes such as age, size, strength, cognitive ability, prior experience, cultural expectations and goals.

4.5.1 Barriers to implementation of a design resource

The chapter has considered a set of issues and future agenda for the design and evaluation of a toolkit aimed at design practitioners and other experts in the field. Findings point towards an evident lack of readily available resources that are applicable to designers' everyday practice. Found resources are fragmented; however, some of the observed resources have discussed that young children have a limited understanding of risk and rules regarding safety, as also described in the literature sources (Morrongiello, 2005:538), and this should be considered by manufacturers, designers and other experts. Due to the shortcomings of existing guidelines and tools, a review of existing models was carried out and adapted to the purpose of this research. However, it is likely that materials like this will not contain the same level of prescriptive or definitive guidance as the materials available for adults because of the nature of working with young children.

Tools and resources that are currently available for designers are either difficult to use in practice or not very accessible. Findings point to the fact that

- Tools and resources that are currently available for designers are either difficult to use in practice or not very accessible.
- Designers need up-to-date and more accessible human-factors information to support safe design for young children.
- Many of the available resources are not relevant to meet the needs of secular trends, and changes in the way children are interacting with technology and communicating brings new risks.

Findings from this resource review indicate that much of the current guidance available lacks an evidential base that draws upon scientific research. The long-term goal is to provide a guide for designing and testing risk communication with children. Many of the resources are not relevant to meet the needs of millennials.

4.5.1.1 Insufficient integration of knowledge

There is a general lack of a synthesis of knowledge from different theoretical fields or research disciplines, and this makes it difficult to determine the applicability of a standard or the appropriate test method to use in evaluation. Most of the existing design guidelines that are relevant to implementing a safer or more relevant design for young children are fragmented and confusing to find. The same resources have been sourced from design practitioners; however, there are more out there among varying fields that would be time-consuming for designers to research, and they do not have the information on hand. Knowledge is not often efficiently shared via the different groups involved, as much information is scattered in various areas among disciplines and between groups involved.

4.5.1.2 Insufficient distinction between different age groups

Consistent with the literature review, this critical review of the resources has concluded there is an insufficient distinction between different age groups within the identified design tools and other relevant resources. Many of the sources detail varying stages and age ranges that are not consistent to developing any defining guidance for certain ages of children. For example, 'young children' may be defined as being within a certain age in one resource and being distinguished as something else in another. Consistent with findings from the literature review in Chapter 2, outcomes from the resource review have shown that that there is insufficient distinction between age groups. Findings have further highlighted that children are a moving target; for instance, in their rapid growth and development during this stage, children of different ages have vastly different preferences and levels of skill.

4.5.1.3 No low-level and easy-to-follow directing principles available for designers

Existing guidelines found in the resource review are predominantly aimed at adults. Some were found for children. Although risk-communication information and other guidance may be useful on a high level, they lack specificity that a designer will need when making design decisions. Alternative approaches to the design of effective risk communication aimed at the target user group, which are used to translate theory into more accessible forms to be used by designers, are needed. Given the lack of available research and information, this process has consequently looked at other evidence from currently used resources, models and reports in collating evidence-based support for the designer. Some of the available information has derived from human factors and ergonomics as well as the area of inclusive design guidance and examples. The collation of information, models and data aims to help facilitate understanding and awareness among designers and other stakeholders of the specific risk-communication requirements of young children and their caregivers.

Moderators specific to young children, including age-related (developmental) physical and cognitive changes, dependence on the caregiver and prior experience, are developed in the review of the resources. However, further research is required as there is lack of exploration and surprisingly few studies published about child-warning interaction and processes, including limitations for children, particularly in the process of interacting with risk communication.

4.5.1.4 Gap between theory and practice

One of objectives of this study was to contribute towards a framework (a conceptual model) encapsulating design and evaluation of risk communications for young children. This chapter hoped to contribute to a holistic understanding of the academic research as well as an anecdotal understanding of practice. This study identified relevant theories surrounding child development and materials currently used in practice, which may be of relevance to designing risk communication for young children. Relevant theories include Piaget's genetic epistemology theory (Piaget, 1973) and Vygotsky's sociocultural theory (Lantolf et al., 2015). The principles in the conceptual model are underpinned by developmental stages and psychology and presented in a manner that aims to be accessible to designers and other stakeholders involved in child safety. Such information

can be applied to serve as a bridge between warnings research, design and other fields that relate to safety perceptions and behaviour of young children. The relationship between theory and practice is illustrated in Figure 4.5.

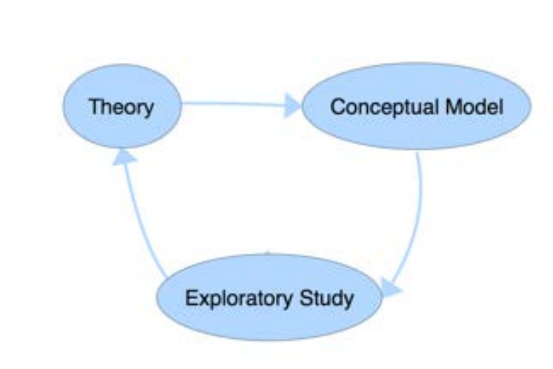


Figure 4.5: Theory practice relationship

The literature and resource review has described the best practices for the design of warnings for other groups and has determined recent studies that consider the characteristics of individuals from a population relevant to the design of risk communication. However, theory and methods that have been applied in research contexts are often difficult to implement in real life. A more detailed description of tools and methods used by industry type is required, as is not easily understood how designers might use this information in practice. In short, there is a gap between theory and practice, and there is a need to further obtain the requirements from designers and other groups involved to better develop a practical aid that helps to create awareness among risk communication developers that offer easy-to-use information and tools to apply the methods to diverse target groups (in this case, young children).

4.6 Conclusions

The overall aim of this exploratory study was to answer the following research questions:

- What types of tools and resources are currently available for designers when designing for children?
- What types of information is the researcher able to source from academics and practitioners?

The study has provided a comprehensive understanding of what materials are readily available for designers along with the complexity designers are face in sourcing information and materials to aid in design decisions. In addition, the study has provided an understanding of the difference in knowledge between academics and practitioners of types of available resources, the different formats and where to source them. In doing so, the review of the resources has built upon the previous research in the field and currently available guidelines from empirical research (Waterson & Monk, 2014; Waterson et al., 2012) in expanding on the design and valuation guidelines.

The study has considered a set of issues and future agenda for the design and evaluation of a toolkit aimed at design practitioners and other experts in the field. A literature review consolidation was performed consisting of a documentary analysis of recommended reports provided by external experts, media items on the subject and child-safety websites, which provide an overview of previous work in relevance to unintentional injury and the developmental stages of young children. An examination within the literature was subsequently conducted, and a risk management framework was developed by the researcher based on previous work. The framework requires further development in providing a clearer understanding of how it might be used and developed for the purposes of design practitioners.

The model has been further developed to include anecdotal information on children's development stages and caregiver interaction; however, the requirement for qualified child supervision is not defined as to what these interactions are between child and caregiver to improve safety. Components of moderators that are specific to children, such as age-related changes, dependence on caregiver, motivation, gender and cultural differences, were further identified from the content of the included resources. The next step is to gather requirements from designers in everyday working practices to map the risk management tool onto the design process.

Indeed, it was found that there is no such thing as design for all the children covering 3–12 years old. At a minimum, children's age ranges were distinguished into three categories: young (3–5 years old), mid-range (6–8 years old) and older (9–12 years old) children. Different needs range far beyond the imperative to design differently for pre-readers, beginning readers and moderately skilled readers.

The review of the resources has drawn upon a sample of published studies, in conjunction with the theoretical literature and methods, combining risk communication theory and design practice. The framework could be implemented as a set of questions

that a design practitioner should ask to guide the choice of design and create the associated project methodology. The design aid should reflect state-of-the-art knowledge on risk communications and should be easily connectable to already existing models discussed in the previous chapter to aid in the process of how this evidence-based knowledge can be translated into an understandable format for stakeholders. The next chapter provides the requirements of stakeholders for the design aid to meet these needs. A more detailed description of tools and methods used by industry type is explored in the following study (Study 2).

Chapter 5: Gathering the requirements from designers

In Chapter 4 (which details Study 1), a critical review of available resources and models has been conducted. Study 1 has collected information on the resources and tools available to designers to understand better the safety needs and requirements of young children in design, further developing the risk management framework presented in Section 2.8.6 at the end of the literature review in Chapter 2 following "Study 1" and "Chapter 4" in the bullet points below. That study details the methods available to practitioners and used in the design industry to review a product intended for use with or around children and concepts to promote safe, efficient, and reliable performance. Its findings suggest that current resources and support information lack, for example, insight into the emotional and behavioural capabilities of young children and other information relevant to practice.

This chapter details Study 2, which develops an evidence-based toolkit for designers, which provides visual aids for industry experts. The goal of this risk management support tool is to help constrain the design solution space and give the designers guidance about how to accommodate young children within the area of risk communication. In summary, this chapter addresses the following three questions:

- What types of information do designers need, to support safe design for young children (aged 5–11 years)?
- Is the framework (proposed in Chapter 4) useful?
- What is needed and what form must the risk management framework, developed by the researcher (Figure 4.6) take to be usable?

In sum, this chapter details the requirements of such a toolkit, based on the needs of the designers.

5.1 Chapter overview

Requirements were collected from designers and other groups primarily to understand what information must be incorporated in a design tool, including relevant human factors, along with design and evaluation methods that may be useful to apply in practice.

This chapter describes the results of qualitative interviews and observation through contact with 'key informants' with particular expertise in the field of design and other relevant areas, such as child injury prevention.

The discipline of ergonomics relates to the application of specialist knowledge of human factors through a structured approach to the analysis, design, and evaluation of the interaction between humans, technology, and work systems (Widdowson & Carr, 2002). The inaccessibility of materials, including the complexity of standards, creates a barrier to applying a structured approach to the interaction of children with products, systems, or services. Thus, the weight of these issues when considering the design, format, and content of the tool forms the basis of this chapter's investigation. A generalised vision of needs, characteristics, and requirements of children within the relevant age-groups must be gathered to gain a more holistic understanding of what designers consider in designing risk communications and products for young children's safety. As the overall aim of the research is to develop support for designers, this chapter presents the information needs of the identified stakeholders gathered through the empirical study, contributing to the future development of a toolkit in the form of a collection of information sources and practical guidance for design practitioners.

An expert's evaluation of the framework is also presented in this chapter, to promote the toolkit's flexibility for different types of designer involvement and other potential user groups. This evaluation provides an evidence base for considering children in design, of risk communications with potential for other applications, and expands upon the existing knowledge to reach a deeper understanding of how designers' requirements fit with the components of the researcher's systems model of risk communication for young children, a model based on McLaughlin. This analysis determines how the design process and requirements of the toolkit (e.g., its scope) are understood. The integrated framework will be used to guide the research and collate the information and requirements for design and evaluation of products aimed at children aged 5–11. Findings will be used to further inform the design and development of early-stage concepts for the tools. This chapter ends with an analysis of Study 2's results, with recommendations for the next phase of research.

5.2 Overview of the research process

In assessing the requirements and knowledge needs of designers and other groups involved, this study's qualitative approach aims to 'give more realistic information,

which is richer due to it being performed in natural surroundings or everyday circumstances', as described by Coolican (2009, p. 52). Thirty semi-structured interviews with experts and designers were conducted over a six-month period, as well as an ethnographic study with six experts; see Table 5.1 for a breakdown of the interview participants, domain expertise, and methods used by the researcher (i.e. observations and interviews). The table also details the tools and methods currently used in design practice for the design and evaluation of products by industry type and any other opinions participants expressed on certain resources.

There is a need to understand the characteristics of the different groups of knowledge users so that comprehensive information can be produced and delivered to designers in a format that can be holistically applied to varying design and evaluation processes. This study has advanced from the previously developed guidelines and determined difficulties that are faced in implementing human factors and ergonomics guidance within the design process and, indeed, in the workplace environment.

5.3 Data collection and analysis

Interviews were conducted with stakeholders in the field, according to guidelines for inductive qualitative research (Khanom et al., 2013). A total of 30 semi-structured interviews with experts took place, each lasting approximately 60 to 90 minutes, and they explored the participants' knowledge needs and the problems they encounter in design and risk communication for young children. Some observations were also carried out with six participants.

5.3.1 Sampling strategy

Participants from the different stakeholder groups were recruited and interviewed. All participants had at least five years of work experience in their field. The three main types of data collected and analysed in the qualitative research included in-depth interviews, direct observations, and written documents. These types of data require a researcher to identify a target population, community, or study area.

Consultation with experts involved in working with children and further organisations involved in child safety was sought for this study. Consultation with external experts and

relevant researchers had been utilised throughout this study. Informants were initially contacted by email to determine their availability.

Interviewees were drawn from relevant stakeholder groups to achieve a structured-convenience sample (Bryman, 2004). Qualitative research pursues information from specific groups and sub-groups within a population as opposed to seeking a representative sample via random selection, as in quantitative sampling (Hancock, 1998). This study aimed to explore designer's preferences and attitudes towards developing guidelines for design for young children's safety. Views were collected from all relevant professional contexts, largely identified in the literature review; these included design, ergonomics, paediatric experts and development specialists, engineering, industrial design, child safety, testing labs, and government organisations. Stakeholders were drawn from areas other than design practice to represent individuals from across a range of domains, some with knowledge in the areas of child physiology, child development, epidemiology, and other areas. Designers who had previously designed for children but had not worked in the field for approximately 10 years were considered not to have current knowledge. The sample therefore included both designers less experienced in the area or without experience designing for children and participants heavily involved in the field, with vast knowledge and experience of design for children and knowledge of the relevant design standards for children's products.

5.3.2 Procedure

Participants in this study were recruited using a range of methods over a period of six months, with stakeholders recruited from each area specified within stakeholder groups. Recruitment was conducted via email and LinkedIn to each of the eight target stakeholder areas. Follow-up communication was also sought with some of the experts involved in Study 1, as they already possessed background knowledge of the research and are actively involved in the industry. External experts were asked to provide advice and guidance where necessary throughout the study. Ergonomic and other experts in the field of child safety and design were identified in discussion with the authors of one of a prominent study in the literature, '*Design, for Children*' (Rice and Leuder, 2008). These experts (e.g., the authors of recent child-safety guidance documents) were identified initially through contacts with the Child Accident and Prevention Trust (CAPT).

Responses were received from a mix of stakeholders, including human-factors experts; design professionals; child-safety organisations; authors; commercial organisations, including the British Standards Institution (BSI) and National Trading Standards; academics; public-health experts; applied child-development specialists; and testing groups. Interviews were conducted face-to-face where possible; however, some of the participants requested that the interview be conducted using Skype, as some of the organisations have a presence in other locations (e.g. America, Asia, or other locations in Europe). As interviewees were dispersed over the described locations, some of the interviews were conducted over the phone, at the request of the participant. In both cases, the same method was used to maintain reliability. Participant distribution is graphically illustrated in Figure 5.1, and Table 5.1 describes the specific tools used by stakeholder's (N = 30) who took part in the semi-structured interviews. The table describes participant demographics and each participant's specific domain (e.g., safety expert), interviewee number, and specialisation, including types of products or guidance.

Figure 5.1 Distribution of participants

Of specific interest to the researcher was their involvement in designing for children, advice on types of information that would be useful, their level of experience, and age (see Appendix B1 for a full list of the participant demographics). Recruitment initiated targeting individuals residing in Leicestershire and surrounding areas. However, this effort expanded to include experts in the field from the US and other areas. The main reason for this expansion the discovery that, historically, much work in the field of child safety began in the US; thus, the researcher was quickly introduced to various child safety and ergonomic practitioners residing in the US. The sample size was established through data saturation. Therefore, when no new information was identified within the analysis of interview transcripts, recruitment ceased.

5.3.3 Ethnography study

The ethnographic research was carried out within the participants working environments to gain additional insight into differences between companies, work processes, teams, and their complex information needs. The ethnographic study reported in this describes the current H/FE and design support they currently use in practice. The ethnographic study was made up of a total of 6 participants, consisting of 3 safety experts and 3 designers. Participant observations took place in various locations with a mixture of work environments. Participant 26 [S2-26] who's working environment was within a major test house; and 1 company involved in product recalls for children's products [S2-21] where 2 safety specialists took part, as well as three participants working in wider design companies involved in product development [S2-01], [S2-05] and [S2-23]. The ethnographic observations took place for a maximum of two hours on site and over the duration of the study and depended mostly upon when participants were available to take part. The included participants are highlighted in grey in Table 5.1.

5.3.4 Qualitative interviews

The critical review identified gaps and issues in developing evidence-based tools to be addressed during stakeholder interviews. It was thus considered appropriate to use interviews to collect individuals' experiences and opinions of the various forms of guidance, resources, and techniques that they currently use when designing for children (if any) and to explore their preferences and attitudes towards developing guidelines for design for young children's safety. Furthermore, these interviews were used to find out what would be a useful design aid to better support them when designing for the identified age group. The interactive interviews in this study helped to define key components involved in their design processes; these particularly helped to identify the areas where further support might be required. The analysis from these interviews informed the initial understanding of requirements for the toolkit.

Each interview was conducted following a prepared procedure (see Appendix B4). Since risk-communication research has tended to focus on adults, with a lack of focus on young children, interview data with expert input was viewed as the most suitable form of information to supplement the existing findings and further refine the framework initially developed for older adults. Semi-structured interviews provide the ability to

examine topics of interest in varying degrees of depth, an approach that suited the exploratory nature of this study (Robson, 2002). The use of semi-structured interviews was further deemed most suitable to meet the aims of this study for many reasons. Firstly, the lack of empirical research into risk communication aimed at young children prevented the use of document analysis alone. Semi-structured stakeholder interviews were conducted initially within the UK; however, further 'key informants' were identified from America, including the author of one of the major sources: 'Design for Children: Designing products and places for toddlers and teens' (Lueder and Rice, 2008). This book was consulted to ensure stakeholders would represent a variety of disciplines and to assess the issues highlighted as important in designing risk communication tailored to the needs of young children and their carers. The in-depth interviews allowed respondents to adequately describe their personal experiences relating to design interactions and interdisciplinary collaboration.

5.3.4.1 Design of interview questions

A standardised interview schedule was designed, based on the findings and framework established in the critical review of resources in Chapter 4, where findings highlighted that there is a need to provide designers and other groups with more appropriate resources. Once the interview schedule was devised, it was piloted with an interviewee, and it was subsequently modified to form the final schedule (See Appendix B4). The final schedule included four sections: background, sources of information, the model and components, and design recommendations. Interview questions were designed to address the following topics:

- *Part 1—Background:* The interviews gathered information on the participant's background, role experience, and involvement in the field of design for children aged 5–11.
- *Part 2—Sources of information:* Information on design and evaluation methods and processes participants currently use was collected. Information was gathered regarding participants' knowledge of current tools available to support safe design for children, as well as tool format, how information is currently used in the design process, and effectiveness.
- *Part 3—The models and components:* The risk management model and its components were presented to participants, with design participants describing an example design scenario for how they might use the model in practice.

- *Part 4—Design recommendations:* Interview questions elicited participants' opinions on the model and recommendations on how the model and its components could be improved, for example, with regard to the format in which they would like the information.

Any further issues or comments were discussed at the end of each interview. These areas were investigated to gather insights into whether the participants believed that current tools and methods benefitted the design process and what aspects were found to be difficult in designing for young children's safety. Information was also gathered on what the participants thought the strengths and weakness of these tools and methods were, as it was felt that this information would be valuable when creating the resource. In accordance with university ethics, each participant was informed that they were under no obligation to take part. They could end the interview at any time, and company, employee, and project data would be kept anonymous. Interviewees, having agreed to participate, were briefed verbally about the nature of the research and supplied with written information; additionally, informed consent was obtained (see Appendix B2) and were informed of their right to request any data held about them at any time during the study. in written form from all stakeholders before questioning began. All interviewees were then asked their current role and prior experience. Interviews were recorded digitally (once permission was gained from stakeholders) and subsequently transcribed verbatim, each lasting approximately 30–90 minutes. An invitation was sent to all other participants requesting an interview. Due to the dispersed locations and time restraints of many participants, some of the interviews were conducted via Skype, as this medium allowed for face-to-face discussion without excessive travel. Where participants were unavailable for a skype call, a telephone interview was conducted instead.

To maintain reliability, all participants followed the same semi-structured procedure listed:

1. Initial contact by email or follow-up telephone call

2. Invitation to participate in face-to-face or Skype interview (depending on location and availability)

3. Interview conducted for approximately 40–60 minutes

The primary focus of this qualitative interview study was to bring together relevant information on considerations for child safety, determining the needs of designers, and

furthermore, the views of other stakeholders, with knowledge of the included disciplines.

Issues were discussed with each stakeholder to gain a better understanding of what information might be needed surrounding the factors considered significant in using design resources or tools to aid designers and other groups when designing for young children's safety.

5.3.5 Analysis

The use of qualitative methods and data collection often results in large volumes of textual material that must be analysed and interpreted. Textual data in this instance included field notes from participant observation, transcripts from semi-structured interviews, stories or narratives, and existing resources and guidance. Initial analysis of the interviews identified the main problems with implementing human factors and ergonomics guidance. Interview transcripts were imported into the software programme NVivo 10 and used to aid the researcher in examining the possible relationships among the research themes. The frequency and distribution of codes were used as a means of making 'connections' within the interview transcripts, as advocated by Crabtree and Miller (1999, p.169).

In the preliminary analysis, the researcher read through the scripts to become familiar with the data. A few *a priori* codes, reflecting areas highlighted in advance as important to addressing the research question, were drawn from theory in the literature. Template analysis was utilised to 'code and then rearrange the text from the semi-structured interviews' as advocated by Crabtree and Miller, 1999, p.165. Template analysis characteristic of organisational research was used in this study to structure the qualitative data. In using the template, the researcher developed a template or codes from prior research and theory related to the research topic and applied them to the data before proceeding to the next phases. The template was constructed *a priori*, based on prior research and theoretical perspectives as advocated by King (1998). This researcher compiled a list of codes occurring in each transcript. The distribution of the codes within and across transcripts helped the researcher to draw attention to the aspects of the data that warrant further examination (King, 1998). The researcher also identified some emerging themes, in line with the original objectives of the study.

Three waves of interviews were planned, commencing with a semi-structured pilot interview based on the conceptual framework of the researcher. The use of one-on-one interviews is supported by Barbour (2008, p. 128), who states that one-on-one semi-structured interviews may be the most commonly used qualitative method and have become almost the "gold standard" approach. The second and third waves are interspersed with by phases of iterative analysis, facilitating the development of the template. Template analysis was used to specify the *a priori* themes used. Additional themes that emerged from the interviews are also discussed in this chapter. Template analysis was utilised to code and then rearrange the text from the semi-structured interviews (N = 30). To organise, analyse, and interpret the text, Crabtree and Miller (1999:165) describe that when using a template, the researcher should define a template or codes and apply it to the data before the phases of the analysis process. In this study, an *a priori* list of codes was drawn up based on a selection of child development and risk communication research from the field of human-factors adoption (McLaughlin and Mayhorn) and implementation research. King (1998) advocates compiling a list of codes occurring in each transcript, and the distribution of the codes within the transcribed interviews helped in drawing attention to aspects of the data that required further examination. Initial analysis of the interviews identified the main problems with implementing human factors and ergonomics guidance. Further analysis identified gaps in information and the knowledge needs of design practitioners and other experts. Initially, seven main themes emerged as a list of *a priori* codes from the resource review, showing the key findings of factors in design for child safety (see Table 5.1). During the analysis phase, patterns were found in the data, and the focus was on finding the key requirements of the knowledge needs of designers when prioritising young children's safety. The researcher started with an initial coding template, which was then modified through data collection and analysis. *A priori* themes used in designing the interview questions are included in Table 5.1. Each of these emerging themes is discussed and further developed in the interview findings.

5.4 Overall findings

The results from the observation and interviews revealed the need for tool flexibility, to make these tools useful and relevant in the everyday context of a designer. The tools are needed at several points in the design process, with respect to several factors and considerations.

5.4.1 Ethnographic study outcomes

Part of the ethnographic study involved trading standards providing examples of various children's products and products aimed at adults but likely to be in a child's environment, for example a phone charger which had been recalled. Products failed in a number of ways, including but not limited to being choking hazards or fire hazards. Participants provided further information on product recalls and examples of inappropriate labelling on the products. An international product-testing lab provided a report from the Product Safety Enforcement Forum of Europe (PROSAFE), which was in part funded by a grant from the Executive Agency for Health and Consumers (EAHC). This report contained research on products for children, and it identified experts in the field of child development who worked directly with young children aged 5–12.

During observations within the design companies, additional insights were gained concerning the design process, as the research was immersed in the environment and could better understand the differences in the ways that the companies carry out their everyday design tasks. The companies' approaches to design differed. For example, companies have different design models, and different structures, attitudes towards standards, and methods are used to test and evaluate products. The product testing companies involved in the study indicated that they have a safety process that encompasses a company's entire business process and ensures products are designed considering safety from the start, as safety is an integral part of the design process.

5.4.2 Sources of Information

Current tools and design activities were gathered and are presented in Table 5.1. The table describes the domain, for example whether the participant is a safety expert, an academic, or a design practitioner. Participants described their roles, tools, and methods used in design and evaluation, and they further explained how they use these tools (also listed in Table 5.1).

Table 5.1 Tools and methods used by industry type

Code/Domain expert Method	**Industry Type**	**Design & Evaluation (Tools & Methods used relevant for input to design)**	**Observations from interviewees on currently available/ used tools**
S2-01 Safety expert Human factors/engineer (Senior ergonomist) (Multidisciplinary consultancy) **Method:** Observation & interview	Human factors/engineer (Senior ergonomist) (Multidisciplinary consultancy)	H/FE Toolkit, Guide 50 Fitness for purpose (a type of task analysis)	Independent testing, assisting with the collection of anthropometrics for children, sits on the standards board, writing anthropometric standards for children. At the beginning of the design, 'fitness for purpose' is used to understand the purpose of what they are trying to achieve and how they are trying to achieve it. That is the key part of how they assess or design; the designer's write and log those goals and then aim to fulfil them.
S2-02 Academic/consultant (UK university) **Method:** Interview	Academic/consultant (UK university)	Data visualisation tools Adult data	Research into older adults, product research, human factors, testing, and evaluating products Research on data visualisation and design optimisation for human use
S2-03 Toy safety experts, British Toy and Hobby Association **Method:** Interview	Toy safety experts, British Toy and Hobby Association	EN 71 Toy standard Risk assessment (of use and use error) Child data	Independent testing of toys and other products for children, writing safety standards concerning children's products
S2-04 Academic/Consultant (UK University) **Method:** Interview	Academic/Consultant (UK University)	Prompts Finger probes	Made own prompts for testing and evaluating children's products and environments. Gathered strength data on children for assessing the safety of a particular product. Strength data for children is important in considering safeguarding products muscular control and precision of movement while developing increased muscle strength.
S2-05 Head of product design **Method: Observation & interview**	Head of product design	Spider web model Booklets created in-house related to children and play Risk management models Observation Prototype Involvement of children and caregivers	Developing standards for children, designing, prototyping, testing products. Use child data for physical sizes and European Standards for Playground Equipment: EN 1176 and EN 1177, although the standard did not suit the type of equipment being designed for indoor play, so the designer used their own judgment. Retrospective or current legal requirement but represents good practice in the event of an accident claim. Their limitations should be recognised: Compliance will not automatically create a safe playground.

Code/Domain expert Method	Industry Type	Design & Evaluation (Tools & Methods used relevant for input to design)	Observations from interviewees on currently available/ used tools
S2-06 Product design **Method:** Interview	Product design	Sensory and cognitive factors. Resources mentioned cover mainly physical aspects.	Designing and evaluating products. Normally uses tools at the research stage and does not tend to use them at the subsequent design stages. Various early years products, including a baby bottle. Market research.
S2-07 Academic/design (UK university) **Method:** Interview	Academic/design (UK university)	Evaluation for understanding use and reasonable foreseeable misuse of a product. A framework to foresee a typical use scenario and what's reasonable misuse. map that out as a scenario use a task analysis to step it through. Used the general product safety regulations, EN 71 Toy standard mechanical part 1 that looks at sizing in product development.	Evaluation of a walking aid for children. Looking at reasonable use and foreseeable misuse, in other words predict the behaviour of a child in interacting with the product. This technique is used to understand the hazards, from finger entrapment to limb entrapment, potential choking hazards, regulations, and standards, and use these as a basis to evaluate the different aspects, the designers were aware of some of the key hazards posed when designing for children.
S2-08 Academic in the department of design (UK university) **Method:** Interview	Academic in the department of design (UK university)	EN 71 Toy standard Risk assessment Child data Prototype	Additive manufacture, product design, industrial design, design futures, concept development, design research, inclusive design.
S2-09 Product designer **Method:** Interview		Child data EN 71 Toy standards Regulations for childcare articles	Designing infant products. Various early years products including a baby bottle. Market research.
S2-10 Product designer Makie-lab (Children's toys). **Method:** Interview	Product designer Makie-lab (Children's toys)	Child data EN 71 toy standards	User-centred designer or maker of consumer products, children's toys and games, interactive digital/physical installations and web/app UI/UX. Often the development is out of their hands after the initial concept stage there is often a rush to market.
S2-11 Safety expert. Safety evaluation Engineering Education to university students and industry	Safety evaluation Engineering Education to university students and industry Executive director for Kids in Danger	Product recall data Risk analysis	Evaluating the safety of products. The tool is used in academia, for their engineering students to be educated on how to include safety at the start of the design, rather than to make a costly mistake; it was applied practically in the redesign of a physical product to make it safe for children. Integrating product safety into engineering course.

Code/Domain expert Method	Industry Type	Design & Evaluation (Tools & Methods used relevant for input to design)	Observations from interviewees on currently available/ used tools
Executive director for Kids in Danger International Consumer Product Health & Safety Organization (ICPHSO) board member **Method:** Interview	International Consumer Product Health & Safety Organization (ICPHSO) board member		
S2-12 Safety expert Product testing and risk analysis **Method:** Interview	Product testing Risk analysis	Product recall data Risk analysis	Writing standards for children's product safety. Injury data. Assess the hazards associated with the product.
S2-13 Human-factors consultant **Method:** Interview	Human-factors consultant	Child data	Product research and evaluation. Medical device development. Although the participant has used physical data, such as height or weight there was a lack of information on children's emotional needs in using medical devices. The designer also required information on product safety regarding button cell batteries at the later stages of a design. The designer was unaware where they could find information on button cell batteries and child safety requirements.
S2-14 Product designer **Method:** Interview	Product designer	Child data	Car seats, infant products, toys, textiles.
S2-15 Product designer Toys, education	Toys, education	Child development, play	Toy design, game design, learning materials, licensed items, construction toys, baby care items.
S2-16 Safety expert Product safety Commission **Method:** Interview	Product safety commission	The age determination guidelines	Product safety, standards, testing, product regulations.
S2-17 Product designer	Product designer	Child data EN 71 toy standards	Design consultancy owner, graphic design, children's products.

Code/Domain expert Method	Industry Type	Design & Evaluation (Tools & Methods used relevant for input to design)	Observations from interviewees on currently available/ used tools
Method: Interview			
S2-18 Product designer **Method:** Interview	Product designer	EN 1176 and EN 1177.	Designing outdoor equipment, meeting the safety standards for outdoor play environments. Children's outdoor equipment, climbing frames, swings.
S2-19 Product designer. Toy designer at the Early Learning Centre **Method:** Interview	Toy designer at the Early Learning Centre	Child data Prototyping	Develops early years, educational products. Use tools in concept development, design, development, prototyping
S2-20 Product designer Product development and retail specialist **Method:** Interview	Product development and retail specialist	Child data EN 71 toy standards	Product development, education, buying specialist working in the global retail sector. Strong background in sourcing, packaging, design and development, and copy writing and editing, training in child development.
S2-21 Safety expert Trading Standards Organistion. **Methods: Observation & interview**	Trading standards	Child data EN 71 toy standards	Product development and safety. Utilises product recall databases such as the Rapid Alert System for dangerous non- food products (RAPEX). Identifies and notifies the relevant countries/ persons of the unsafe product.
S2-22 Product designer **Method:** Interview	Product development	Child data EN 71 toy standards	Product development
S2-23 Ergonomics consultant **Methods: Observation & interview**	Ergonomics	Child data EN 71 toy standards CAPT	Product development. Regularly uses anthropometric data for adults. Used some text books which information for children was not easily found. Were largely unaware of where to access information on hazards relevant to young children, for example choking hazards and other information relevant to child safety.

Code/Domain expert Method	**Industry Type**	**Design & Evaluation (Tools & Methods used relevant for input to design)**	**Observations from interviewees on currently available/ used tools**
S2-24 Child development expert **Method:** Interview	Child Development specialist	Sources from psychology, Child data	N/A
S2-25 Product development Engineering designer **Method:** Interview	Product development and Engineering.	Child data, website CAPT	Consultancy working with different groups in-house, including engineers, designers, human factors
S2-26 Safety expert STUUV testing house **Methods:** Observation & interview	Major international testing house based in the UK.	Finger probes Dummies Other types of machines to gather measurements	Major testing house tended to use more quantitative-based measures, for example collecting data on specific measurements for entrapment of fingers.
S2-27 Industrial designer	Industrial designer/user experience.	Child data EN 71 toy standards	Product and services design product development, interface design, and user experience design.
S2-28 Child development expert	Paediatric expert	Child data	N/A
S2-29 Author Human-factors expert	Author	Book—a guide for designing for children	Written guidelines and information on designing for child safety.
S2-30 Paediatric expert	Paediatric expert	Child data EN 71 toy standards	N/A

5.4.3 Emergent themes

The participants (N = 30) comments acknowledged the value of design controls and the potential benefit of good human-factors guidance. HF/E guidance considers ways in which human factors can be applied to the design of products, so that they are designed 'effectively for use by intended users, consideration for the environment in which they are likely to be used, relevant human factors data and principles inherently aim to make products safer. This guidance needs however to be in a useful format, to aid designers when designing for child safety. A variety of feedback was collated from each of the participants, including examples of past experiences in designing for children within the age range and regarding the implementation of design guidance and from the stakeholders. Seven key themes emerged. Most of the dominant themes concerned ensuring that the design and evaluation methods in the design of risk communications meet the needs of the practitioners. While participant comments indicated the importance of a given *a priori* theme, the non-representative nature of the sample means that this finding cannot be meaningfully tested; therefore, it will be reviewed against the framework developed from the resource review in Chapter 4. After re-reading the interview transcripts, additional themes emerged from the *a priori* themes. The themes considered critical (i.e., present in interviews with at least 20% of participants) are presented below in Table 5.2.

Table 5.2 Key themes

No.	**Key Theme: (*a priori*)**	**Emerging Themes**
01	***Current tools***	Guidelines and information sources (usability, availability, and accessibility) Format of the current tools are presented in (Booklets, books, tables and datasheets) Methods: product testing and evaluation
02	***Specific issues in designing for young children***	Specific safety issues: new products appearing too quickly in the market Standards unable to be developed quickly enough for new products entering the market
03	***Designers***	Knowledge areas Designers current attitudes knowledge and understanding HFE input

No.	Key Theme: (*a priori*)	Emerging Themes
04	***Design process***	Information and content Design lifecycle and supply chain Child involvement Expert involvement Caregiver involvement
05	***Audience***	Characteristics of young children: risk perception Stakeholders perception of safety and design for young children Expert involvement Role conflicts
06	***Role of environment***	Standards and legislation Building regulations Risk assessment Proprietary data Testing and test methods Injury data
07	***Stakeholder cooperation***	Differences between groups and specific disciplines (e.g. academic & disciplinary, cultural). Collaboration level, users and community-based stakeholders User feedback Globalization

5.4.4 Current tools (01)

Current tools available to support safe design for children were discussed by participants. Additional themes also emerged, including tool format, applying information to the design of risk communications, and their effectiveness.

5.4.5 Information needs and requirements

Designers were asked what methods, tools, or resources (if any) are used and information would be useful when designing for the age group of young children. Participants commented on the benefits and weaknesses of the methods and tools presented in Table 5.2. The information needs, and the requirements of designers are further described in the following sections. Often, teams require different types of information when designing for children, and technological developments and continuous innovation mean that information sources must be continuously updated to

match designers' needs. The resources found to be used in practice are mostly secondary data sources, due to time and budget constraints. Types of primary and secondary data discussed by participants include the following:

1. Primary data that designers collect themselves (e.g., measurements, quotes, pictures, recordings, prototype testing results, anthropometrics)

2. Secondary data used with the initial brief or collected from available design and other resources and reports, thought design development (e.g., anthropometric data, academic papers, newspapers, articles, case studies)

5.4.5.1 Format

Views on designer's current attitudes and knowledge regarding the use of support tools and resources in the design process were gathered. Overall, the feedback highlighted designers' requirements for tools that are more visual. For example, 26 of the interviewees discussed the need for more visual tools; some discussed visualisation tools, and a few participants discussed the need for quantitative analysis and analytical tools. However, a variety of the interviewees pointed out various barriers to the use of tools or information resources when specifically designing for children, in achieving safer design:

> [S02-08] "…it's abilities as a visualisation tool are probably equally as important as its ability to perform quantitative analysis".
>
> One resource was developed due to fragmented information; however, this was collated into a book, which is not always accessible to designers as it is not light-weight, mobile or compact for designers to carry and use at their convenience:
>
> [S02-29] "We used a lot of human-factors professionals in writing the book because while there are design guidelines for toys, playgrounds, cribs, and so on, it was not gathered in one place where a designer could look for information. Thus, we put what we could into our text as a design guide".

To summarise, the currently used design aids and resources that the interviewees discussed being aware of for use in designing for the age group of young children include the following in the described formats:

- Tables
- Standards

- Risk analysis process (show example risk analysis) and scoring
- Different versions of risk assessment processes, e.g., a spider web model, agile-risk analysis process-design (one design participant who designed nursery products produced resources and booklets on children and play and on child development)
- Human-factors standards
- Cards
- Risk analysis models (used by human-factors researchers)

Further comments from safety experts pointed to other forms of information which would provide support to designers on the relationship of stages of development to certain types of injuries; this support can be accessed online:

> [S2-16] "The Child Accident and Prevention Trust and RoSPA [Royal Society for the Prevention of Accidents] have pages on their websites about the relationship between child development and of different kinds of injuries to children".

5.4.5.2 Methods: Product testing and evaluation

Interviewees were asked about the design of effective risk communications to reduce specific risks and designing for vulnerable user groups. Interviewee [S02-24] commented, for example, that

> [S02-24] "…all interventions must be developed to be mentally sensitive to the stage of development of the child".

The types of methods and information commonly used by safety experts (e.g. those in testing facilities in product evaluation) included the following:

- Expert evaluation
- Material evaluation
- Detailed measurements
- Anthropometric measurements
- Force measurements
- Centre of gravity
- Risk assessment
- Task analysis

Reasonable use and foreseeable misuse was also discussed by some participants, the safety experts discussed this technique as few designers discussed this topic. Reasonable use and foreseeable misuse means that manufacturers are required to anticipate the possible use of their products and therefore understanding child behaviour is important especially in considering what constitutes as responsible foreseeable misuse by the consumer.

5.4.5.3 Usability engineering process

A key stakeholder from a child-safety organisation that teaches engineers how to design for child safety discussed having a more structured usability engineering process when implementing safer design for children within the age group. Overall, interviewee suggested that designers should do the following:

- Follow a structured process to ensure that user needs are met
- Have active user involvement in the process
- Make the process an iterative cycle
- Invest in processes depending on the type of product

Twelve other participants discussed the need for a more structured approach. Some discussed active user involvement in the process, but many discussed the lack of time and resources to engage users. Overall, participants recognised that designing for the user group is an iterative process.

5.4.5.4 Feedback on the framework

Participants generally indicated that the that components included in the framework were useful for designers. Their comments illustrate the need for flexible tools when designing for the user group. Feedback on the framework also suggested that investment in process depends on type of product and that the framework would adapt depending upon the complexity of what is being produced. The use of scenarios to better illustrate steps in the process was also discussed by participants. Interviewees commented on the use of the framework within the design and evaluation process, and most participants suggested improvements. Some of these comments are listed:

> [S2-08] "If you have a design expert or child specialist then it makes it easier and then depends on the size or the scope of the product. If it is a very complicated

product, then you have a very different kind of framework so maybe if you have different kinds of scenarios".

[S2-10] "If I was to design a straightforward product compared to a more complex one, maybe the framework might change slightly. If it is a very complicated product, there may be more steps in between more steps feeding into if it was a straightforward product, maybe just a cutlery set for babies, then maybe it is much more condensed".

It was discussed that the framework should be able to be able to be flexible and to cater to the needs of different levels of guidance depending upon what is required.

5.4.6 Specific issues in designing for young children (02)

Participants mentioned specific issues in designing for young children; specifically, four safety experts talked about the issues of new products appearing too quickly in the market. Standards cannot be developed quickly enough for new products entering the market. Information content within guidance standards, use specification, human abilities design guidance, sample sizes for usability is not always displayed in a way that designers can easily follow that can be easily translated and understood between the various groups involved. There is a lack of communication between stakeholders involved in design for children. Standards developers are separate from those who test and evaluate products, namely another set of experts who do not see themselves as designers. Product testing experts and child safety organisations have much knowledge about human factors and safety issues concerning children, and that could be communicated clearly to designers.

5.4.7 Designers (03)

5.4.7.1 Designers' current attitudes and understanding

Commonly, designers have agreed that resources for designing for child safety would be beneficial; however, they did have concerns over what this might look like and how it might work with existing standards and the design process. Some of the more experienced designers seemed to rely much more on their knowledge and experience in the area rather than following guides or standards. Designers also discussed their brief

involvement in initial design stages, working within a fast-paced environment and with rapid turnaround times. One designer discussed that they have been heavily involved in concept development; however, after that stage, products are often rushed to market, and the latter stages of development are usually out of their hands. Hence, some participants raised concerns about whether resources would be used in practice, particularly in implementing guidance on human factor ergonomics into design practice:

> [S2-06] "Where human-factors guidance must sit creatively, that is quite a challenge, and it's revealed as a mostly unsuccessful challenge because of the range of tools that are already out there for good design. I am not talking about children, though. I am talking about things like inclusive design, design for disabled people, who are sometimes ignored".

However, another participant discussed the benefits of utilising HF/E experts in developing design tools that can be easily accessed by designers in their everyday tasks:

> [S2-29] "We used a lot of human-factors professionals when writing the book because while there are guidelines for toys, playgrounds, cribs, etc. it was not gathered in one place where a designer could look for information. Thus, we put what we could into our text, as a design guide".

5.4.7.2 Human factors ergonomics (HFE) input

Human-factors scholars commonly discussed the expenses of HF/E input, including the lack of up-to-date data, as it is expensive to collect, and a lack of adequate resources to convey information quickly and in an easily understood format. Reports from stakeholders revealed that they are aware of injury interventions for young children's safety and see them as beneficial. Information sources and beneficial interventions concerning child safety were mainly discussed with experts in trading standards, child safety, and ergonomics.

Design and ergonomics professionals, however, indicated a lack of primary data on this matter (i.e. a lack of data specifically collected by the researchers to meet the needs set out by the brief). Furthermore, there is a lack of multivariate data on children. Multivariate analysis involves considering many body dimensions and capabilities simultaneously to predict whether an individual can achieve a specified task with a given product or in a given environment.

5.4.8 Design process (04)

5.4.8.1 Design lifecycle and supply chain

The design lifecycle, including involvement of children within the design process, was targeted to gain an idea of the ways in which young children are considered within the process of design for young children's safety:

> [S2-03] "Well, the choice of materials, I guess you just sort of look at, sort of, what's limiting you in each part of the design process, I suppose. I mean, I know that there is much legislation on materials and what can be, but then I have found that you have got to look carefully at what the standards say. They might be standards that say you can only use these sorts of materials, but then they say that only applies to a specific sector of children's products".

> [S2-03] "Toys are noted explicitly in the British standards and the American Standards as well. It's got to be explicitly considered a toy for a lot of the material restrictions to come into place".

5.4.8.2 Children's involvement in design and evaluation

Some of the participants described involving children in their projects. However, 90% of these designers did not follow any clear guidelines as to how to go about this process. When discussing support for the designer, one critical issue raised across stakeholder interviews was the difficulty of involving young children in the design process, which supports the need for adequate resources to be developed. There are also several challenges in conducting research child participants, challenges not present in similar research with children over 12 years old or adult groups:

> [S2-24: Child-development expert] "I think that below age of 11 years is touch and go. They cannot really think about their experience and the experience of others, so we limited our study to ages 11 years and up".

In addition to this, interviewees' [S2-05], [S2-03], and [S2-11] reported that one massive challenge for them is that children are a moving target, and they are quick learners. Therefore, a risk-communication design guideline that is appropriate one day may no

longer be appropriate in a few months. Specifically, interviewee [S2-02] commented on challenges in producing practical guidance for this age group:

> [S2-02] "You have got a changing population in a changing environment, and that is then difficult to produce anything useful from which to advise or inform the third party, the creative team".

Additionally, interview [S2-24] said,

> [S2-24] "Lots of people believe that and adults think I have been there and I have children, so I know how they are thinking and what they are doing. Much new research has come out to talk about the things that we did not know before, and children have enormous capacities to learn and to explore".

An expert in child development, Interviewee [S2-28] commented,

> [S2-28] "I think that younger than that [11 years], you know, their maturity and their ability to give useful feedback, on a monthly basis, is a little bit challenged".

5.4.8.3 Expert involvement

In the interviews, designers claimed that other stakeholders were involved in the development process of creating products for children; for example, parents and carers, psychologists and other groups were often included in design and evaluation stages. In fact, various experts are involved in the process of designing for children. As regards the first theme (i.e. design process), in the development of a toolkit it was essential to understand designers' preferences and attitudes towards developing guidelines for design for young children's safety.

- The HF/E and design methods are part of a larger design supply-chain in which HF/E competes alongside other product development priorities (e.g., marketing and branding).
- Many of the designers prioritised human-centred data, as opposed to other such conflicting priorities.

5.4.9 Audience (05)

5.4.9.1 Characteristics of young children

Also emerging from the interviews is the need to consider young children's behavioural attributes, cognitive capabilities, and limitations. Ergonomics experts commonly discussed the need to understand the user, the task, and the environment. This point was not as often mentioned by designers. Practitioners and experts commonly discussed questions that should be considered by the design team:

> [S02-03] "For designers? I think it is important for a designer to understand the products and the audience of the products. Who is the audience? If the audience is children, then the designer must understand children's cognitive development, their social, emotional needs, their physical development, and what kind of factors are conducive to learning".

Another human-factors scholar, with experience in product and risk communications, commented on the need to understand the physical constraints of the user group:

> [S2-02] "What are the physical constraints that are defined by my user group? Who are my user group, what do they want to do, and where do they want to do it?"

Results from the interviews identified that the tools should be developed, with the various groups involved and various specialisms in mind. They need to be tools that can be collaborative, easily adapted to fit with working practice, and understood by a variety of stakeholders.

5.4.9.2 Stakeholders perception of safety and design for young children

Stakeholders perception varied depending on their role. Safety experts had an in- depth understanding of children's perceptions of risk and how to consider it within the process of design and evaluation. They had a clear idea that safety needs to be considered at the start of the design process and that it is necessary to carry out research prior to design stages. Designers often gained knowledge through their everyday design practice and often found that they had limited or no time available to carry out prior research. Thus,

designers relied heavily upon their individual experience of design rather than looking for information at the beginning stages of the process, would often come back at a later stage in the design as an afterthought. Some designers described the later stages of the product development being 'out of their hands' as they were often briefed by marketing to come up with a concept and once the conceptual drawings were complete the drawing was handed over to product development where they had no input into the design at the later stages.

5.4.9.3 Role conflicts

There are differences in groups and role conflicts exist where other priorities take over from longer periods of product development which ensures the design and evaluation stages have been adequately carried out. As discussed, development priorities such as marketing and branding often conflict with testing and evaluation, where companies are hoping to decrease time from initial conceptual design to production. Understanding which sectors specific design standards belong to are often difficult to navigate. Human-factors professionals are often used when writing design guidance and this is often not in a visual, light weight accessible format. Engineering and design experts are mainly concerned with integrating engineering and design processes, however child safety experts and development experts, emphasise the importance of understanding knowledge related to child characteristics, including capabilities and limitations. Further conflicts exist where designers are often not aware of the requirements of manufacturers and vice versa.

5.4.10 Role of environment (06)

The groups mentioned the role of the environment in risk assessment, using guidance and accident data, and other test methods discussed by groups. It was established that foreseeable use and misuse of products were necessary for designers to consider:

> [S2-22] "…they have to be very careful, and they would put designs out to test houses to ensure the safety, but of course, as a designer, you have got to foresee all of that and design products that can't do any harm".
>
> [S2-27] "I think your most significant challenge, as you have probably already realised, is the fact that there is little or no up-to-date, systematically collected

accident data in Europe that provides the level of detail that a product designer needs. There is US data on the NEISS (National Electronic Injury Surveillance System). Most of the accident data used in Europe is likely to relate to specific incidents, sometimes deaths that are reported in the media or through complaints. It may be the case that events that result in serious injury are not the same as those that lead to a minor injury, which is, of course, far more numerous. (There are about 20 A&E attendances for each hospital admission)".

[S2-03] "That is right indeed for toys, and those experts will know more than me, but the standard is regularly updated, and sometimes it is weird, but the requirements come out before the method for testing and things like that. So, if a company cannot work out how to get something tested, it is difficult for them to comply with the standard which says it can only be an *x* size or whatever, so those aspects can be quite tricky".

5.4.10.1 Injury data

Injury data was seen as an important aspect of designing safer products and considering risk communication. A paediatric expert discussed his views on the financial limitations of previous systems, that it was expensive to collect data, and he also discussed the shortcomings of attempting to set up similar systems, which did not have a focus on injury prevention, rather it as focused more on the legal aspects:

[S2-30/27/16] "If the Department of Health had collected the data, I think that that would have made a difference, but because the system was run by the Department of Industry they could not see what was in it for them, it just costs them money, so they abandoned it. Ironically, at a time other European Union countries were using HASS and LASS (Home and Leisure Accident Surveillance System) as a model to set up similar systems of their own, although on the continent it was a bit wired because the focus there was very much on a legal point of view. It was to do with protecting people or protecting governments or corporations from litigation".

The importance of injury statistics and their value in injury prevention was acknowledged by the majority those involved in child safety, in particular 2 of the paediatric experts interviewed. They discussed that there was a gap in knowledge as the data is no longer collected in this way, however the previously collected data is still

available online which gives an in-depth understanding of 'how and why home and leisure accidents occurred' paediatric experts discussed them as a valuable source so that interventions are able to be put into place to prevent future events:

> [S2-30/27/16] "…all I know is that we found those statistics very useful at the time, and nothing has replaced them since".

As with much of the research on children and injury prevention and risk communications, there is little empirical evidence of what contributes to reduction in injury or injury risk as described:

> [S2-30/27/16] "Unfortunately, we could not sustain it because the same issue arose where were we going to get the funds to keep running if the hospital was happy to do it on a pilot basis, but they expected someone else to take over, like the health board. That never happened and part of the reasons for that was it is difficult to demonstrate that injury surveillance systems of that kind contribute directly to the reduction in injury or the reduction in injury risk. It is tough to do, that you would have to run trials experiment, you know, by having an injury surveillance system in one place and not in another and then compare the two. That has never been done, or it may have been attempted, but methodologically it is so fraught that people would argue over it".

Other conflicting views arose from an academic and paediatric expert with several years' experience of child injury prevention who was sceptical of the value of the data collected:

> [S2-30/27/16] "Myself, I spent a large part of my career focusing and analysing and collecting data, and on the one hand that's very interesting, and it leads to lots of publications which as an academic I always needed of course; whether it prevented a single injury I am a bit more dubious about. I have to say, and that might sound a bit odd, but I think we have to be a bit sceptical about it after all. It does not really matter where you run these systems, they tend to throw up the same information over and over again".

5.4.11 User data

The main outcomes were that designers are missing different types of development information, user capabilities, and contextual data. The resources are based more on physical rather than cognitive or emotional data, and caregiver interaction was rarely

considered in the design process. The following themes were commonly discussed when asked about methods and tools:

- Type of product
- Testing with children
- Age factors
- Weight and height

> [S2-01] "Based on the population group, we do a dimensional analysis if it will fit to see, whatever the purpose of it is, if it is suitable for that age group, you know—the weight, height…."

Participants commented that they use safety standards during the development and evaluation phase.

5.4.12 When this information is of use

One participant indicated that the tools would be useful to use when considering types of information for communicating use and any risks associated with use of medical devices, as it is crucial for the interface to fit with young children's needs and expectations. Additional information is often required that can be usefully provided to the child to aid comprehension of how to use the medical device correctly, and thus to use it safely.

5.4.13 Stakeholder cooperation (07)

5.4.13.1 Differences between groups

Differences were found among participants between groups and within specific disciplines, including academic, disciplinary, and cultural differences. Considering other fields, interviewees sometimes expressed a conflict of principles, for example, individual differences and attitudes or conflicting interests. The main finding in the research is that designers do not necessarily fully understand the role of human factors.

5.4.13.2 Stakeholder cooperation

Most stakeholders involved in the areas of child health and child development discussed the existing barriers to injury prevention and highlighted the complexity of differences in the various groups involved. One participant, with over 10 years' experience, discussed that the primary design intent of the designer or the design organisation needs to be established before one can choose what one thinks is appropriate to what the stakeholders are trying to achieve. Various stakeholders have different views that are not always very well aligned with one another. One paediatric expert explained historical issues and perceptions of safety and child-injury research:

> [S2-30] "In case people argued that there is an element of negligence in lack of product safety in causing injuries so there the rationale was a bit different and it may have been in the UK that there was a different rationale, I cannot really remember".

In general, participants with good knowledge of childhood injuries, such as paediatric experts, provided a good practical experience and a knowledge-based foundation for the development of a toolkit, with their support and expertise of child safety, including the CAPT and the RoSPA:

> [S2-07] "A different combination of knowledge relevant to what people are trying to achieve in their design…. if someone were designing a toy to help children identify different colours...from a human factor point of view, you would instantly research both sensory and cognitive factors".

5.4.13.3 Collaboration level, users, and community-based stakeholders

Community-based campaigns were discussed in the context of road safety:

> [S2-30] "That is one of the dilemmas of this field you focus on these relatively rare events, or you focus on the bigger picture, such as road safety, where we do not need new data; you probably need new forms of intervention that are then evaluated by a rigorous academic study".

5.4.14 Safety

Commonly, specific safety issues were discussed across domains. Safety concerns included the fact that new products are appearing too quickly in the market, which means that standards are not being developed fast enough, in line with new products appearing on the market:

> [S2-16] "One other issue that you may like to consider including in your research is that standards, and probably product design changes are never rigorously evaluated regarding changes in injuries".
>
> [S2-30] "…so a new product comes along it exposes children to risk, cases are identified and written up, there is a flurry of activity, and then people move onto another safety issue, and it disappears. Against a background of the kinds of things we know about the overall patterns of childhood injuries, spikes appear every so often of new products and new injuries for some reason affecting relatively small numbers of children".
>
> [S2-30] "The other issue is of course that when you design toys, the production volumes are enormous; you're making hundreds of thousands, possibly millions, so huge volumes mean that very, very, large numbers of different things happen to your product".

5.4.15 Support for the designer

The future implementation of tools and information resources as a means of perusing safety for young children was also discussed. Implementation was found to be of importance across sectors, including HF/E, industrial designers, design engineers, marketing experts, manufacturers, trading standards, customs and importers, and distributors. The author of the book *Design for Children* points to the importance of HF/E input in designing for children and the difficulties in accessing this information.

5.4.16 Summary of key findings

Current sources used by design practitioners include property data, standards, and legislation. Most sources of information (e.g., anthropometric) collected on children are

proprietary data owned by the manufacturing company concerned. Obtaining this data is difficult and costly, and it is often inaccessible, piecemeal, or hard to follow. The legislation covers the safety of toys, and other product changes concerning the age of the child and contexts depend largely upon the type of product and environment.

Additional themes emerged from the interviews, particularly on the needs of designers for the tools to fit with good practice and the need for more flexible tools, due to the diverse groups involved in the process.

5.4.17 Knowledge needs of design practitioners and other groups

The goal of the support is to help constrain the design solution space and give the designers guidance about how to accommodate young children within the area of risk communication. In summary, this chapter addresses the following three questions:

- What types of information do designers need to support safe design for young children (5–11 years)?
- Is the framework (proposed in Chapter 4) useful?
  What is needed and what form will it have to take to be usable?

The output from the chapter is to develop a set of requirements for a toolkit based on the needs of the designers.

Table 5.3 Forms of support for the designer: Design guidance and constraints

Designer Needs	Toolkit	Constraints
An easy-to-understand and efficient resource, i.e. one available for use quickly in an accessible format	- Fit tools with working practice. - Use an accessible format that is easy to understand. - Use infographics to explain complex information quickly. - Provide a digital solution, i.e. a website. - Define guidelines.	- Authorship - Proprietary data

Designer Needs	Toolkit	Constraints
	- Offer examples of good practice.	
Knowledge of user group (child-users), including limitations and aspirations, to gain information on child-users that becomes developmentally situated and contextually valid	- Define developmental stages. - Develop child-based personas.	- Policy or ethical issues, which make it difficult for children to be fully involved in the design process
Methods used for working with groups of young children and extracting information from children	- Describe participatory techniques and methods, which are useful for extracting information from and working with young children. - Outline the ethical considerations for working with children.	- Gathering useful information for innovation can be more difficult for children than for adults - One issue is the interchangeability of a design problem - Children find it difficult to conceptualise ideas that are abstract in nature
Factors that influence product use or handling by children in general	- Define product characteristics that appeal to children.	- Where the responsibility leaves the designer or manufacturer and moves to the carer or user themselves i.e. modification or misuse of a product despite the original intent of the manufacturer
Consideration of users' tasks in line with capabilities, recognising that changing contexts are dependent upon the type of product and environment	- Develop a taxonomy of children's products requiring different skills, such as cognitive, balance, physical, vision, sound, environment.	- Parental expectations of their children's safety, often over or underestimate child's ability at different stages of development
Implementation at national, regional and local level across sectors	- Implement resources covering required skills knowledgebase to fill the gaps. - Implement a framework design lifecycle.	- Different problems for different areas with different products or environments - Manufacturers often not UK-based
Key safety, design, packaging and other issues to be considered in relation to products	- Define safety requirements in line with accidents.	- Differences between groups - Design community is creatively motivated and does not often like

Designer Needs	Toolkit	Constraints
		constraints, whereas human-factors specialists constrain designers
Implications for designers and manufacturers	- Outline current standards and legislation that are relevant.	- Some products intended for use by children, but used by younger age groups than originally intended, which might lack proper standards reflecting the age of current users
Child development and behaviour	- Determine children's body size and anthropometric data, motor development, physiological development, and cognitive development.	- Individual differences in gender, culture, attitudes, and beliefs
Hazards relevant for children, e.g. gaps and openings, sharp edges and points, electrical appliances, etc.	- Define hazards relevant for the age range.	- Certain demographic groups seem to be out of reach of certain levels of information with various things including products safety

5.5 Current knowledge (professional perspectives)

This section discusses expert opinions regarding the tools, resources, and models used in practice, and it also describes the activities in which H/FE information for design is used.

Notably few resources were used when designing for children. A vast knowledge gap exists regarding child-development resources and their use in design. Various reasons were given for this lack of knowledge, including time constraints, market competition, a lack of funds, and the complexity of navigating standards. One interviewee [S2-12] working at a well-known testing house had multiple years of experience with testing products. The participant suggested that although standards exist and represent good practice, they must be intelligently employed by the user during the design phase, which does not always happen. Standards are not static, as new versions appear and are regularly updated. The safety experts noted that standards are often not a legal requirement. Another limitation they mentioned is that merely complying with a

standard does not automatically create a safe product, as such standards must be used intelligently.

> [S2-12] 'Another source of data analysis is the product recall data, where the product is failing to meet compliance requirements, but other times, the product will have already met all existing and applicable compliance requirements yet still present an unreasonable risk of injury to the consumer. We also monitor that and utilise this information when we are trying to assess the hazards associated with the product.'

Risk management models were used in some instances. One example is the model cited by participant [S2-11]. This individual shared that model with engineering students while instructing them regarding how to redesign a product to make it safe for children. The view of this safety expert was that it is essential for design students to be educated on how to incorporate safety from the beginning of the design process, rather than waiting for a costly mistake. The steps in the model illustrated in Figure 5.2 indicate that once a project has been conceived and initial funding secured, the next step is to gather hazard information before moving to the development and testing stages.

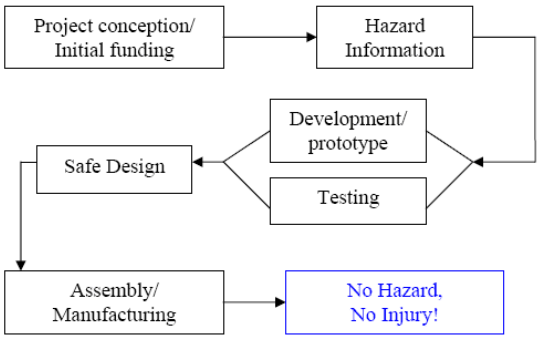


Figure 5.2 Risk assessment model. From: The Hazard Information Foundation, 2008
http://www.elcosh.org/document/1866/d000825/Construction%20Design%20Safety%20in%20the%20Marketplace.html?show_text=1

The model provides an example of a process that designers can utilise to incorporate safety during the design phrase. Integrating safety into the design process from the start via the use of design resources can potentially reduce or eliminate injuries, and doing so also limits the need to navigate complex compliance standards and to incur other costs not visible to the marketplace.

Visualisation tools were not used by the designers; however, they were employed by a number of the safety experts. Testing houses were more likely to use quantitative analysis and analytical tools than other types of entities. Most designers relied on various prototyping approaches, but the exact method typically depended on time and budget.

Some stakeholders discussed possible barriers to the use of tools or information resources when designing for child safety. For example, differences in terminology were noted across the groups. The H/F experts frequently discussed task analysis, while many of the designers were not familiar with that term. Nonetheless, some designers did engage in similar activities:

> [S2-01] 'Yes, the kind of task analysis we use is called "fitness for purpose"— what is the purpose of what they are trying to achieve; how they are trying to achieve it? Yes, that is the crucial part of how we assess it or when we design it; we just write those and then aim to fulfil that.'

The HF/ergonomics investigators and industrial stakeholders had differing levels of experience in designing and evaluating products for children. For example, the child safety experts were particularly sensitive to the varying developmental stages of children:

> [S2-16] 'Interventions must be developed to be sensitive to the stage of mental development of the child.'

Another barrier to the uptake of standards is the cost to the company of buying standards and replacing them with new versions as needed. Companies were not always aware of when standards changed and often did not possess not up-to-date guidance. Time is often spent searching for relevant sources.

5.5.1 Usability

Participants consistently reported that the current safety resources are lacking in terms of usability. These resources were not especially useful for them in practice, and in fact, one participant commented that 'you cannot easily use' the currently available materials.

> [S2-03] 'There are standards for safety, of course, but the types of materials you cannot use—both British and European standards that you can look at, but that are relatively vague.'

Certain groups lacked knowledge as to where to find information:

> [S2-01] 'I know where many of these sources come from, but most manufacturers, of course, do not even know these things exist or do not even look into it; it is rare.'

5.5.2 Experienced in design for children (5–11 years)

The interviewees had varied levels of experience in designing for children and child safety, and the majority of the participants were experts in their fields. Their companies designed products such as pushchairs, baby bottles, playgrounds, play spaces, and toys. The ergonomists had a clear view of testing and evaluation requirements.

5.6 Lack of up-to-date knowledge

With respect to human factors, some of the professionals, designers, and researchers had not been involved in designing for children for a significant period of time. Nevertheless, they provided useful knowledge on the resources available to them during the design process, which gave the researcher deeper insight into how resources had developed in the interim. The researcher identified those resources that practitioners are still using, despite them being outdated.

5.6.1 Theoretical models (e.g., design process models and knowledge transfer models)

Designers discussed the use of various models and processes in designing products for children. However, these models were not specifically tailored to children's needs. The designers found these frameworks useful as a general gauge of safety. However, they reported that the models' main drawback is a lack of data on human capabilities and limitations. Such information would permit them to tailor designs to a child's age and stage of development. Some mentioned strategic design requirements and the need to align the design with a business model. Most designers implemented processes with which they were familiar and tended not to use theoretical models in the design process.

5.6.2 Emerging issues

Conflicts further arise when differences emerge between stakeholders in the production process, as many individuals are involved in the supply chain and design of a product, system, or service. Although standards are high in the UK, imported goods are high volume and often the decision whether the product conforms to the relevant safety

requirements lies with the manufacturer's or importer's declaration. Problems exist because products are not always rigorously assessed in line with changing standards and the type of company; in addition, organisations often vary in their approaches. Some carry out product testing in-house, while smaller companies lack sufficient resources to do so. Additionally, pressures arise from marketing specialists. Industrial designers are often briefed by these marketing experts and are not typically involved in the initial user research (e.g., focus groups). In many cases, manufacturers are not based in the UK, resulting in different components being sourced from diverse locations. This variation makes it harder to detect variations in component quality and thus generates problems in terms of tracking sources. To that end, UK trading standards have expressed the need for the monitoring and evaluation of goods at the national level. At present, this takes place at the local level, and findings are not always recorded in a central database to support the subsequent formation of guidelines. Larger companies whose products are already generally compliant with standards may adopt guidelines, but again, individual companies do not follow the same approach. Certain companies choose not to comply with legislation despite having the resources to do so; stores whose pricing policies are their primary marketing tool are guilty of this practice. Products that meet safety standards are not always intrinsically safe; conversely, products that do not meet standards are not always unsafe. Instead, products should be considered within a broader context, including use, misuse, and the intended user's developmental stage. Moreover, misuse can render a product unsafe; for instance, not following instructions or modifying the design can alter a product's level of safety.

5.7 Problems

Ergonomists and designers face barriers when testing whether a product is safe for children:

> [S2-07] 'I think ethically, concerning children in design and evaluation processes, you would run up against some issues. I think the first step always was to do an expert appraisal because ethically, what you cannot do is take something that is unsafe and give it to children to play with to see whether they injure themselves.'

> [S2-07] 'To get their product to market, they needed something from an independent body, which ISO ergonomics and ESRI (Ergonomics and Safety Research Institute) were…'

[S2-07] 'From what I can recall, you can never say that something is safe, but you can say it does not pose any safety hazards; resulting from that, it therefore can be deemed as safe.'

5.7.1 Comments on the framework

Comments were made by the participants regarding how the risk management framework, that was developed by the researcher, the most recent version presented in Chapter 4, could be made more useful for them in practice. Communicating to designers how tools fit with the design process is essential:

[S2-07] 'So, I think from a design point of view, it is probably communicating whereabouts in the design process these different aspects come in.'

Outlining how the human factor of knowledge can be effectively applied would help designers, as they sometimes lack an understanding of certain aspects with which they are not familiar or experienced:

[S2-07] 'The principles of how to display data to designers are to make it visual, make it relevant, don't leave it like some human-factors knowledge does, that say, "Well, here's a body of knowledge." I think designers need to understand how this knowledge is applied.'

Barriers to using tools within everyday practice were discussed in relation to the design process:

[S2-07] 'Mapping it into the design process and the coordination between the established needs and the limitations of the design budget—and then there are the limitations imposed by legislation.'

5.7.2 Presenting information to designers

The interviewees' feedback mainly centred around the fact that tools need to be flexible and adaptable to designers' needs regarding the level of information. The participants noted that a toolkit's format and overall presentation could play a role in simplifying complex design guidance:

[S2-07] '…something quite high level then, something they can click through to give them some more information and guidance. I mean, some might not even know what a

task analysis or cognitive ability is, so I think it could be displayed more transparently. I guess I would chunk it up, use colour coding, and then supplement it with the necessary examples.'

5.7.3 Design process: Tools and methods used in design

Many indicated that design is not a linear process, but an iterative one. The participants named a variety of key factors that typically affect the outputs of a risk-communication design. The tools and resources used during the design phase are highly dependent on time and funding and what they are able to access. In many cases, the design brief, the research process, and ultimately, the design specification begin to shape the design itself. When thinking about the design process, the interviewees clearly felt that existing guidelines or standards should be referenced at the relevant stages of the process:

> [S2-08] 'At some point, you will have to refer to some existing guidelines. These are used to make the designer more aware of the requirements. It could be health and safety, market requirements; it could be legislation…during development, you usually have different specialists on board.'

A design project often entails a problem-solving approach or a more in-depth investigation of the user. Concept prototypes are made.

5.7.4 Caregiver interaction

An emerging theme during the interviews hinged on the value of including the caregiver in the design process. A significant number of designers were unable to involve children or caregivers in design and evaluation due to a lack of time or resources. Designers valued the idea of involving caregivers in the design and evaluation process:

> [S2-07] '…you need a caregiver to be with the designer because even if a designer has children, it is his or her worldview.'

> [S2-05] 'Children have different types of personalities and ranges of capabilities. You know, not every child is the same, so you have not only the caregiver but also the designer to observe the child.'

> [S2-11] 'You must put yourself into the shoes of the user, and the product would be for the child as well as the mother.'

[S2-16] 'I think the other thing is to think about adult behaviour with children in that environment, you know, what's going to make something safer or more hazardous for children if children and adults are mixing.'

5.7.5 When information is needed in the design process

Over 60% of the participants commented that information is required right at the beginning of the design process. However, they held differing views on how that information might be incorporated. For example, one participant mentioned using it more informally as a feedback tool within a focus group:

[S2-08] 'When the brief is just about to go out, then you can have a sense of the market, you can have a sense of the user needs, you can have a sense also of what are the current problems they face. So, it is a very informal type of focus group activity, and the tool would be a focus group tool, and the feedback would be very informal.'

5.7.6 Requirements for tools

In general, the experts thought that designers lacked resources focusing on children's capabilities, limitations, and behavioural attributes. One academic who had previously worked as a designer made the following comment:

[S2-07] 'I think if you design a tool for children, it needs to have different aspects. I think many aspects about child psychology, child behaviour, or the softer side of growing up— they're not widely available.'

The interviewees noted concerns regarding perceptions of child safety and the balance between risk and play:

[S2-05] 'We are more concerned about child safety from a human adult point of view and not really from the child's view because sometimes you want the child to be playful enough without being inhibited. Again, you need to have some control mechanism…if you want the child to be creative, he should be able to use the product within certain boundaries…when it becomes too dangerous, then it needs to be safer.'

5.7.6.1 Design and evaluation

The majority of the design participants reported that they were unable to involve end users and experts (e.g., professionals in the fields of child psychology or child development) in the design and evaluation process. That said, they indicated that such expert knowledge would result in better outcomes.

5.8 Discussion

The interviewees suggested that experiences and environmental, contextual, physical, and cognitive factors play a role in safer design. Their feedback also provided a more explicit indication as to how tools might align with design activities and how warning theory might translate into everyday practice. Many designers stated that designs for safety tended to be based on experience or intuition; however, the participants also highlighted that experimental data on children's abilities would be a positive addition. Furthermore, very little information exists on what specific factors affect how a child interacts with warning information. A further challenge related to developing guidelines for children is that they are more likely than adults to use products and interact with their surroundings in unstructured ways, a factor that might lead to further hazards. It is therefore essential to develop new methods for evaluating interactions and crafting guidelines based on the specific context in which the risk information will be used. That environment may frequently involve movement, friends, noise, and multiple distractions. Rogers (2004) reported that in practice, designers do not typically use prescriptive models or theories. Instead, they rely on a specific range of methods or tools with which they are familiar and experienced.

Research has suggested that one way to enhance the quality of a warning or other safety-related information is user testing with real children from the envisioned user group (Waterson and Monk, 2014; Boto et al., 2015). The role of children within risk-communication design processes has received an increasing amount of research attention (Druin, 2002; Frauenberger et al., 2012). While the interviews supported that conclusion, both the literature and the interviewees implied that involving children in this process is not always easy to achieve. There were no clear processes that designers followed in terms of including children in the design process in a structured and beneficial way.

5.8.1 Multifaceted and multifunctional tools

The participants expressed a need for a multifunctional tool. In fact, almost 90% of the experts stated that tools needed at least a minimum degree of flexibility. For example, one design expert referred to different types of tools and information depending on the complexity of the product:

> [S2-06] 'It depends on the product really; it depends on the scenario. Different levels of information are needed depending on these. Much of the information covers physical aspects, but what about sensory and cognitive factors?'

Those participants with extensive experience designing electronic products indicated that designing a more complicated product often involves more steps. In contrast, a more straightforward product (e.g., a cutlery set for infants) entails a much more condensed design process.

The design process does not involve only one step; rather, many tools can be used. Design practitioners are often faced with various difficulties when designing for a specific population (e.g., children or the elderly). Expert interviews served to identify issues related to incorporating HF/E information and visual resources into the design process. Initial coding revealed several emergent themes, and further analysis of the interviews identified the knowledge needs of design professionals and other experts. Critical issues related to toolset implementation included the lack of an accessible format, differences among groups involved in promoting safety, the current lack of coordination on the part of those groups, and various national and regional factors. Due to the very nature of their profession, designers have an enhanced understanding of visual resources; thus, they might approach data differently than those in other professions (McGinley et al., 2011, p.189).

This study evaluated the complexity of designing visual safety information for young children. The study has discussed and analysed this issue in terms of the initial coding structure and the scope of the risk-communication environment. Designing visual information for children is not well accounted for the literature has not explored this topic in great detail and designers do not carefully document the steps they follow; therefore, applying a systems approach provides a more holistic—and hence, a more comprehensive—view. In fact, recent studies have illustrated the potential of applying systems thinking (McLaughlin and Mayhorn., 2014). Indeed, this study has confirmed the utility of that approach. The next section continues by further examining the social and

environmental impacts (at all stages of the design lifecycle) of visual safety information designed for young children. Further testing and refinement of the risk management framework developed by the researcher has contributed to the future development of a toolkit. Implementation of the H/FE, design and evaluation methods from toolkit is essential across a range of professions, including marketing experts, industrial designers, design engineers, manufacturers, customs officials and importers, distributors, UK Trading Standards experts, and product testing professionals. This study's outcomes suggest that a more comprehensive approach to designing products, systems, and services for children of different ages should be adopted. The UK Trading Standards Organisation have pointed to concerns related to monitoring and evaluating goods at the local level, rather than at the national level. One way to provide time-efficient toolkit in a more readily accessible format is via a website offering online resources. Another is to provide H/FE design and evaluation method cards as a tool to distribute methods used to inspire more appropriately targeted risk communication design, overall the preference is in providing more visual toolkits consisting of infographics, and animations.

The interviews highlighted the importance of considering the user and the task environment. Practitioners and experts commonly reported that the design requirements for young children were like those for adults and indicated that the user, task, and environment should also be taken into account. Five human factors and ergonomics experts with experience designing for children listed questions that design teams should ask when thinking about designing for a specific user group. One ergonomics expert claimed that the following questions should be asked: 'What are the physical constraints that are defined by my user group? Who is my user group, what does it want to do, and where does it want to do it?'

An interview with the CAPT identified similar reasons for unsafe products including that described above, the differences among groups involved in promoting safety, the current lack of coordination on the part of those groups, and various national and regional factors. The primary outcome of this research was the definition of requirements for a toolkit intended to support designers and other experts working with young children aged 7–11 years. The data captured by this study helped to define the toolkit specifications. Gaps related to designers' information needs and existing tools were identified. Resources may need to be available in different languages or in graphic format for individuals with poor literacy skills. This study's findings reveal a lack of knowledge and evidence-based guidance regarding designing visual safety information for products

targeting young children of varying developmental stages. Thus, there is a need to further develop and distribute evidence-based supporting materials for designers; these materials should feature more accessible and usable formats. In addition, HFE should be implemented at the outset of the design process. The specific safety needs of young children and their caregivers are often not well understood.

Designers frequently lack resources or information at various key stages of the design process. In addition, standards and product design changes are generally not rigorously evaluated in terms of their effect on the injury rate. Products must fit the developmental stage of the child. Some designers attempt to develop products targeting different levels of coordination with inevitable negative results. The European Commission's Rapid Alert System for Non-Food Consumer Products (RAPEX) has indicated that in 2013, toys represented the product category with the second highest frequency of severe risk notifications. Childcare articles and children's equipment ranked fourth (European Commission, 2013). Considering the entire environment and the design lifecycle, a systems approach to safety goes beyond ensuring that a product meets relevant standards. As the UK Trading Standards put it, 'just because a product meets the relevant standards, it does not mean that product intrinsically safe.' Consumer education may be one way to reduce these knowledge gaps and to ensure that products are not modified within the user environment to create further hazards. Interventions across social groups could take the form of information and guidance. For example, current HFE guidelines could be included in a 'visual aid' for designers, closing the gap between both groups. Consumer education represents another potential intervention, as there seems to be a lack of awareness surrounding product safety and the dangers of misusing products. The findings highlighted the key limitations of looking at a sub-group of young children, as resource solutions should not adopt a 'one-size-fits-all' approach. Rather, tools should to capable of addressing individual children's needs and environments. Relevant and up-to-date knowledge is important, as is a theoretical basis; prior studies on sub-groups have been discussed, along with how this study contributes to the literature.

5.9 Discussion and feedback on the model

The proposed framework incorporates several elements, including prior research, a theoretical knowledge base (including models and principles), and examples, design and evaluation guidance, and characteristics of visual safety information designs. The

interviewees discussed design and evaluation activities related to safety, and a number of practitioners provided examples of methods that they employ to evaluate product safety.

5.9.1 The model and its components

Overall, the interviewees considered the model's components a useful design process reference as regards design and safety aspects for children of varying age groups. Many of the model's components were used within the stages of the design process. Several designers did not mention considering caregivers during the early stages of the design process in their day-to-day practice. However, the caregiver's role was significant during the evaluation stages. The designers frequently cited the need for more visual representations of the model's components to bring the information to life (e.g., presenting user insights as full pictorial stories).

5.9.2 Capabilities and limitations

In general, the designers understood the importance of considering young children's unique needs; however, they noted difficulties in locating and adapting information and tools related to human factors.

Table 5.4 Obstacles to using guidelines related to human factors.

Obstacles related to availability	**Obstacles related to alignment with current work practices**
Knowledge not available	Takes too long
Not available when needed	Not beneficial in terms of costs
Information not directly relevant	Opposition from others
Time-consuming and expensive	Would not fit design philosophy
	Other, for example, complex technical design detailing of either all or specific parts of a design.

There is a link to work on human-factors integration (HFI); much of the research in that field has suggested that one barrier to the use of HF/E methods is that they are time-consuming and expensive (Waterson, P.E. & Kolose, S, 2010).

5.9.3 User research

The purpose of user research is to collect data about the characteristics, needs, capabilities, and preferences of the target user population. The following list are topics on which user research considers and that are relevant to risk communication design:

- The critical differences between people (e.g., people may have disabilities, different levels of experience, or dissimilar cultural backgrounds)
- The tasks performed by users and the different environments in which they perform them

The choice of a technique depends on many factors, including the product characteristics (e.g.., originality, criticality of safety features, and complexity). Expert and novice practitioners with and without experience designing for children reviewed the second version of the framework to assess its incorporation of essential issues related to designing risk communications and its perceived usefulness for inexperienced practitioners. Overall, they perceived the framework as reflecting a more structured approach to considering the different aspects of the design process. The participants viewed it as a dynamic and flexible tool that researchers could adapt to a range of design situations. However, they suggested that it could be simplified or presented in a more visual format for designers. The individual interviews tended to stress the need to move away from outdated, complicated, difficult-to-navigate, and conventional representations when designing for children. The participants frequently cited their desire to bring human information to life by presenting user insights as full stories, offering improved visual materials, and moving beyond the use of data alone to understand the needs and abilities of young children. Thus, the task of developing design tools extends far beyond those tools themselves. The interviewees also mentioned the role of existing business models and processes. Furthermore, user considerations have a significant influence on how tools are incorporated into the design process and employed in practice. Using, sharing, and managing knowledge are all complex tasks, and tools may provide an advantage by offering a means of navigating complex standards and a concise overview of relevant information. The challenge is to provide information in an easily accessible, updatable, and maintainable format aligned with current standards and best practices. The review also identified challenges linked to integrating the environment, children's behaviour, and person-fit considerations into existing design paradigms, and warning theory offers an approach

to more closely integrating these elements into the design process. Both warning theory and professional design must undergo a paradigm shift in terms of how teams consider the environment, behavioural interactions, development stages, and communication over the design lifecycle. The 'receiver' is the person whom the message is targeted at, in this case children within a certain age-group. 'Receiver moderators' are moderating variables that may affect children's processing stages as information is delivered to the receiver, the child. The processing of a warning continues through several stages as previously defined in the C-HIP model presented in Section 2.5.1. Receiver moderators that may interact with evaluation are listed in Table 5.5.

Table 5.5 Moderators

Moderators
Age factors
Interactions with caregivers, peers, and responsible adults
Environmental factors
Gender
Cultural factors

Table 5.6 Receiver analysis

Receiver Analysis: Capabilities and Limitations
Cognitive
Physical
Emotional
Other considerations

Other factors to consider when developing risk communications include but are not limited to the following:

- The number of children encountering the product, construction, or service
- The age of the children encountering the product, construction, or service (age-related changes)
- Accessibility

- The risk of injury in case of an accident
- The costs and benefits of injury prevention
- The need for adult researchers to understand children's unique environments

5.9.4 Conclusions

- *What types of information do designers need to support safe design for young children (5–11 years)?*

- *Is the framework (proposed in Chapter 4) useful? What is needed, and what form will the risk management framework need to take to be usable?*

The fundamental purposes of the empirical study were to identify any problem areas concerning the uptake of tools and the proposed model and to shed light on where further research is needed. Both older adults and children are considered vulnerable groups (WHO, 2002), and so adapting the model for older adults to children's needs was a logical first step. The model was then further validated by designers. The relevant stakeholders provided feedback on the adapted McLaughlin and Mayhorn (2012) model, which was modified to cover the unique needs of young children. Their feedback was taken into consideration, and the model was further developed. Hence the risk management framework in Figure 5.3 was developed by the researcher to include more detail on methodological stages from previous research literature, with the model structure mapped onto the design process. More input of appropriate design, testing and evaluation methods and standards.

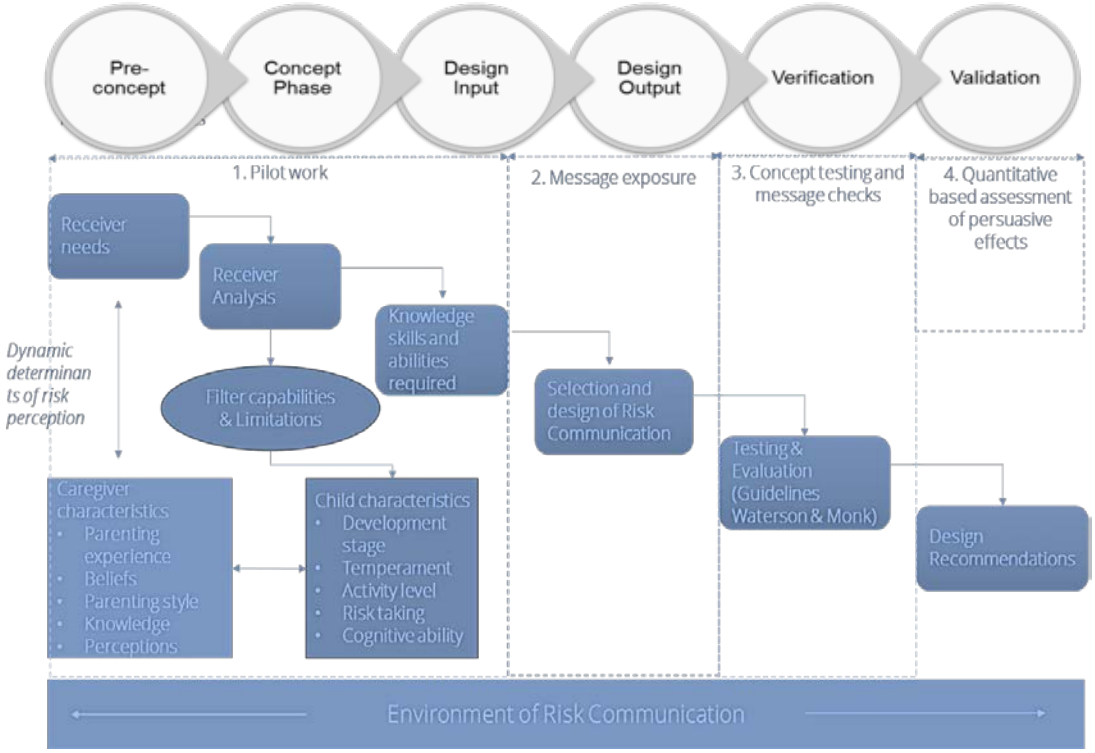


Figure 5.3 Risk management framework mapped onto the design process

The findings suggest that tools must not only support members of the design team, but also encourage collaboration among child-safety design experts. In terms of developing age-appropriate risk-communication materials and also in incorporating children's safety concerns into designs, relevant guidance encouraging a systematic and iterative approach centred on the needs of young children is key. An important consideration, as described by Waterson and Monk (2014), is that comprehension and interpretation are likely to be joint processes involving interactions with adults and caregivers; this factor must be taken into consideration when developing support tools. The next section offers suggestions regarding future work exploring prototyping tools and evaluation guidelines in terms of their practical utility.

5.9.5 Study limitations and future work

One limitation of this qualitative research involved the influence of the researcher on the study. In short, the findings were subject to the limitations inherent to qualitative data analysis, and primarily the subjectivity of qualitative interview data. A standardised analytical approach and the procedures outlined by Bryman (2004), Hignett and Wilson (2004), and Robson (2011) seek to minimise the subjectivity of interview data. Given

that this study utilised a convenience sample of 30 stakeholders, the findings faced certain limitations. For example, the results cannot be generalised to the larger stakeholder populations, as the sample was not representative of each stakeholder group. The individual stakeholder sub-samples were modest in size; however, data collection was carried out until saturation was obtained. Although questionnaires would have allowed for a more significant sample size, the depth of the responses would have been limited as compared to the insight gained through the interviews. The exploratory interview-based approach allowed the researcher to further probe specific issues as needed.

Despite the limitations imposed by the nature of the sample, this study's findings resulted in several useful insights regarding the design of risk-communication materials. Study 1 established that a multidisciplinary approach to context-aware risk communication is crucial. First, an understanding of children's cognitive abilities (e.g., linguistic and communication skills) is essential. Second, risk-communication research and theories create a foundation for tools capable of communicating contextual information to users and allow designers to develop age-appropriate risk-communication strategies.

A stronger infrastructure must be established in the hopes of decreasing the number of unintentional injuries to children. This study's findings must be further considered alongside emerging issues and designers' information needs with the goal of presenting these elements in a more economical and appealing format that supports knowledge transfer. The increasing complexity of the products and systems entering the market makes it necessary to prioritise safety aspects, particularly for vulnerable groups.

Problems arise when designers are unable to obtain direct input from the target user groups, in this instance, children of varying developmental stages. Designers frequently find themselves dependent on secondary sources when attempting to move beyond their own understandings and experiences. The knowledge needs of designers—and indeed, of other professionals engaged in designing visual safety information—need to be acted upon. Presenting individual professional groups with the right sources of information at the correct time would result in more efficient visual information designed for young children. Information sources or tools may be further developed to meet the broader design requirements of specific items, such as products intended for children or products used in close proximity to children but not necessarily meant for them (e.g., electrical products). The use of this tools in the design process by design teams and those in the

target community, for example manufacturers, would further validate the effectiveness of the theoretical framework and support its continuous development.

5.9.6 Designers' role

One company, [S2-05], featured a central design team that carried out all design and evaluation activities. In contrast, at the larger company involved in this study, professionals from different disciplines (e.g., engineers, designers, and human-factors experts) participated in developing the components of the brief. The human-factors expert [S2-23] working in the more extensive multidisciplinary UK-based company with multiple stakeholders had been brought in at a late stage of the medical device development process to provide advice on child safety concerning button cell batteries and the accompanying labelling and warning information. The engineer noted that the company had not initially found it necessary to consider child safety, as the product was not primarily intended for children. However, the fact that the product could potentially be used around children made this factor relevant. This example demonstrates that human factors and children are not always considered a priority during development stages, leading to potential issues at later points.

> [S2-26] 'The other thing is that safety information is vital. Safety information must be very clear...graphical instructions are very, very good; pictograms are good.'

Clear pictograms and few words are preferable when conveying information to the user.

[S2-26] 'Sometimes you can get things lost in translation with just paragraphs and paragraphs of words. Some of the best instruction manuals that you will see are quite short and have some great pictograms about what to do.'

The following Chapter, discusses the development of the tools in considering using pictograms, and user information relevant to designing risk communications, taking the findings from this chapter into account.

Chapter 6: Toolkit development

6.1 Introduction

The previous chapter presented the findings of the 30 semi-structured interviews and the six observations with groups involved in considering safety in designing for children. The chapter discussed the requirements for designers and introduced means of supporting designers, along with needs and constraints linked to using information in design. This chapter describes the steps involved in the development of these tools. The previous studies used to create prototypes of these tools, which took the form of child personas, are also discussed. Moreover, the chapter outlines the link to the above-mentioned findings and the relevance in terms of designing risk-communication materials applicable to children aged 5–11 years. To reduce the failure rate of risk-communication materials, the designer's conceptual model must match the end user's mental model, including his or her knowledge, skills, abilities, and prior experience.

6.2 Procedure

The literature review highlighted the need for further behavioural testing with the target age groups to assist designers in developing appropriate risk communications. Consequently, to design a suitable tool, the researcher first had to understand how multiple domain ontologies might be modified to enhance child safety. A deep understanding of children's needs and abilities, along with other key components, may result in less time spent designing and re-designing risk information. The prototype tools presented in this chapter were developed based on the findings of the resource review in Chapter 4 (Study 1) and the interviews in Chapter 3 (Study 2). The outputs from these two studies resulted in further development of the evidence-based risk management model. More specifically, input from ergonomists, standards developers, design practitioners, and safety experts was incorporated. The first section of this chapter details the methods employed to create chid-personas which represent the average child user's behaviour and risk perception, and the subsequent sections present outcomes regarding the nature of the personas and the card tools in the context of the proposed framework.

6.3 Method used for persona creation

As only few studies have centred on the use of personas to convey safety considerations, the data collection approach used to develop the tools included consolidating existing frameworks and collating the available resources, processes, methods, and models. Developing the personas via this process helped the researcher to create unbiased characters and contextual scenarios deriving from various ontologies. These elements were based on sources recommended by the CAPT, while additional data were obtained from the cognitive psychology literature. Interviews with industry experts further enhanced the framework and shed light on what they need to empathise with the end user. The designers generally did not consider themselves well-informed regarding the unique characteristics of children. At the same time, the interviewees recognised that as a user group, children are not readily available to participate in the design and evaluation process. Hence, the interviewees perceived personas as a useful tool for filling knowledge gaps. When developing and evaluating products and accompanying safety communications, designers require the knowledge gained from such personas about children's abilities and needs. Such information is critical in terms of decision making about potential risks and the types of content and formats that children can easily comprehend. Designers that do consider themselves well-informed regarding designing for children can use the personas to complement their existing knowledge or processes.

6.3.1 Development of an evidence-based support tool

This section also discusses the need to incorporate this information into the tool in a format relevant for designers. The designers' responses shed light on what they need to understand current and future ergonomics and psychological data on children. The use of persona tools in the design process creates opportunities to apply information on a wide variety of developmental stages. Theoretical categories emerged from the framework, concerning children' characteristics and risk communication design and the persona tools developed from this basis, aim to ensure that relevant academic content in relation to risk communication development is applied in practice.

6.3.1.1 End-user input

During the process of gathering the designers' requirements (see Chapter 5, i.e. Study 2), the participants frequently stated their desire to bring human information to life through, for instance, presenting user insights regarding various stages of child development via fuller stories. In addition, the designers reported a need for improved visual tools offering more than data alone when attempting to understand the needs and abilities of young children. Hence, the persona cards developed as part of this research are based on both theoretical and empirical research with designers and other key groups. Personas represent 'hypothetical archetypes of actual users through which designers can develop a precise description of [the] user and what he wishes to accomplish' (Cooper 2004). Designers are increasingly relying on personas due to their ability to provide insights regarding users (Antle, 2008). To meet children's needs, create safer designs, and reduce the injury rate, designers must adequately consider children's characteristics when developing risk-communication materials and interfaces targeted at them. Bødker (2002) has suggested that 'The use of personas has replaced traditional models because personas are a more refined solution to the memorable caricatures with extreme representations.' In other words, personas limit the number of assumptions that a designer must make regarding the user; their purpose is to provide a theoretical, empirical, and experiential framework for creating the most appropriate designs. Assumptions or conventions can be integrated into the persona, and that task is generally the purview of designers with limited experience with children or the particular design context. Other methods to compliment persona use should be considered, and Grudin and Pruitt (2002) have reported that as much quantitative and qualitative information about users as possible should be collected to enable the 'tool to evolve'. Personas could provide evidence-based support aids for the developers of safety and risk communications to have an early focus on the children for whom they are designing and prompt the designer to produce better, the types of interactions children find useful and accessible. Feedback on tools from Chapter 5, relevant to their future development is listed in Table 6.1.

Table 6.1 Requirements for the tools from interviewees

Tools
- Fit tools with working practice. - An accessible format that is easy to understand.

Tools
- Use of infographics to explain complex information quickly. - Provide a digital solution i.e. a website. - Define guidelines. - Examples of good practice.
- Define developmental Stages. - Develop child-based personas.
- Describe participatory techniques and methods, which are useful for extracting information from and working with young children. - Outline the Ethical considerations of working with children.
- Define child- appealing characteristics of products
- Taxonomy of children's products requiring different aspects such as Cognitive, Balance, Physical, Vision, Sound, Environment
- Implement resources covering required skills knowledgebase to fill the gaps. - Implement a framework /Design Lifecycle.
- Define safety requirements in line with accidents.
- Outline current standards and Legislation that are relevant.
- Children's body size and anthropometric data; Motor Development Physiological development Cognitive development.
- Define hazards relevant for the age range.

Working with children

- Describe participatory techniques and methods, which are useful for extracting information from and working with young children.
- Outline the Ethical considerations of working with children.

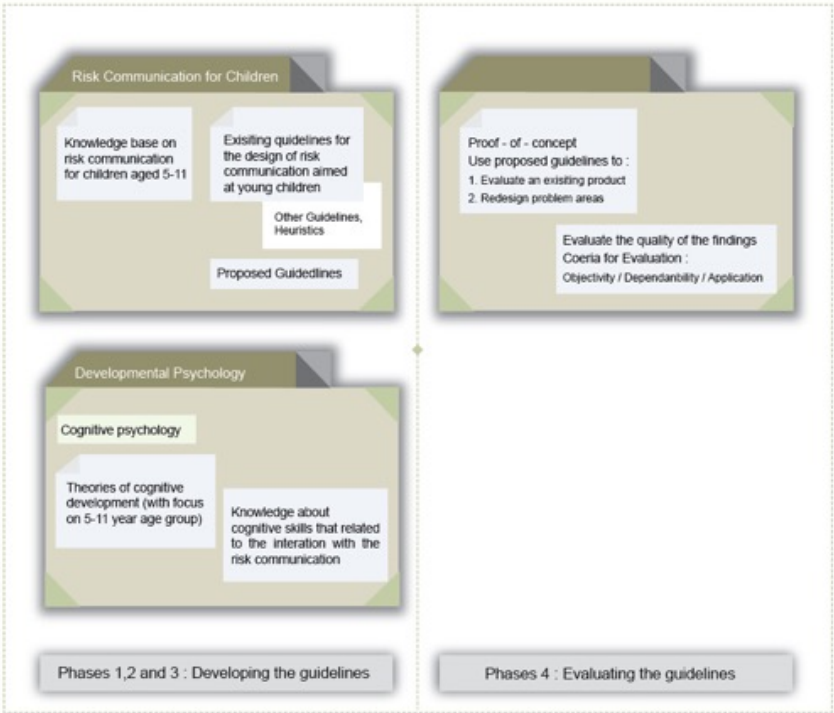
- Define developmental Stages.
- Develop child-based personas.

6.4 Designing in accordance with the framework

A pattern analysis informed by the proposed framework was carried out, the synthesise of patterns developed persona characteristics and were used to create the persona narratives. Available resources related to the characteristics of children were reviewed, as were design sources currently in use. Figure 6.1 contains a high-level overview of the persona development process and the guidelines incorporated therein. More specifically,

guidelines from Waterson and Monk (2014) and other authors shed light on the knowledge needs of designers engaged in developing appropriate risk-communication materials for children. The theoretical and practical knowledge gathered throughout the research process sits behind each of the sections outlined in Figure 6.1. Together, various methods and tools form the full toolkit. Based on the collected information, a set of characteristics and objectives to be incorporated into each persona description was defined in a short narrative about the persona and the associated perception of the risk.

Figure 6.1 Methods and design guidance



Developmental psychology

Knowledge regarding children's developmental abilities and limitations was integrated into the tools and the framework to ensure that future risk-communication materials are age appropriate and aligned with the skills of the intended audience. Details regarding developmental abilities, questions, and field data relevant to each risk-communication activity were incorporated into the persona descriptions to ensure that subsequent interactions matched children's capabilities.

6.4.1 Development constraints in relation to the tools

Few studies have examined the use of personas to convey safety considerations. The theories and methods applied in research contexts are often difficult to implement in real life. In short, there is a gap between theory and practice and a need for practical and simple tools intended to create awareness among risk-communication developers designing for diverse target groups (in this case, young children). The data gathered from external studies were thus appropriately formatted to help designers develop more appropriate risk communications and may also be used to craft safer products for young children. This goal was achieved following multiple iterative and evaluative stages.

6.4.2 Persona development

The persona development process is detailed in the following sections, along with a description of how it reflected the state of the art regarding risk communications, and specifically, those targeting children. The framework outlines a systematic approach with clear links to the existing models discussed in the previous chapters.

The theoretical findings revealed a risk-communication framework that had initially been developed for older adults and then tailored to child-based communication. Thus far in this study, general risk-communication categories are elaborated upon. Information relevant to risk-communication design was explored with the goal of incorporating it within an accessible, easy-to-use, and more flexible format.

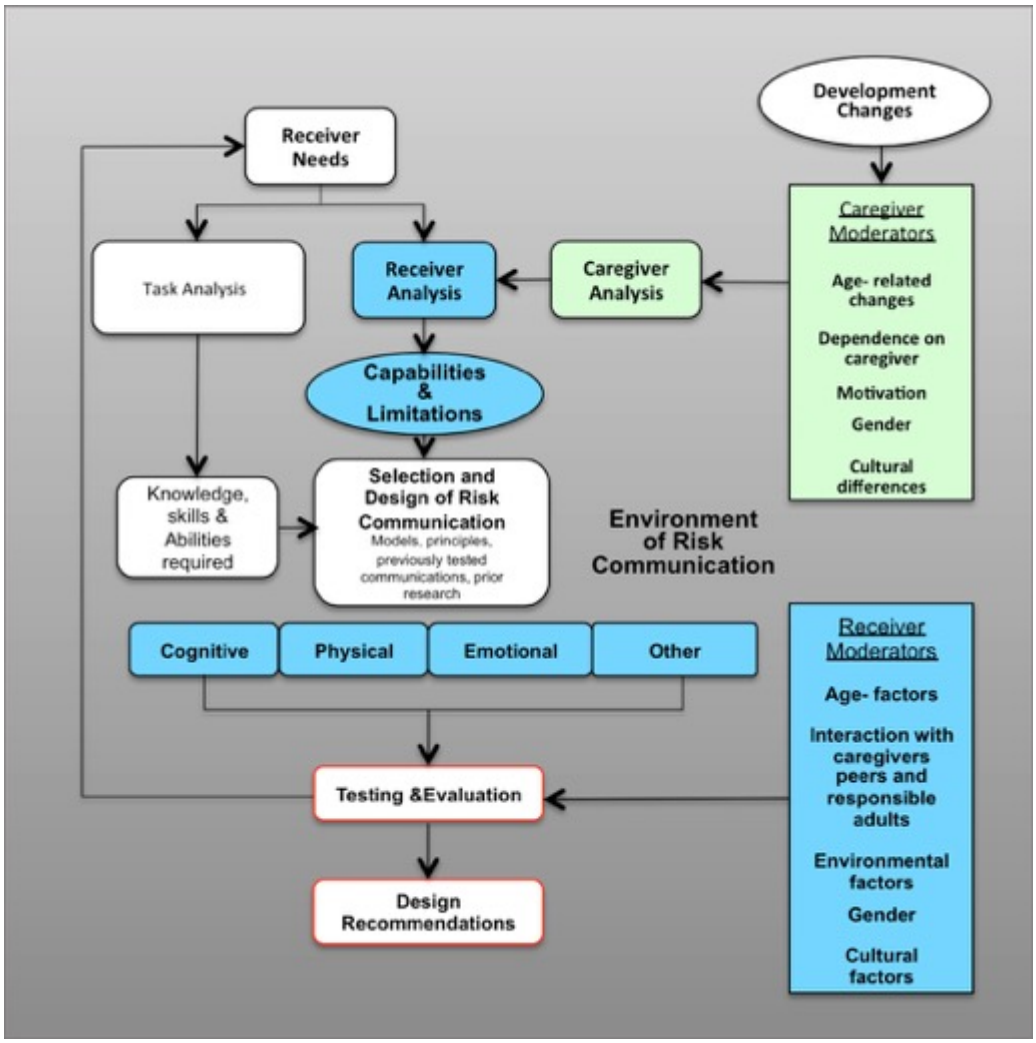


Figure 6.2 Integrated risk management framework

In certain cases, caregiver interactions need to be reflected in the process of designing, which means that designers must be able to use the tools flexibly, as described in the below systematic risk management model.

6.4.2.1 Defining the content of the personas

Based on this framework and the larger evidence base, card tools were created, as described in this section. It describes the design and evaluation methods, the cards themselves, and the child personas. The child personas featured a name, age, grade, caregiver interaction, hobbies, activities, risk perception, and narrative to contextualise each child's abilities and limitations. The developmental phases were based on Piaget's

stages; these were expanded upon in the section of the framework presented in Figure 6.3.

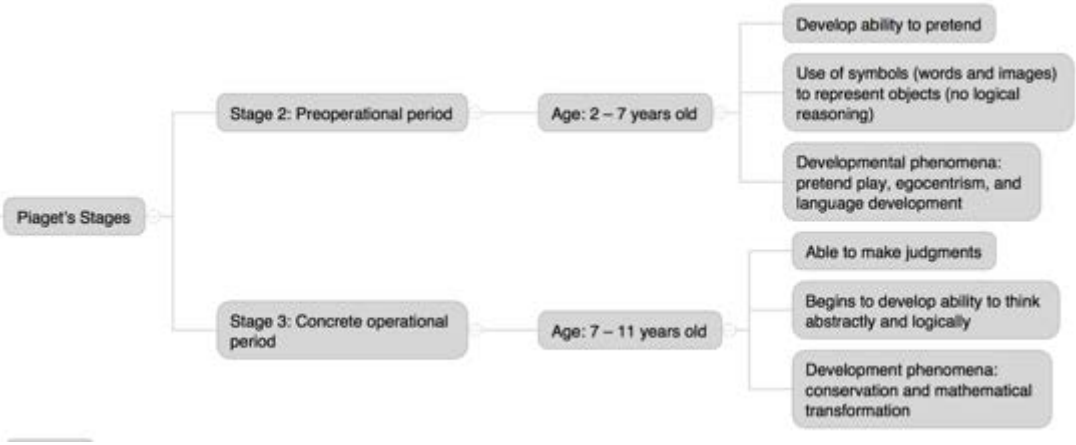


Figure **6.3** Development stages according to Piaget. Developed by the researcher.

The persona cards illustrate theoretical knowledge regarding, for example, children's perceived level of awareness about potential dangers and the relevant stage of development. The proposed personas, which are based on the outcomes of the researchers previous two studies, detailed in Chapter's 4 and 5, are expected to be used by designers and other teams involved in developing and analysing existing interfaces, communications, and products. The inherently visual nature of designers' work and the need for a tool to generate empathy with a difficult-to-access user group meant that the risk management framework and child personas represented the most suitable approach.

Based on this framework and the collected data, methods cards and two child personas were created, as described in this chapter. Detailed knowledge of the intended audience allows a designer to select appropriate communication objectives, to contextualise the message in a suitable manner, and to deliver the message via communication channels frequented and preferred by members of the target audience. Consequently, the following seven attributes were arranged, in no particular order, into persona cards:

- Demographics: name, age or developmental stage, gender, and family structure
- Activity types: typical activities to demonstrate the child's capabilities and limitations
- Environment: typical environmental considerations and a description of where the user group is likely to interact
- Perception of risk: details regarding risk perceptions at various stages of development

- Interaction: information regarding expected interactions between a child and his or her surroundings at a particular age
- Social interaction: events that interfere with children's social interactions
- Caregiver interaction: activities that interfere with caregiver interactions

This framework outlines the relevant content that risk-communication materials aimed at children aged 5–11 years should address. The result is a common platform consisting of methods cards designed by relevant stakeholders and intended for use by that same group.

6.4.3 Incorporating end-user input into risk communications

The persona tools are based on the available literature and the opinions of experts and thus provide a tool for incorporating important needs and requirements the about the end user of the risk communication and allowing the designer to better empathise with children's capabilities and limitations. Interviews with designers were conducted (see Chapter 5) to obtain individual feedback from the tools' end users regarding, for example, their specific knowledge, needs, and preferred formats. The comparison of the available literature and the opinions of experts identified knowledge gaps in designers' current understandings and insufficiencies in current resources. The persona tools address these gaps and encourage the adoption of a holistic perspective.

6.5 User journey

The user journey for the persona tools illustrates their intended use (see Figure 6.4).

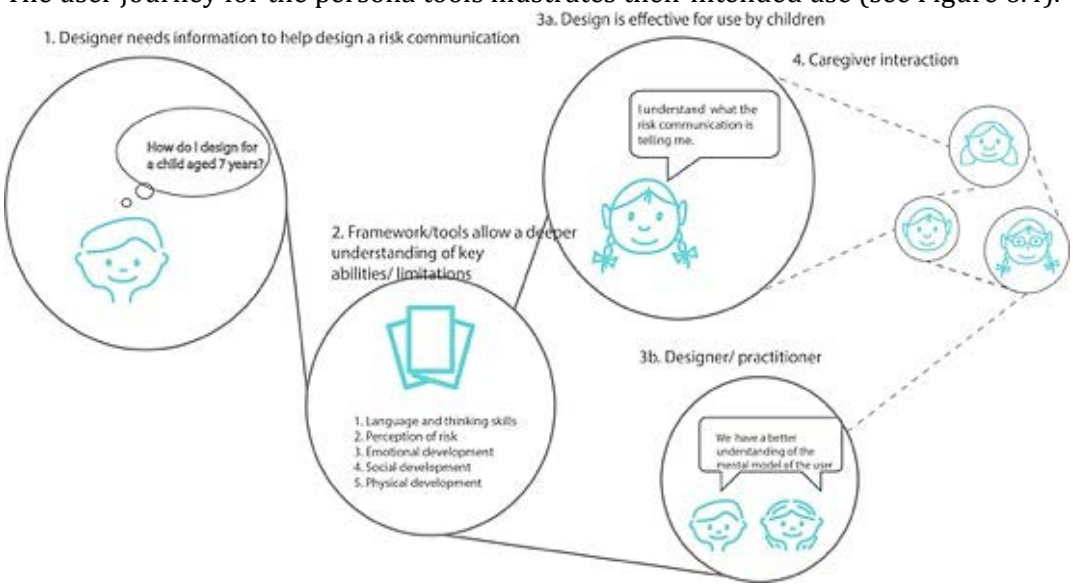


Figure 6.4 User journey for the persona tools

The goal of the toolkit is to visually illustrate how existing ergonomic data and other information relevant to risk communication targeting children aged 5–11 can be clearly presented and integrated into practice.

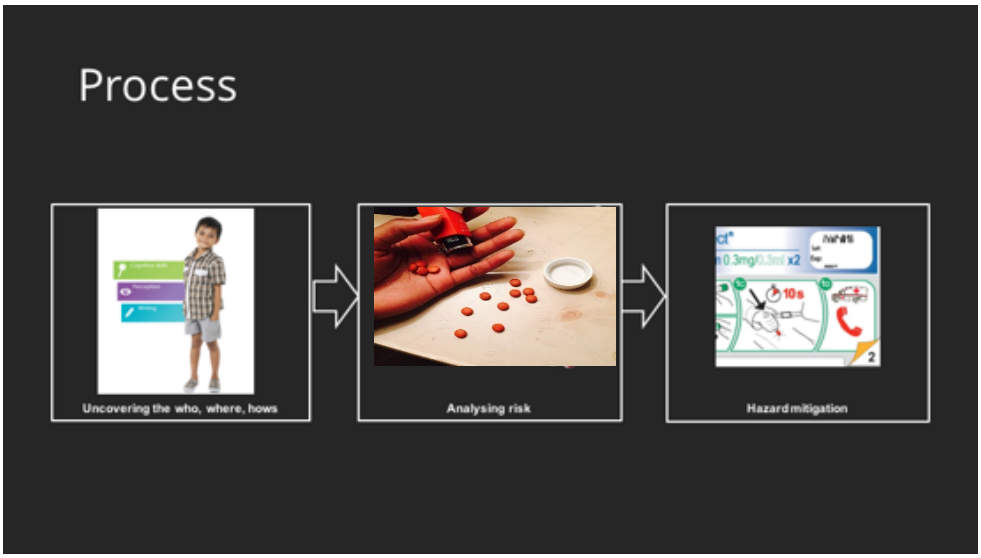


Figure 6.5 Visualising data in design

Visualising data for use in design enables shared understandings on the part of multiple groups. Toolkits seek to meet the needs of users and are particularly useful in guiding design processes (Dong and Clarkson, 2005). Design toolkits are often developed in response to direct requests or on the basis of industry or stakeholder needs. In other cases, toolkits are co-developed and tested with input from potential users trialling them during a live project. This approach serves to more closely align a toolkit with appropriate design processes. A simplified example of the process of designing for children is outlined in Figure 6.6. Verification and validation are stages that designers often struggle to incorporate into the process due to limited time and resources, and the interview findings presented in the previous chapter support that conclusion.

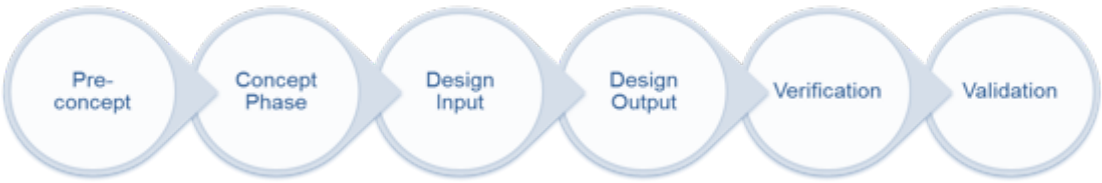


Figure 6.6 Design process

6.6 Needs analysis

H/F tools and methods cards have been developed consisting of information relevant to assisting designers, and other groups involved, in the design and evaluation of risk communications. The persona tools, intend to be part of a wider toolkit, that includes methods cards for design and evaluation. The persona cards have been developed to reflect a typically developing child in order to describe a child's cognitive skills, fine motor skills, knowledge, memory, emotional states, and specific safety requirements at each developmental stage and in terms of how they differ from adults. We can then derive the implications these differences have for designers when they are designing for young children's safety. Methods cards that describe various other methods for working with children are found to be relevant, such as classroom discussions; storytelling techniques to inform children about risks; and methods for co-designing with children. Other cards detailed caregiver interactions and aspects such as communication and children's preferences regarding interacting and gaining information.

Figure 6.7 Child persona version one

6.7 Card format

The cards were designed to display the relevant information in a simple and usable form, as the goal was for designers to be able to quickly locate key facts. Considerations applicable to strengthening risk-communication designs aimed at children are explained in more depth on the individual cards. As many of the designers were not experts on children, several required additional information on the persona cards, such as more specific descriptions of the steps involved in a child's cognitive processes. The cards constitute a reference for designers and are not intended to replace any mandatory standards. They simply represent one possible way to formalise design and evaluation methods targeting children and to support researchers in analysing and reflecting on their practice's complexity. The cards are primarily directed at less experienced design practitioners, although more experienced professionals may also benefit from the reminder regarding key elements involved designing relevant communications and the suggestions concerning how to address those factors.

Figure 6.8 Child persona version two

6.7.1 Limitations

The data collection phase was time-consuming; however, drawing on rich sources of contextual information during the document analysis proved beneficial. Developing the child personas was likewise a time-intensive process, and therefore, the researcher had only limited time to arrange for designers working on an actual project to evaluate the personas in that context. The next step was to develop a survey to collect initial feedback on the current tool, as that approach could reach a much wider audience within a limited timeframe.

6.7.2 Conclusions and next steps

The developed personas incorporate information from multiple resources and feedback from relevant experts. The next chapter describes how the persona tools were evaluated in an online environment by several designers and a range of other targeted professionals. An online survey was developed to assess the adequacy and completeness of the persona descriptions. In the next chapter, the results of the validation questionnaire are presented; a panel of designers and other professionals in the target community also provided feedback. The personas were further evaluated and revised as necessary.

Chapter 7: Research study 3 - Online evaluation of the tools

It has been noted that tools are frequently designers cannot access tools when designing for young children. Part of the focus of this research is on investigating designers' perspectives on using the tools and what content and format will meet designers' needs when using it in designing risk communications for children aged 5–11 years. Feedback from designers and other experts involved in design for children on the early concepts for child persona tools presented in Chapter 6, Figures 6.7 and 6.8 were evaluated, with the intention of improving information sources and the implementation of age-appropriate risk-communication design for children. A questionnaire survey was therefore conducted to obtain further insights regarding the requirements on the requirements for the tools, including preferences in terms of content and format, and to further address the following research question:

- Which theoretical perspectives are useful for enhancing user-focused design when designing for children aged 5–11 years?

7.1 Research method

A questionnaire survey was conducted in order to obtain further insights regarding what designers require of the toolkit on the toolkit requirements and to obtain general insights into the sample group's attitudes and opinions (Creswell 2014) with regard to the concept and value of the toolkit, as well as its efficiency, format, integration into the respondents' current working practices and their requirements.

7.1.1 Choice of method for evaluating the toolkit

Questionnaires offer a very flexible means of rapidly collecting large amounts of data from large groups of subjects. Questionnaires have been used in many forms in order to collect data on numerous issues concerning human factors and design. Questionnaires can be used to collect information regarding almost any subject, including usability, user satisfaction, opinions and attitudes. They can be readily used in the design process to evaluate concepts and prototypical designs, to probe perceptions and to evaluate

existing system designs. Specific questionnaires can be designed and administered during the design process.

7.1.2 Survey design and rationale

The survey approach is used to provide general insights into the knowledge, awareness,

Figure 7.1: The questionnaire's focus areas

attitudes, opinions and/or behaviour of the population (Creswell 2014) with regard to the concept and value of the toolkit in terms of its efficiency, format, integration into their current working practices and their requirements. Figure 7.1 summarises the questionnaire's focus areas; these were selected based on the findings of the interview study. The survey was divided into six main areas, which were structured in a such a manner that the evaluation of the tools was central.

The first section of the survey was used to obtain background information concerning the participants, including age, gender, professional role within the design industry and number of years' experience in design for children (if any). It was important to gauge the levels of knowledge and experience that the participants had when designing products for children. Their names and dates of birth are not reported for reasons of anonymity. The respondents were also asked questions concerning the suitability of the content of the proposed tools with regard to the design and non-design tasks described in the following sections. Generally speaking, there is a lack of knowledge regarding the resources intended to assist designers to better understand the capabilities and limitations of children and allow them to empathise with the children user group. It is extremely challenging to translate children's capabilities and limitations into design.

In order to reduce the length of the survey and to make it easier for the respondents to answer, a number of questions were presented using the Likert scale. The Likert scale is a rating scale that was developed by Renis Likert in 1932 (Jackson, 2015). During the interviews conducted in Chapter 5, for gathering the requirements from designers, it was noted that general design tools demonstrated a lack of integration, or 'fit', with working

practices and that the interchangeability of a design problem and the limited amounts of time available to complete tasks were among the major barriers. A section of the survey focused specifically on fit with working practice and how users could envisage the tool functioning within the design process or being used in carrying out their everyday design tasks.

7.1.3 Coverage

Part of the work conducted for Study 4 involved qualitative interviews with designers, which were conducted in order to assess their information needs. When designing, a designer should first consider the requirements of users, as well as their limitations (Kim, 2010). In the literature review, it was noted that it is not always possible to include children in the design process due to their limited capabilities. A research gap was also identified in the resource review conducted in Chapter 3, the findings of which indicated a lack of empirical evidence and that a limited number of tools that cover the specific capabilities and limitations of this age group are available to designers. A section of the survey focused specifically on the requirements of this age group at different stages, on the requirements of this age group at different stages with regard to how they interact with risk. Information requirements include, among others, developmental stages (defined as knowledge of what children are capable of at a certain age, i.e. age-related changes), cognitive abilities, behavioural attributes, and physical and emotional development. A further aspect, which is unclear in the literature, is the role of a caregiver in in interactions between a child and a risk communication or product. A section of the survey focused specifically on these aspects. In addition, the literature review conducted in Chapter 2 revealed that children have design considerations that differ from those specific to adults and demonstrate certain limitations that may place them at greater danger of unintentional injury or pose different types of risk than those confronted by the adult population. Children's specific characteristics can also affect their involvement in the design process; therefore, gathering useful information for innovation from children can be more challenging than gathering it from directly from adults. Furthermore, cognitive psychologists have shown that children find it challenging to conceptualise ideas that are abstract in nature. Therefore, it was important to include a section that focused on the capabilities and limitations of children and the behaviours adopted by young children that may affect their interactions with a product, system or environment.

The first section of the survey was used to obtain background information about the participants, including age, gender, employment status and number of years of experience in design. As stated previously, their names their names and date of birth are not reported for reasons of anonymity. Thereafter, the respondents were asked questions concerning the content of the proposed tools with regard to the design and non-design tasks that are described in the following sections.

7.1.4 Format and usability

The information needs of designers should be presented in a format that provides guidelines; and addressed using tools that provide appropriate support. Information requirements in relation to format are further clarified in a section on the respondents' preferences in terms of the format of the tools. Questions regarding the layout, integration and efficiency of the tool were included in this section.

7.1.5 Compatibility with current design standards

It is important that the tool can be smoothly integrated within current work practices, as indicated by the findings of the interviews discussed in Chapter 4. Hence, one of the questions that participants were asked in this section was “To what degree do you feel that the tool works well with current design standards?” Furthermore, it was considered important to establish what further information, if any, designers may require when utilising the tool. The question of “To what extent do you need to know other information when using the tool?” was included in this section.

7.1.6 Fit with working practices

It was considered important to include a section that investigated the tool's fit with the designers’ tasks, as the primary purpose of the tool is to allow designers to fit with what the user will typically engage in whilst using the toolkit. Kim (2010) stated that the

application of guidelines can ease this process for a designer, as they can reduce mental and physical stress. Henninger et al. (1995) noted that the use of guidelines in the development process of other areas of interface design can reduce the time required for the number of iterations involved in the design-evaluation-redesign cycle of Human Computer Interaction(HCI) development (Kim, 2010). A section titled 'fit with working practices' was thus included in the survey; it included topics concerning how the tools might be used in the context of the designers' everyday tasks. Examples of the topics investigated include how the tool may accommodate work/design tasks specific to designing for young children, the extent to which it would comply with standards and whether it would allow designers to complete their tasks more rapidly and/or efficiently. These were issues that were identified in the literature review and during the qualitative interviews as being challenging for many designers.

Research was conducted on previous questionnaires relevant to the topic; these were checked and analysed in terms of their structure and content. Elements of a standard usability survey were included, with slight changes, in the survey conducted for the purposes of this research; these included simplified versions of specific questions. Incorporating relevant questions from other questionnaires offers many advantages; e.g. such questions have already been pilot-tested for reliability. The questionnaire went through various stages during the design and development phases. Many factors were taken into consideration; e.g. questions needed to be specific, short and easy for designers to understand. Rather than creating long questions, Likert scales, with specific statements and tick boxes, were incorporated. Comment sections were also included at the end of each section to allow participants to provide additional comments.

7.2 Pilot study

Each question in the survey was pilot-tested for reliability and validity before being implemented. Due to limitations in terms of time and budget, the researcher carried out informal pilots using a small number of participants. The average time given to answer the questionnaire was approximately 10 minutes. A pilot study was conducted using the questionnaire survey; both the online and paper-based versions focusing on the following points:

- Checking the wording and structure of the questionnaire;

- Ensuring that the responses provided were as anticipated;
- Capturing the time taken to complete the survey; and
- Developing a strategy for data analysis.

7.2.1 Participants

A convenience sample of designers was obtained; these included participants who were easy to find or available to participate in the study (Owen 1998). The use of a convenience sample is a straightforward and time-efficient method that is commonly used in pilot studies. A total of 50 participants participated in the pilot study, the majority of whom were ergonomists, designers, safety experts and academics. The group of participants used represented the various the various parties involved in designing for child safety, such as practicing designers, and they coincided with this group.

7.2.2 Materials

The standard strategy employed in the inquiry is the use of an online questionnaire survey design. The role of the questionnaire survey in this study is to ensure that standardised interviews are conducted with all subjects, meaning that all respondents are asked appropriate questions in the same fashion (Brace 2013). The primary reason for choosing the online survey was that it had the potential to reach a wider range of participants in a shorter period of time.

The intended sample size for the survey was (n = 50+); it was therefore important to consider various data collection tools. The most suitable option was Survey Monkey, which is competitively priced, comes with full features for one year and has the ability to send link to surveys to contacts and other organisations via email; in addition, its data can be exported to Excel or SPSS, which saves time. Survey Monkey is available online at **https://www.surveymonkey.com**. The completed questionnaires will be stored electronically and securely for a maximum of six years before being disposed of. All data are be stored on a secure, password-protected computer, and the data concerning them will be treated as in accordance with the Data Protection Act 1998.

The advantages and disadvantages of using an online questionnaire survey are as follows:

Advantages:

- It allows a researcher to reach large amounts of people in a short space of time;
- A cost saving is achieved by moving from a paper-based to an electronic medium; and
- It provides access to participants whom it may be difficult to access through face-to-face survey methods.

Disadvantages:

An online questionnaire survey may exclude members of the sample group(s) that do not have access to the Internet.

Survey Structure:

The survey's structure is summarised in Table 7.1 below:

Table 7.1: Summary of the questionnaire

Section	Detail
1	Introduction
2	Section 1: General information
3	Section 2: Assessing end users' perceptions of coverage
4	Section 3: Assessing attitudes towards the format of the tool
5	Section 4: Assessing the effectiveness of the toolkit (i.e. its fit with current standards and working practices)
6	Efficiency
7	Satisfaction
8	Thanking the respondents for their participation

7.3 Analysis

The questionnaire survey was developed in order to draw generalisations from a sample concerning their attitudes their attitudes concerning the use of the toolkit in general. The

results were expected to provide general insights regarding designers' perceptions of the toolkit.

7.3.1 Key points

Small typographical modifications were made to some of the questions to improve clarity. Other specific changes include the following:

- In the section on 'coverage', the meaning of each development stage was further clarified in order to provide the participants with a clearer understanding of these topics; and
- Some participants felt that they needed to provide further details concerning their preferences with regard to the format of the tool; therefore, a 'comments' section was included at the end of each section in the survey.

The pilot study showed that the responses were as anticipated: The majority of participants took no longer than 10 minutes to complete the online version of the survey. A copy of the final questionnaire can be found in Appendix C.

7.3.2 Data collection (Questionnaire survey)

Various organisations were approached for the survey, and their agreement was obtained for the distribution of the questionnaire via emails. Some examples of the organisations consulted include major design consultancies involved in design for children and child-safety organisations such as CAPT and the Royal Society for the Prevention of Accidents (RoSPA). Snowball sampling was used as a strategy to increase the number of responses.

7.3.3 Sampling strategy

Various sampling techniques were reviewed in the methods chapter, including simple random sampling, systematic sampling, stratified sampling, quota sampling and convenience sampling. The suitability of each method for this study was assessed; ultimately, a stratified purposive sampling technique was used (Robson 2002).

According to Owen (1998), there is a link between sample size and the accuracy of the collected data; e.g. if the sample size is large, then the data are likely to be accurate. The author notes that a researcher should attempt to obtain a sample size of a reasonable number, taking time and budget into account. Therefore, the proposed sample size for the questionnaire survey was n = 40–50; this was thought to be a reasonable number in terms of gaining a robust data set for statistical analysis.

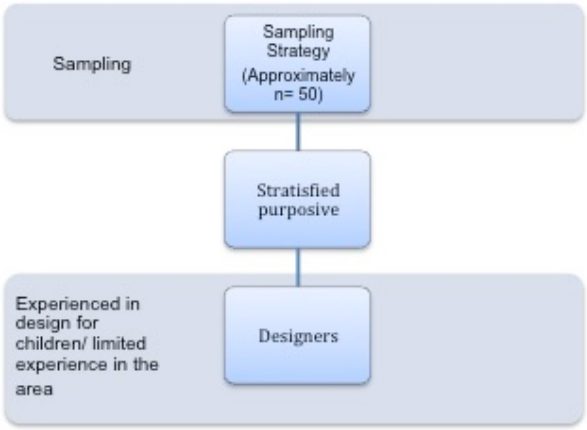


Figure 7.2: Sampling strategy (stratified sampling) (Robson, 2011)

For the purposes of the survey, inexperienced designers were defined as those having limited or no experience with design for children. The sample was divided into 2 sub-groups by experience in design for children within the age range of 5-11 years and by those who lack of such experience. The data obtained from the questionnaire were analysed using Excel in order to obtain a general understanding by focusing on the entire sample, and differences in terms of experience with designing for children and lack of knowledge thereof were explored.

7.4 Results

A total of 50 respondents participated in the online survey between March 2016 and March 2017. The respondents were working full-time in a design capacity with a range of experience and professional occupations. The results of each question will be presented in this section.

7.4.1.1 Question 1: Respondents age

Most respondents were in the 18–24 years old category and this was followed by the 35–44 years old category. The 25–34 years old and 45–54 years old categories had the joint third most respondents. This means over 40% of respondents were aged 18–34. There was one respondent over 75.

Table 7.2 Respondents' age profile

Age Category	Response Percent	Response Count
18 to 24	27.5%	14
25 to 34	15.7%	8
35 to 44	21.6%	11
45 to 54	15.7%	8
55 to 64	13.7%	7
65 to 74	3.9%	2
75 or older	2.0%	1

7.4.1.2 Question 2: Respondents years of experience in design for children (aged 5–11 years only)?

The largest number (22) of respondents has less than one year's experience, followed 14 respondents with 1–3 years' experience, this shows that 70% majority of respondents had less than 3 years' experience.

Table 7.3 Respondents' experience

Experience (yrs.)	Response %	Response Count
less than 1	43.1%	22
1–3	27.5%	14

3–5	5.9%	3
5–10	5.9%	3
10–15	7.8%	4
20–30	7.8%	4
30 +	2.0%	1

7.4.1.3 Question 3: To what extent do you think that the proposed child persona is useful in conveying the following information to the designer? Developmental stages (Defined as knowledge of what children are capable of at a certain age i.e. Age-Related Changes)

Respondents said that the proposed child persona was best at conveying behavioural attributes with an average rating of 3.8. Cognitive abilities, physical development and emotional development were all similarly scored at 3.6, 3.5 and 3.6 respectively. The role of the caregiver was the least satisfactory category at 3.4.

Table 7.4 Usefulness of the persona at conveying different attributes

Aspects of the proposed child persona	**Unsatisfactory**				**Satisfactory**	**Rating average**
Role of the caregiver	2	8	17	15	9	3.4
Physical development	2	6	15	19	9	3.5

Aspects of the proposed child persona	Unsatisfactory				Satisfactory	Rating average
Cognitive abilities	1	5	15	22	8	3.6
Emotional development	1	6	17	18	9	3.6
Behavioural attributes	0	6	10	22	13	3.8

7.4.1.4 Question 4: In the development of a toolkit, what is your preferred format?

The most (51% of the respondents) preferred a checklist matrix as the toolkit format. The checklist matrix was closely followed by the cards with 49% of respondents choosing for this. Both are traditional paper-based resources. The app-based resource was the third most requested choice with 45% of the respondents choosing for this. The app was closely followed by online and webpage, with 39% and 35% of the respondents.

Table 7.5 Preferred format for the tools

Toolkit format	Response %	Response count
Checklist Matrix	51.0%	26

Toolkit format	Response %	Response count
Cards	49.0%	24
App	45.0%	25
Online	39.0%	24
Webpage	35.3%	18
Mini-booklet	25.5%	13
Software for laptops	13.7%	7
Table of instructions	11.8%	6
CD-ROM	0.0%	0

7.4.1.5 Question 5: How likely are you to use the tools if they were available?

Most respondents strongly agreed that they would the toolkit if it were available today. The weighted average was equal for respondents who thought the toolkit was well integrated, would feel very confident using these tools in a project and believe that most people would learn to use this toolkit very quickly. There were also strong feelings towards agreeing that the toolkit appears easy to use. Respondents reported the lowest score for requiring additional information when using the toolkit.

Table 7.6 Usability of the persona tool

Usability aspect	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly agree (5)	Rating average
To what extent do you need to know other information when using the tool?	1	5	16	13	16	3.7
I think the tool appears easy to use	0	5	13	18	15	3.8
I would imagine that most people would learn to use this toolkit very quickly	1	3	11	23	13	3.9
If these tools were available, I would feel very confident using these tools in a project	1	1	16	18	15	3.9
I found the various functions of the toolkit were well integrated	2	3	9	22	15	3.9
If this toolkit were available today, how likely is it that you would you use this toolkit frequently?	0	1	7	24	19	4.2

7.4.1.6 Question 6: To what extent is the tool too simple / complex?

Twenty-nine percent of the respondents reported that they found the toolkit to be simple, while 41% reported that they found it in the category next to simple. No respondents reported that they found the tool to be complex.

Table 7.7 Persona tool complexity

Simple/complex	Complex	Much effort	Effort	Little effort	Simple
Number of respondents	0	4	11	21	15
Percentage	0%	8%	22%	41%	29%

7.4.1.7 Question 7: To what degree do you feel that the tool works well with current design standards?

Fifty-three percent of the respondents reported that there a medium level of effort was required for the tool to work well with current design standards. Thirty-two percent of the respondents felt that more or much effort was required for it to work well with current design standards, while only 16% felt that less effort would be required than that expended at present.

Table 7.8: Compatibility with current design standards

Compatibility with current design standards	**Low effort**	**Little effort**	**Medium effort**	**Some effort**	**High effort**
Number of respondents	1	7	27	12	4
Percentage	2%	14%	53%	24%	8%

7.4.1.8 Question 8: Fit with working practices

Respondents reported that the toolkit would assist them to design more efficiently and speed up/facilitate their work processes to an equal extent. The highest efficiencies were seen in how respondents felt the toolkit would fit into their general work practices

Table 7.9: Fit with working practice

Answer options	**Inefficient (1)**	**2**	**3**	**4**	**Efficient (5)**	**Average rating**
To what extent would the toolkit fit into general work practices?	0	4	11	24	12	3.9

To what extent would it help you to design more efficiently?	0	1	19	23	8	3.7
To what degree do you think using the tool would speed up/ assist with your working process?	0	2	20	22	7	3.7

7.4.1.9 Question 9: How well would the information provided in this tool support the tasks you need to achieve?

Very few respondents reported that the tool would provide little support to tasks they need to achieve. The majority of respondents (68%) reported that the tool would support to tasks they need to achieve.

Table 7.10 How well tools support design tasks to be achieved

Answer Options	Little Support	Minimal support	Somewhat	Supports	Good Support
Number of respondents	3	3	10	20	15
Percentage	6%	6%	20%	39%	29%

7.5 Discussion

Overall, there was a good response to the toolkit for helping designers in practice. However, the needs of designers and other professionals involved in designing visual safety information need to be further adhered to in developing a tool that fully supports their needs. This survey was conducted to identify key requirements and initial insights into the early-stage prototype persona. Problems arise when designers are unable to obtain direct input from the target user groups; in the case of the user group of young children, for example, they may become dependent upon indirect sources or outdated information such as that described in Chapter 4 (Study 1) or purely rely on their own

experience and intuition when designing for children. The child persona cards were created in order to convey the capabilities and limitations of children and to allow designers to better empathise with their unique characteristics and meet their needs.

The problems with the existing resources were also outlined in this chapter; thus, research is needed into how knowledge of this concept could be transferred and how developed persona tools could be further translated into a more economical and desirable format for use by practitioners in their everyday working environments. The needs of designers, and indeed other professionals who are involved in designing visual safety information, need to be taken further into consideration to allow the design of visual information for young children to be further developed in order to meet the needs of designers' everyday working practices.

7.5.1 Age

As it was deemed important to gather insights from different age brackets, the researcher obtained information from young, middle-aged and older designers in order to obtain a broad representation of the attitudes and needs that exist when it comes to designing for very young audiences or users. The majority of the designers had a great deal of previous knowledge and experience in the field of design. Those who lacked experience or had not designed for the age group for a long period of time commented on specific needs when considering designing for a younger age group.

7.5.2 Experience in design safety

The respondents had mixed levels of experience in the field. In this context, the term experts referred to a range of a range of professionals involved in keeping children safe through design, testing and evaluating products aimed at young children. Those that had less than 1–3 years of experience were from the younger age brackets. Nine respondents had over 10 years' experience, making them highly experienced experts in the field. A retired child accident-prevention specialist shared her expert opinion of the persona cards. A consumer representative who sits on a number of British Standards Institute (BSI) and other European Standards Committees that develop standards for children's products participated in the survey. Another consumer representative on the standards

committee, who also works with engineering students, participated. She had more than 10 years' experience in the field and were mainly focused on developing standards for younger children but also worked on other products, including toys. Other participants with over 10 years' experience included a toy designer/play expert, two industrial designers, a quality manager in the toy industry and a consumer representative in the same industry. A few of these respondents mentioned that they had some form of involvement in developing standards or regulations or were involved in committees. Those with 30+ years' experience were considered experts in testing and evaluation.

The experts were involved in order to provide guidance on aspects that may not have been noticed by less experienced designers. The majority of respondents had 0–3 years' experience in design for children, whereas the older age group included safety experts for children's products or individuals who had over 10 years' experience in designing for children.

Those with over 10 years' experience often relied on their own knowledge of designing for children. The largest number (22) of respondents had 0 years' experience, followed by 14 respondents with 1–3 years' experience; thus, the majority (70 percent) of the respondents had less than 3 years' experience.

7.5.3 Usefulness of the proposed child persona

The respondents indicated that the proposed child persona was best at conveying behavioural attributes, with an average rating of 3.8. Cognitive abilities, physical development and emotional development were all rated similarly, at 3.6, 3.5 and 3.6, respectively. The role of the caregiver was the least satisfactory category, at 3.4. This result was not surprising to the researcher due to the focus on conveying age-related changes to designers and developing a child persona for evaluation, meaning that there was a lack of information concerning caregivers input.

7.5.4 Format preference

Due to the diverse design groups involved in child safety, it may be the case that more than one format is used for tools. The most preferred format for a toolkit was a checklist matrix, with 51% of the respondents choosing this option. A checklist matrix contains a list of questions that provide support for the analysis of a product. A checklist matrix was closely followed by cards, with 49% of respondents choosing this option; both are traditionally paper-based resources. An app was the third most requested choice, with 45% of the respondents choosing this option. An app was closely followed by online and webpage, which could be similar in design; these were chosen by 39% and 35% of the respondents, respectively. In the additional comments section, the six respondents who provided comments stated that the most important aspects of a toolkit for them are that it is visual, regularly updated and easily accessible.

The most important requirement for participants was that the format of the tools would be up-to-date. A desire for more interactive tools was reflected in the comments provided by both designers and safety experts. They had fresh ideas concerning the direction that tools could take in order to remain relevant and up-to-date with today's technology trends and working practice.

- An engineer designer expressed a desire that tools be visually accessible and up to date.
- Feedback from respondents included the requirement of testing the tools in various use environments as well as the tools being able to adapt to future trends and advances in technology:

"Standards developer and consumer representative on a variety of BSI & CEN committees: I find that it is often useful to be able to change settings to see what effect that has on other attributes. Learning thorough doing".

"Designer: Futuristic trends - Toolkit on wearable and other devices (based on availability and location). Digitisation with relevant and simpler infographics might help in conveying information easily and quickly".

- The retired child accident-prevention specialist commented that his preference for the tools would be to include photographs as much as possible.

7.5.5 Usability

The majority of the respondents strongly agreed that they would use this toolkit if it were available today. The respondents also offered a number of additional comments concerning the usability of the toolkit:

- The respondents expressed a desire for detailed anthropometric and performance information;
- A number of respondents suggest providing links to more detailed information concerning the developmental stages, e.g. what research the toolkit was based on and what proportion/percentile of children of a certain age meet each developmental milestone;
- In general, respondents would like to see additional information regarding the terminology used on the card tools, e.g. defining “physically active”;
- A few respondents would like the relevance of the information to the design of risk communications to be explicit in the tools, for example the relevance of Cultural information to developing a risk communication; and
- Standards requirements to be displayed as often respondents highlighted the fact that standards are not easy to follow.

Other groups and uses for the tools were established: It was noted that it was not solely designers who would find the tools useful, as the retired child accident-prevention specialist and the author of child-safety guide commented that they would be useful to refer to when developing product standards. Again, many of the respondents expressed a desire that the evidence-base of knowledge that the tool was developed from should be made more transparent to those individuals who would use the tool, as this would encourage trust in the information that it presented. Further comments included the following:

> “Retired child accident-prevention specialist: Something of this sort would have been very useful when developing a product standard, as it is 'all in one glance” and all members of the committee could understand it. However, maybe there should be links to more detailed information about the developmental stages, e.g. what research this information was based on or what proportion/percentile of children (percentile) of an age meet each developmental milestone. Users should feel confident about the validity of the information presented 'at a glance'.

“Consumer representative on a variety of BSI and CEN committees developing standards for children’s products: Some of the language doesn't seem very [clear to] designers", for example it was not clear how to interpret the percentages. Not clear what emphasis should be given to different elements”.

“Chief financial officer: To cover the lesser-acknowledged development stages listed above”.

“Engineer designer: Can you give additional information of your 'level' description, for instance: of 80% physically active. Means: spending time in sport or moderate to vigorous activity 30 minutes a day, etc”.

“Product designer: Cultural information”.

“UX designer: Are they one of or many of the same age? What information was used to inform the constructions?”

“Digital product designer (UX/UI Designer: Standards requirements”.

“Stories” and “scenarios” were discussed as playing an important role in helping designers to understand or develop a clearer impression of children’s interactions and behaviours and how the tool could potentially be used:

“Consultant: Pictorial behaviour situations relevant to children and risk communications presented by images or a short story telling.”.

“Design consultant: How will the child behave when using the specific toy under different circumstances?”

“Consumer child-safety specialist: What other aspects of the toolkit exist, as I can only see the persona? Perhaps a scenario or two to capture some of the persona’s task and experience goals would be useful - maybe a play session or how they would respond to a certain question in class. Also, some guidance on how to use a persona would be useful. It needs to be clear that this is not a 'real' person but represents a grouping of individuals based on behavioural characteristics. Maybe some guidance on how to create a 'day in the life of' or some other framing tools to help the designer to envisage how the persona would interact with their product”.

“Lecturer/ Designer: To be clear, the responses in Section 5 are based on the assumption that I have been tasked with designing a product or service for 5–11-year-olds. I think a brief cogent description of some of the terminology used could be useful. This is where an online variant would be useful; for instance, I could click on

the phrase 'psychomotor outburst' and get a brief description of what this is, potential causes, and coping strategies".

"Student: I'm not currently designing for children, but if it went through young adults, I'd probably refer to it...even for lit review".

"Supervisor of Product development: More details that apply directly to a particular type of product".

"Testing Laboratory: Standards.

"Expert in safety toy regulations: Information on how representative the personas are, what the percentages mean, how to use the personas effectively in design (e.g. so they don't just become stereotypes). Further information on user capabilities, responses, desires, etc. would also be helpful".

"Industrial designer/researcher: If this is going to be designed for a designer's toolkit, more images and symbolic description will be intuitive. Most designers don't have enough time to read; they need to scan the information and [it] will be easier for them to use the information".

7.5.6 To what extent is the tool too simple/complex?

Generally, the tool was not found to be too complex; however, additional information was required in terms of whether they were sufficiently integrated into the design process to allow them to be used by designers in the intended fashion. The amount of time required for designers to process and use the information presented in the tools was the main concern; however, it was felt that they would not be intended to speed up the process but rather to aid a designer in thinking about developmental stages, particularly the less recognised developmental stages of children. The tools themselves were not deemed excessively complex; however, the terminology used in in the field of children's development is frequently not well understood or translated to designers in an accessible format. Therefore, more explanations concerning what terminology means and what the consequences of the information provided in the tool are when it is applied to design would be useful and help to reduce the complexity of this information.

7.5.7 To what degree do you feel that the tool works well with current design standards?

Suggestions were made concerning integrating standards into the tools. Some of the respondents commented that it depends on how the tool is developed, i.e. if the toolkit was developed from evidence and input from standards, then it would be beneficial to use and apply to design.

7.5.8 Fit with working practices

The respondents expressed interest in more information concerning how to apply the tool in practice, more information on terminology and explanations of what the consequences of a stage in development mean in relation to design practice:

> "Engineer designer: It provides a good start but does not give enough information on how to apply the tool".
>
> "Product design: Potential is there but it depends what information informed the development of the tool and if the person can for example read/comprehend above the average what does it actually mean?"
>
> "UX designer: It should be tested by designers".
>
> "Digital product designer: UX/UI designer: The persona format is a well-established design took for keeping design thinking relevant to the user. As somebody with little experience of designing for 5–11-year olds, if the persona could also act as a gateway to more detailed information about the psychology and behaviour of children, then I think its use as a toolkit in the design process would be enhanced".
>
> "Designer: It is some years since I was involved in design-related activities, and these were mainly products used by children and adults or nursery goods, so I am hesitant about the relevance of my responses to your research".
>
> "Retired child accident-prevention specialist: Although aware of use of personas, I do not actually design products, so find it hard to relate to how I might use this information. I like the idea of fitting safety/developmental criteria into the persona format and think some measure such as the colour coding could work well but imagine percentages are not easy to interpret by some".

"Standards developer and consumer representative on a variety of BSI and CEN committees: I would need to know how the persona fits into a wider demographic, but once that is [known] it should speed up the process [as] you wouldn't need to do this yourself!"

"Consumer-child safety specialist: All the information would be in one place, speeding up the process".

"Chief financial officer: Readily available user information would reduce the time [spent] researching and avoid irrelevant designs".

"Lecturer/ designer: Unfortunately, I am not an expert in designing for children safety, and I am not aware of the general working conditions and available tools and standards".

"Consultant: May offer information quickly in a condensed format".

"Student: It helps provide some insight; I don't think it would speed things up, except if it encouraged designers to skip user involvement, which would be a bad thing".

"Supervisor of product development: Where required, industrial designers rely on the specialist support of the client and rarely design on their own".

"Testing laboratory:…again, because it is very much based on verbal communication, it makes it time-consuming for most of the designers.... it needs to be visual, the information provided is crucially important for any product development, it has to be easy and straight forward to be able to communicate and deliver the necessary info".

7.5.9 Level of support for design tasks

Additional comments were made concerning how well the information provided in the tool would support the everyday design tasks carried out by design team or others involved in the process. A designer with little experience in designing for children commented that, to ensure that it is used effectively in everyday practice, the tool would need to provide introductory information aimed at the user concerning how the support tool can be used appropriately to support certain design tasks. The consumer representative who sits on a variety of BSI and CEN committees that develop standards for children's products discussed a need for more information in order to assist

designers to understand the tool's use in the design process. She mentioned the need for the tool to be well integrated within the design process. This view was commonly expressed by interviewees in Study 2, Chapter 5:

> "Designer: It needs a careful but very short introduction or strap line to make sure itis used appropriately".

> "Consumer representative: It could show how the tool relates to a product development process".

One participant with over 30 years' experience in design for child safety discussed the CEN-CENELEC child safety documents and resources that the researcher reviewed and collated in the resource review in Chapter 4 (Study 1) and further developed in the design tool. He discussed They discussed the need for information concerning the evidence-base used in the development. They thought that this was the correct approach to developing tools for child safety:

> "Retired child accident-prevention specialist: I would like more background on how the persona derived - is this based on the relevant CEN-CENELEC child safety documents and trying to turn these into a more visual form? I do think it is worth persevering".

A UX designer without experience in designing for children commented that it was important to conduct user research when designing, as a persona may not be sufficiently in-depth enough without doing so. The evidence base behind the tool's development was not clear to those who evaluated the tool online, as it was difficult to translate the extent of the research to those who participated. They also discussed requiring more information concerning the how the tool would function in practice. Furthermore, they mentioned a need for the tool to be well integrated within design practice:

> "UX designer: I am not sure if a tool of a persona would be in-depth enough for me to design for children safety, without doing any user observations or interviews. The information you provided in the first page was a static image, and I did not really get well what the dynamics of the tool would be in practice".

It was considered important that the tools were visual and accessible to a wide range of designers, including those who may not speak English. It was further noted that it could be presented in a more systematic manner, with clear labelling, more infographics and colour codes to help navigate the tool.

"Child-safety specialist: More infographic so it's easy for the brain to catch the point subconsciously and be easy to understand for designers who don't speak English".

"Product designer: Some of the graphs would benefit from clear labels (i.e. axis labels; colour codes). More images could be incorporated".

"Design consultant: A bit about the importance of real user involvement if possible and some tips on how to do that".

7.6 Limitations

The adoption of an online approach to evaluating the tools meant that a good number and variety of designers could be could be interviewed during the limited timeframe available. However, it only made it possible to obtain some early stage feedback on the tools. The tool's relationship with the theoretical model is difficult to translate online. More information is required to help designers understand its use; such information could be mapped onto the design process.

The online evaluation only provided a limited amount of feedback on the tools; it would be more beneficial to gain in-depth qualitative feedback from designers working with the tools in practice. Although the researcher has identified where the tools could fit into practice, it is not entirely clear where designers would find them of most use without testing them over a period of time using in-situ designers working on a live project. The comments made by participants via the online survey, however, made it possible to obtain richer insights into the tool's fit with working practice and the opportunities in terms of wider applications of this research and the toolkit.

7.7 Improvements

The tool could provide more information on the methods used in working with children and include this information in the design process. The tool needs to provide clear explanation of risk-communication terminology. The characteristics of behavioural attributes, cognitive abilities and the role of the caregiver were the most needed source of information that would be relevant to supporting designers in their design activities.

As the findings of the resource review have shown, these attributes are currently lacking or hard for designers to find in other sources of guidance.

7.7.1.1 Fit with working practice

It is possible that designers may lack experience or knowledge concerning how to use the persona in an effective manner, and some of the feedback provided by the respondents indicated a need for guidance on how to use a persona. There is also the danger that designers may lose touch with the complexity of a 'real individual' child, as a persona is representative of a grouping of individuals based on behaviours and other characteristics.

Walkthroughs of practical application and the intended use for the persona by designers when developing a sign aimed at a seven—year-old child should be provided. Further outcomes were the use of scenarios or framing tools: "Guidance on how to create a 'day in the life of' …some other framing tools to help the designer to envisage how the persona would interact with their product".

The respondents expressed a need to obtain information concerning the evidence–base that was used in the development of the personas; as discussed in the previous chapter, the tools are grounded in theory, and this could be further explained and demonstrated during a walkthrough. This indicates that it is important that the tools are further evaluated in practice in order to measure their efficiency and further improve them based on practical evidence, as well as the demonstrated theoretical inputs.

7.7.1.2 Context of use

The tools could be used in a wider context and may be appropriate for use in child injury prevention; e.g., they could be used as a "visual reference in the development of product safety standards". The evaluation expert commented that "this would be useful to refer to when developing product standards".

7.7.1.3 Additions and improvements to the tools

Suggestions for additions to and improvements of the tools included the following:

1. Development of "stories" and "scenarios";

2. Mapping out where the tools are used;
3. Integrating information on methods of working with and involving children in design research;
4. More detail concerning graph information and the meaning of data on characteristics;
5. The addition of colour codes;
6. Providing interactive information concerning the complex terminology involved in child development, for example explain what is meant by terminology such as psychomotor outbursts;
7. Providing detailed anthropometric and performance information;
8. Providing links to more detailed information concerning the developmental stages, e.g. what research the toolkit was based on and what proportion/percentile of children of a certain age meet each developmental milestone;
9. Providing additional information concerning the terminology used, e.g. defining "physically active";
10. Explaining cultural information/relevance; and
11. Discussing standards requirements.

7.8 Summary

The initial persona tool developed in Chapter 6 has been evaluated. The respondents indicated a preference for a checklist matrix was the preferred format for the tools, followed by the persona tools. The results indicate that it is important to integrate standards requirements; this may have been a preference largely because it would provide a more systematic means of designing risk communications and a clearer guide to where the tools and method could be used. The developed evidence-based toolkit would help designers to constrain design solution spaces in a more structured manner. The tools may need to be used in conjunction with one another, as in addition to a more structured approach, the respondents indicated a preference for storytelling and interactive information.

This chapter discussed the feedback provided on the application of the tools, i.e. their 'fit' with working practice. In addition, it specified improvements to the tools based on the

feedback provided by designers. An evaluation of the initial persona as a possible format for the tool, and the early feedback collected on initial prototypes enabled concepts to be refined iteratively alongside the results from the research. The findings obtained from the questionnaire are used to further inform development of the tools in Chapter 8. There is a need to further develop and evaluate the tools by conducting further testing with designers, perhaps in a series of in-vitro case studies. A roadmap for future work that discusses this topic further this is presented to conclude the research in Chapter 9.

7.8.1 Next steps

The next steps are to discuss these findings in relation to the framework. A mixed media approach to the tools would make them more accessible to designers and better able to meet the diverse needs of the various groups involved in child safety. A checklist matrix, cards and a digital format were the top three preferred formats for the tools. It is clear from this research that there is a need to provide designers with a holistic view of child safety that provides them with insight into topics such as caregiver interaction, the impact of environments, lesser-known developmental stages and integration of the tool providing such information into design processes.

Chapter 8: Results and discussion

8.1 Introduction

As discussed in the literature review conducted in Chapter 2, for risk communications to be evidence-based, they must be consistent with scientific knowledge. This chapter provides an overview of the system models; in addition, it describes the development of the risk management model derived from the knowledge gained from the overall research, which is intended to provide support for reflective practices in designing for child safety. The framework seeks to answer the research questions, including the following:

RQ4 How can various relevant theories be formalised (modelled) to help designers' practices, and how can these be used to support designers of risk communications aimed at young children and their carers?

An empirical model of risk communications in the context of children aged between 5–11 years has been gradually developed throughout this thesis; this model was developed based on the research outcomes and was documented at the end of each of the three empirical studies included, which can be used to guide and frame subsequent research and the development of risk communications. From the studies considered within this thesis, a clearer understanding of the requirements of industrial designers, as well as other professionals involved in the target community for the development of support tools for designing for young children, has been obtained through the use of various qualitative methods, and the use of a web-based evaluation. This chapter discusses the findings of this research and positions them in the context of the literature to date, thus reflecting upon the overall research. The significance that research outputs has in terms of contributing both to theory and practice lies in improving the design, and hence the communication, of messages aimed at reducing the likelihood of common risks and injuries to children within the age groups considered. The risk management framework contributes to academic knowledge in the field. Theoretical input to creative practice is provided through collating a comprehensive understanding of the requirements of a practical design aid aimed at designers which is intended to be implemented into the everyday working practice of the design teams and other groups involved. The discussion conceives a theoretical and practical approach to bridging HF/E and design practice, describing the theoretical contribution of the developed risk management

framework to human-factors research, and personas contribution to design practice. The concept is for the tools to aid in development by offering a user interface that is consistent with children's experiences and expectations at varying stages of development. The findings regarding the overall research questions outlined in Chapter 1 of this thesis are discussed individually.

8.1.1 Overview

The new risk management framework and tools developed as an output to the overall research are presented, along with a description of how a designer (or other professionals in the target community) would be expected to use to use the framework and to use these persona tools. To do so, this chapter discusses the following topics:

- The final framework in relation to the existing literature and knowledge in the field;
- Contribution to knowledge;
- The extent to which the study answered the research questions;
- The overall contribution to theory;
- The overall contribution to practice, including a walkthrough example of how the framework might be applied and a description of how a designer might implement the support tools/persona within everyday design practice.

8.2 Defining the framework for risk management

8.2.1 Organising the complex elements of safer design for children

This research has thus sought to identify and investigate weaknesses and gaps in the field in order to propose useful theoretical constructs and tools with which to address them. The findings of research studies have been presented throughout this thesis, with outputs being integrated into the staged development of the various components of the risk management framework. In this section, the key findings are discussed in relation to the risk management framework and existing knowledge.

The analysis of the results of the online survey presented in Chapter 7 identified aspects that have an impact on the tools' suitability, i.e. their 'fit' with working practice. The analysis specified improvements to the tools based on the feedback provided by the design practitioners and other experts. A designer must consider a multitude of elements when designing and evaluating risk communications or indeed products for children. In order to allow designers to better address these aspects, they have been mapped onto the framework (Section 8.2.4). Table 8.1 lists the theoretical information and models that contributed towards the development of the framework and outlines its contributions to knowledge in the context of the literature.

8.2.2 Issues and needs

This section outlines the theoretical constructs relevant to the development of improved resources and the persona tools created for this research, describes the existing gaps and identifies where these shortcomings have been strengthened by the development of the new risk management framework. Constructs are derived based on the various resources and guidelines available on developmental psychology and the behavioural characteristics of children and incorporated into the adapted systems-based risk-communication framework for children based on the work of McLaughlin and Mayhorn (2014). The outcomes of the interviews and questionnaire studies revealed that, without tools and techniques for bringing children's behaviour and the other information discussed within the thesis to the attention of decision-makers and designers, there can be little influence on risk-communication design, development and operation. It was found that, although many tools and techniques are available, a great deal of information, particularly that concerning risk communications, is fragmented or not readily applicable and that numerous issues remain to be addressed by new technology and research. Throughout this research, various models have contributed to the process of identifying and narrowing these gaps (see Table 8.1).

8.2.3 Theoretical inputs

The list of references presented below summarises the theoretical information and models that contributed towards the development of the framework and outlines this research's contributions to knowledge in the context of the literature.

Table 8.1 Positioning of the risk management framework in relation to the literature

HFE/ Model	Model/ framework & Source	Relevance	Gaps in knowledge	Risk Management Framework Contribution to knowledge
HF Model 001	The communication-human information-processing model (C-HIP) (Wogalter et al., 1999).	The model collates the findings of previous research into warnings. It is an iterative process for understanding how people interact with and process a warning. The model considers sources and channels of communication.	The model does not consider does not consider a risk environment in a holistic manner in relation to vulnerable groups.	The model collates the findings of research into children's characteristics and other warning and risk-communication research relevant to children.
HF Model 002	The environment of risk communication for older adults (McLaughlin & Mayhorn 2014).	A framework for the development of risk communications, aimed at older adults. This framework considers both environment and individual characteristics.	The model does not consider children or caregiver interactions.	The developed framework integrates child characteristics and caregiver components.
HF Model 003	Waterson and Monk's (2014) guidelines for the design and evaluation of warning signs. Flowchart of design and evaluation activities (based partly on the work of Keates and Clarkston [2004, p. 154]).	Guidelines were produced and evaluated, and an iterative design and evaluation model based on a model developed by Keates and Clarkston (2004) was presented. The developed guidelines were discussed in Chapter 4, Study 1, and are displayed in Appendix A; they pertain to colour, font, etc.	Development of more comprehensive guidelines for the design/evaluation of children's warning signs, the need for behavioural evaluation and establishing a wider context for design/evaluation. May be developed to include the caregiver interaction within the model.	The developed framework integrates the design and evaluation guidelines developed in previous research by Waterson and Monk (2014).
HF Model 004	STEP approach to message design and testing (SatMDT) framework of Lewis et al., 2014; Lewis et al., 2009.	Integrates four distinct methodological steps into the framework to be considered in developing and evaluating the content of a message.	Designed for application specifically to road safety; the authors discussed the possibilities for application in other areas.	The risk management framework incorporates the methodological steps and makes them more accessible to decision-makers and designers.
HF Model 005	Adapted risk management framework: The systems approach to risk communications	A systematic process for design and safety evaluation. Development of more comprehensive guidelines for into	Needs a clearer outline of the steps involved and how they fit into design process; needs to be turned into	An outline of how the developed risk management framework would be used in the design

HFE/ Model	Model/ framework & Source	Relevance	Gaps in knowledge	Risk Management Framework Contribution to knowledge
	for young children based on McLaughlin (2014).	design and evaluation guidelines. Considers children and caregiver interactions and the characteristics of children.	formats that can be used by designers.	process is illustrated in Section 8.5.

Table 8.1 presented the models considered throughout this thesis; this section begins by discussing these models further. The first model (**HF001**), the communication-human information-processing model (Wogalter et al., 1999) lacks information concerning the broader environment of risk communications with regard to young children. McLaughlin and Mayhorn's (2014) framework (**HF002**), which was developed specifically for older adults, does not take into account young children's developmental stages and needs. The flowchart model (**HF003)** of design and evaluation activities (based partly on Keates and Clarkston [2004, p. 154]), which was adapted by Waterson and Monk., 2014, requires further development for use in practice. The STEP approach to message design and testing (SatMDT) framework (**HF004)** of Lewis et al. (2014) and Lewis et al. (2009) integrates four distinct methodological steps to be considered in evaluating a message. The developed risk management framework (**HF005**), which integrates the models mentioned above and the research studies considered within this thesis, promotes a more holistic approach intended to aid decision-makers and designers in the complex domain of design for children in warning and risk communication development. Further research is required to test the final risk management framework (**HF005**); such research could be conducted, for example, within live projects that involve decision-makers and designers, as outlined in the roadmap for future work (see Chapter 9).

8.2.4 The risk management framework

The framework contributes to both research and practice by identifying possible ways forward with regard to closing the gap in the research. The risk management framework has been produced as the output of the overall research process. It collates an evidence base and relevant knowledge more systematically, and it is intended to serve as a reference for practitioners when considering the process of producing risk communications aimed at the target age group and additionally when considering the potential implications of each variable involved in the risk-communication process. The

development of the proposed risk management framework contributes to knowledge by closing some of the identified gaps in the research that has been conducted to date. The design process can be complicated to navigate when designing for children, as there are often different groups involved in the process. The framework does not automatically provide guidelines to follow but instead provides support for better understanding the effects that the elements of the process may have on its output and therefore supports the planning process. In this respect, it is not limited to novice practitioners, as it can also be used by experts before validating their plans. Among the few other frameworks that have been created for risk-communication practice with children, that which is most related to the risk management framework is that of Sluis-Thiescheffer et al. (2011), which was described in the section (2.8.3) of the literature review conducted in Chapter 2 in which methods for designing with children were described in Chapter 2. By offering a framework for comparing early design methods targeted at young children, Sluis-Thiescheffer et al. (2011) addressed the selection of appropriate techniques according to children's diverse intelligences and simultaneously explored how the outputs of different design techniques can be evaluated and used for design purposes. This framework shares with the developed risk management framework the intention to support the selection of resources to be employed in design and evaluation sessions focused on children. While Sluis-Thiescheffer et al. (2011) focused on specific aspects, such as a variety of techniques and the outputs of early design methods for young children, the risk management framework considers session design and how to support the decisions made regarding the different aspects that affect its outcome. The systems model of risk communication for young children also delivers both risk management and guidance via an integrated process. The concept is that the framework and tools should be applied by decision-makers and designers in everyday practice when devising key aspects of interface and message content likely to enhance communication and promote safer designs for children. The framework identifies steps and maps them onto a typical design process.

The toolkit components expanded upon in the resource review conducted in Chapter 4 underlie each of the steps in the framework. They describes the stages of a standard procedure, illustrating its iterative nature; the following components were integrated within this research:

- **Stage 1:** Receiver needs. The first two steps relate to considerations involved in the development of message content personalised to the needs and abilities of the intended receiver.

- **Stage 2:** Receiver analysis (capabilities and limitations) (This stage considers developmental changes, including cognitive, physical, emotional and other).
- **Stage 3:** Caregiver analysis (caregiver moderators). The third step in the process considers the effects of any caregivers or responsible adults' interactions within the process.
- **Stage 4:** Task analysis is integrated as a means of gaining a better understanding of the interaction within the type of product or communication and the environment of use. The selection and design of risk communication are influenced by any existing policies and standards.
- **Stage 5:** The testing and evaluation stage integrate the guidelines offered by Waterson and Monk (2014) and relates them to considerations regarding individuals' responses to such messages (in order to check whether such responses align with the expectations or intentions of the message developers). The final step also relates to the evaluation of persuasive outcomes.

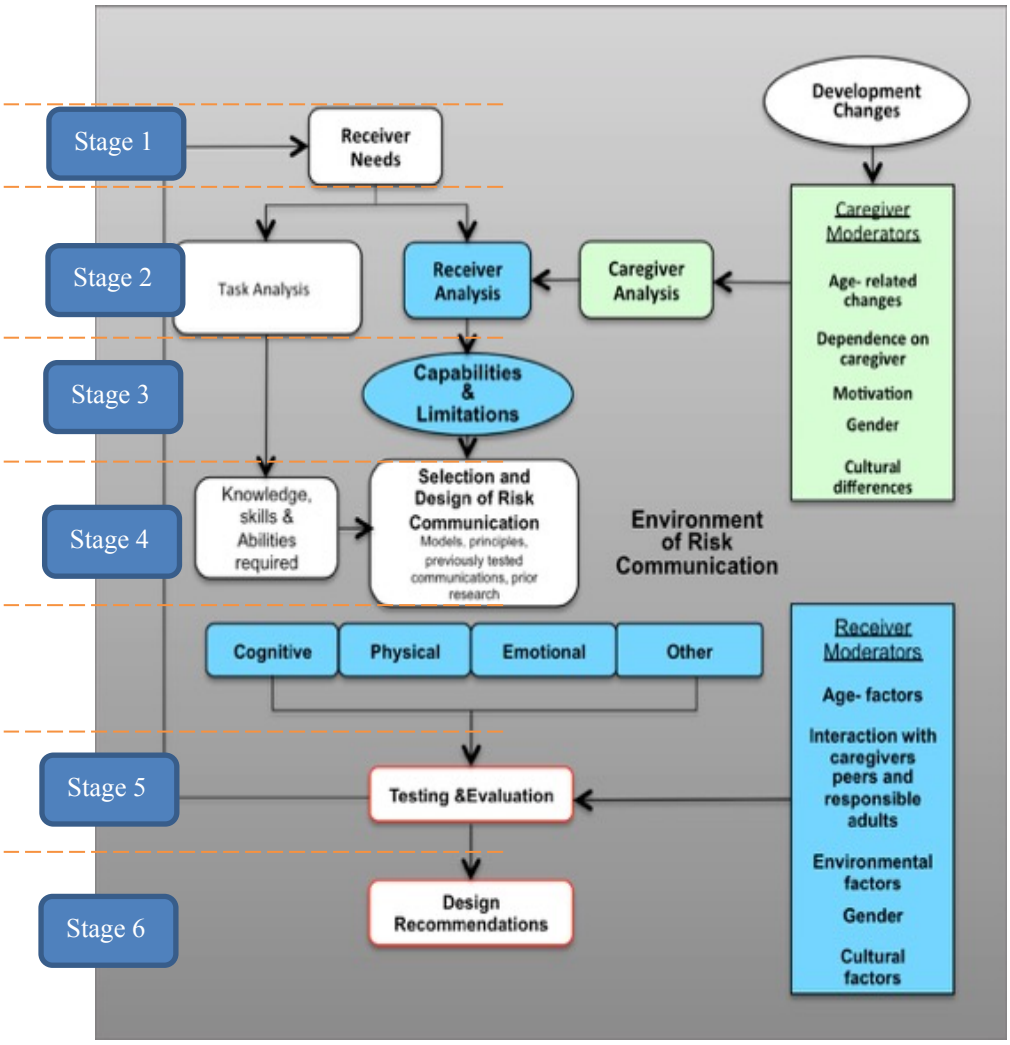


Figure 8.1: Risk management framework

8.2.4.1 Background to the framework

Previous research has acknowledged that "theory is crucial to campaign and message development" (Fishbein, 2003). There is an abundance of theories in the domain that are often unable to be applied in practice; as such, it has become unclear to the developer which approach should be implemented in a particular context. However, the findings of the literature review have shown that many theories were not designed intentionally for the explicit purpose of informing the development of the content of messages aimed at young children. This is also true of the development of public-health message content (see Slater, 1999, in relevance to health campaign development). The research discussed within this thesis has explored ways in which the predominant theories within the risk-communication literature could be translated in such a manner that they could be usefully applied in everyday practice, with the intention of introducing knowledge of design for child safety into design practitioners' decision-making. Attempting to bridge the evidence/practice gap assumes that practical knowledge derives merely from research knowledge, but such a translational effort requires an iterative approach to developing, introducing and evaluating the tools/decision aids.

When considering the evidence-practice gap, ergonomics guidelines can sometimes be too general to be applied with confidence; alternatively, they may be too specific to the application for which they were originally derived. Most guidelines do not consider users' psychological characteristics, including their previous experiences with a product or risk communication, expectations and perceptions of risk or attitude. One exception is the model developed by McLaughlin and Mayhorn (2014), which does take these important attributes into account. It was therefore considered appropriate to adapt the model to include research into young children's characteristics.

- The adapted McLaughlin and Mayhorn model (2104) considers children's psychological characteristics, their interactions with a caregiver or responsible adult, their previous experience with a product, expectations and perception of risk and attitude.
- The analysis of previous and current literature sources revealed there was a gap in terms of considering children and caregivers in the process of developing warning information.
- A documentary analysis intended to provide guidance and an evidence base for the development of tools was performed by translating current research into risk

communications and warning theory in such a manner that it could be applied in practice.

Based on resource review consolidation and the previously discussed model (McLaughlin & Mayhorn, 2014), a model was developed in Chapter 4 that aimed at designing effective risk communications for older adults. In Chapter 4, the few resources available concerning children's capabilities and limitations, previously developed guidelines, models, risk perception and caregiver supervision, which constitute the building blocks of this model, were discussed as the starting point for the development of a general framework. The literature and resource review revealed a small but distinct body of work on models, guidelines and other tools that may be made relevant to the process of facilitating risk communication in the context of children. This is still a growing area, as, given the different sub-fields of health, message design is still 'emerging', as the body of research lacks both rigorous empirical evidence and evaluation research on 'event-specific risk communication efforts'. The risk management model represents a step towards developing an evidence base. The main difference between the developed model and the others described from previous research is that it has been adapted to take into consideration the needs of young children, i.e. it integrates gathering the needs of children's 'receiver needs', and their interactions with caregivers, peers and responsible adults, as well as other components that may affect child and caregiver understanding of a message. These elements were detailed and expanded upon previously, in Chapter 4. The risk management framework has been developed from a theoretical grounding, encompassing already tested communications and prior research, including the design and evaluation guidelines established by Waterson and Monk (2014). It demonstrates an iterative process that feeds into the design and evaluation stages illustrated in the model, with the arrows feeding back into the various stages (Figure 8.1).

8.2.5 Stage 1: Receiver (children's needs)

Identifying and describing the characteristics of risk communication in the context of children remains an essential first step in improving child safety in design. Feedback from designers prompted the development of an initial child persona tool, which was facilitated with the input provided by the resource review, in which the researcher integrated the knowledge gathered concerning cognitive skills, capabilities and limitations related to interactions with risk communication, including developmental

psychology and theories of cognitive development regarding the 5–11-year-old age group. The outputs of the online evaluation conducted with the assistance of designers included requirements for the content of future development tools. These outputs addressed three main categories, namely format, compatibility with standards and fit with working practice. Aspects of the proposed child persona were evaluated. The respondents concluded that the intended child persona was best suited to conveying behavioural attributes. Further feedback concerning the proposed child persona was that the role of the caregiver was the least satisfactory element of the persona; therefore, this needs to be further integrated into the tools.

An unexpected outcome of the online evaluation was the fact that the tool might also be useful in the context of standards development. Suggestions for a broader context and other settings that the tools could be applied in were provided. There were suggestions that the tools may prove useful in child injury prevention, e.g. by using it as a visual reference in the development of product safety standards. Others commented that the tools would be useful to refer to when developing product standards. The accessibility and content of the tools were found to be important in encouraging their uptake in practice. Suggestions were also provided concerning further guidance on how to use a persona may aid designers in a practical scenario. Additional suggestions included the need to develop 'scenarios' or framing tools to assist designers to envisage how the persona would interact with their products.

The following sections develop these findings in order to envisage how the persona could interact with the framework and how these two elements could work together in developing a risk-communication sign aimed at a seven-year-old female. The conceptual approach outlined in the model initially adapted at the end of the resource review conducted in Chapter 4 integrated psychological, physical, emotional and environmental concerns, including caregiver supervision, in an early design phase. This approach was intended to provide an organised process that could allow designers to identify and understand children's needs, environmental considerations and caregivers' needs, how best to satisfy these requirements and how improvement options should be evaluated during the design process.

In the following sections of this research, it was found that additional introductory information or guidance on how to use the tool and on the (evidence-based) background of how the personas were developed should be integrated into the tool. Researchers have found that story-based techniques can lead to meaningful and lasting changes in people's

behaviour (Ricketts 2015); However, when adopting such techniques, one should not just target children but ensure that caregivers are aware. As readers make increasing use of story-based safety messages, a need will arise for guidelines that aid in the design of such interventions. The development of "stories" and "scenarios" in order to facilitate effective communication includes a balanced mix of general facts, along with anecdotes that illustrate how those events can play out in everyday life (Ricketts 2015). Worldwide, research has shed considerable light on methods of using stories or anecdotes effectively in health messages. Nevertheless, results must always be interpreted in the context of research and methodologies. The outcomes of this study include the requirements of a wide range of designers and experts with regard to improving support for design and evaluation, including new approaches to understanding children's unique needs. The designers' requirements are identified from the online questionnaire discussed in Chapter 7 including the elements displayed in Section 7.7.1.3. The actions to be taken going forward are based on feedback and comments made by survey participants.

8.3 Information used in evaluation

Outcomes from the interviews with designers suggest that the caregiver's role is significant in the evaluation stages of the design process. Overall, the components of the model were beneficial in the evaluation stages. Many elements of the model were tasks already used by some practitioners within the stages of the design process. However, few of the designers mentioned caregiver consideration in the early stages of the design process; this was rarely considered in their everyday practice. In contrast, the caregiver's role was significant in the evaluation stages. The primary outcome of this study is its contribution of knowledge about the role of the environment of risk communications in the context of design. The study has highlighted the importance of this environment, for example with regard to the differing motivations from various organisations involved in the process.

8.3.1 Input to practice (tools)

To date, research has outlined the need for the development of a more comprehensive guide for the design and evaluation of children's risk communications (Waterson & Monk, 2014). Results have highlighted the lack of research into children, and the lack of any concrete guidance for practitioners on how to accomplish communication

objectives. For example, authors have acknowledged that terminology used in both risk-communication theory and child development is not easily understood by the designer, and must be more accessible to better contribute to practice. The risk management framework and concept tools developed thus far aim to reduce the gap between theory and practice, as they have attempted to explain these theories in a manner that clarifies their value in practice. However, little recent work focuses in detail on the daily working processes of design teams when designing and considering safety aspects for children; their interaction with other groups; communication problems and barriers; and the influence of large-scale extrinsic factors such as organisational culture. The present study has explored some of these aspects. For instance, it showed that communication barriers further exist between design and ergonomics teams. To address foreseeable barriers to future implementation,

- The risk management tools proposed in this study were developed with input from specialists in the area, including but not limited to ergonomists, standards developers, design practitioners, and safety experts.
- The tools were evaluated online, and this yielded insight into their further application; the persona tools were refined and developed to reflect this.
- The new risk management tool includes methods for enabling the various groups to understand the user group of young children and design better accordingly.
- The resource will help embed risk management and visually aid the designer in considering safety aspects for children relevant to their capabilities and limitations.

Theorists in this field and other related behavioural fields have advanced the thinking and developed many useful theories in the domain (Maibach & Parrott, 1995) which are relevant to safety communication research in building upon the theoretical knowledge and other areas discussed in this thesis. However, Maibach and Parrott (1995) state that theories of human behaviour and communication processes provide only half of the information necessary for the practical design of, for example, a health communication message. The authors discuss that the rest of the knowledge is produced through a thorough understanding of the target audience. Indeed, this has been highlighted and further developed in this study in relation to young children. There is a crossover with risk-communication research outlined in this thesis, where the present study has identified components necessary for designing effective risk communications for young children. It has also identified further special considerations for the unique user group relating to the environment of risk regarding caregiver interaction.

The risk management framework developed throughout this thesis, prompts better understandings of complex roles of psychological, social, and cultural influences on risk perception and further identifies several areas, still little explored, in which qualitative studies could be extended. It contributes to gaps in the literature, as the model considers Wogalter's (1999) view that newly developed models should consider the environment of the risk communication. The McLaughlin and Mayhorn model (2014) is based on the previously developed C-HIP model and views on risk perception and environmental considerations stemming from the research contained in this thesis; hence the McLaughlin and Mayhorn model considers the role of the environment in risk-communication design and evaluation. Conceptual models have thus far been used in the literature to describe the overall research on warning interactions, as highlighted throughout this thesis. Some of these models were relevant to developing the present study; they are listed below and outlined in Table 8.1:

- **HF Model 001:** The communication-human information-processing model (C-HIP) (Wogalter et al., 1999).
- **HF Model 002:** special populations (older adults) (McLaughlin & Mayhorn, 2014); defines risk communication source credibility;
- **HF Model 003:** Design and evaluation guidelines from Waterson & Monk (2014) as well as the flowchart developed from the authors outlining the research of design and evaluation activities (based partly on the work of Keates and Clarkston [2004, p. 154].
- **HF Model 004:** methodological development health communication literature (Lewis et al., 2009); results from the reviewed literature, highlighting key studies and synthesising and comparing results;
- **HF Model 005**: Adapted risk management framework: The systems approach to risk communications for young children developed by the researcher and based on McLaughlin (2014). and other research listed above.

It was found in the present study that previously developed models, for example the C-HIP model (Wogalter et al. 1999), discussed within the literature review and other sections of this thesis, have not been developed to explicitly take into account children's attitudes and behaviour explicitly, or other unique needs such as the concept of adult-child interaction. Therefore, the McLaughlin model has been adapted using the present study's findings to develop a more holistic or systems-based view of risk communication for children that integrates all aspects that the designer should consider. These aspects include the following:

- Beliefs and behaviour;
- Environment; and
- (Receiver characteristics) The information available on the individual factors that may affect children's interaction with warning or risk communication.

The factors identified in the literature include cognition, attention, perception, memory, and decision-making; body size, strength and dexterity; and the ability and willingness to process and react to information, and caregiver interaction. Detailed knowledge of the intended audience allows the message designer to select appropriate communication objectives, to contextualise the messages correctly, and to deliver them through communication channels frequented and preferred by members of the audience.

The following section describes the risk management framework within the broader context of the human factors integrated structure of risk-communication design. The framework brings together previous work on caregiver supervision and on the active components of caregiver decisions regarding injury prevention strategies. The key aim of the framework is to highlight the relationship between the variables in designing risk communication that better meets the needs of young children. The proposed risk management framework emphasizes the variables and fills the gaps identified in previous studies (for example, Waterson et al., 2012; Waterson & Monk 2014) to establish and build upon the previously developed design and evaluation guidelines and consider them in a broader context. The included models commonly describe the first stage of risk-communication development, concerning identifying the needs of the group encountering the risk. In this way, empathy with the user is established and user requirements are assessed in the early stage of development of the communication. Designers thus have a better understanding of the target audience and are able to better empathise with their needs. Furthermore, they can assess the user characteristics of the child during the required stages of development, his or her cognitive level, and perception of risk. The 'theory' discussed in the present study represents various barriers and challenges to effective communication, trust, and credibility pertaining to both individual and organisational factors, the message, and the medium for communication. The 'effect' describes exactly how the theory is applied to communication.

8.4 Contribution to knowledge

The contribution to knowledge of this study is twofold. Firstly, it contributes to the steadily growing literature on safety considerations and risk communications in the context of design for children, both theoretically and practically. Secondly, it has translated theoretical knowledge and its contribution to design for children (Input to practice (tools) 8.3.1) into a more accessible format for those involved in the design. In addition, it has developed relevant communications into a practical toolset for applying this knowledge in practice (8.4.3). In this context, this study has developed a strong evidence base, bringing a much more holistic and accessible knowledge base to the designer on aspects such as caregiver interaction, environment, and lesser-known development stages. The outcome of this study can be better integrated into design processes via a risk management framework and proposed persona tool. Furthermore, this study explored the development of human-factors methods for children to enable the transfer of theoretical knowledge to design practice. Thus, it makes contributions relevant to developing appropriate risk communications and safer design for children aged 5 to 11.

8.4.1 Summary of research questions

This study aimed to determine effective strategies for interventions for childhood unintentional injuries by identifying and raising awareness of the components of design and child characteristics. This was achieved by implementing other relevant components derived from the literature, and studies contained in this thesis for example, the elements of caregiver supervision. Furthermore, by answering the research questions proposed in Chapter 1, an original contribution to knowledge is the Risk Management Framework and card tools, including the child-based personas.

8.4.1.1 What resources are available to designers when designing for children?

A comprehensive literature and resource review was conducted. This consisted of documentary analysis of recommended reports provided by external experts; media items on the subject; and child-safety websites, which provide an overview of previous work regarding unintentional injury and the developmental stages of young children.

This identified knowledge gaps, such as the lack of an evidence base for young children, and determined further research questions.

- Literature review (Chapter 2): This chapter addressed the current and previous perspectives on child safety, gaps in the existing body of work, and how to consider the theoretical inputs concerning adult groups in the context of young children.
- Resource review (Chapter 4): What types of tools and resources are currently available for designers when designing for children? What types of information was the researcher able to source from academics and practitioners?

It was found from this review of the literature and research study that there was a lack of uptake of resources used in design. The information is limited and often outdated there was a lack of resources that cover internal cognitive processes of children as they are not easily integrated into everyday design practice.

Based on the resource review, a framework was developed for the design and evaluation of risk communications for young children. This served to fill a gap in current knowledge about young children's developmental abilities and other characteristics.

8.4.1.2 What do designers need?

Chapter 5 detailed a comprehensive study to identify designers' requirements. Semi-structured interviews were conducted with 30 designers. The discussion guide was created using components of the risk management framework developed by the researcher, to gather further insight into the multiple factors involved in considering children in design. The conceptual model was tested against the findings for the user study. This showed that the model provided useful attributes of the various factors that constitute integrating children and caregiver characteristics and other variables into design.

8.4.1.3 How can various relevant theories be used to support designers of risk communications aimed at young children and their carers?

Caregiver components are integrated into the Risk Management Framework. These consider the caregivers and their role or involvement in the design process, their

interactions with children, and effects on the risk-communication process. The division between theory and practice is apparent in the area of risk communications. Theorists in the field of communication and other related behavioural fields have advanced many essential theories about warnings and risk communications. However, some of these theories should be explained in a manner that clarifies their practical value in design for child safety. A framework is a structure given to support or enclose elements (Collins English Dictionary 2011). In this case, a framework was used to encompass methods created to support designers or other professionals in the target community. As previously discussed, the studies carried out by the researcher, confirmed that the proposed methods are of value and appropriate, but also highlighted the need to revise and expand the framework, considering additional insights and feedback.

8.4.2 Contributions to theory

The results of this study add to knowledge derived from the previous empirically related guidelines and research on methods with children (Waterson & Monk., 2014; Waterson et al., 2012). The study contributes to knowledge about the target audience of young children aged 5 to 11 (child characteristics) and about caregiver supervision. Waterson et al. (2012) and Waterson and Monk (2014) found that there was a need for further behavioural testing and evaluation with this group of young children. The present study builds upon available methods aimed at designers for testing and evaluation with young children aged 5 to 11. Furthermore, this work translates the risk communication knowledge of previous research into practice with the development of the framework and tools relevant to practice.

The proposed risk management framework integrates the identified literature and fills the identified gaps therein for a holistic approach. The new framework strengthens the integration of state-of-the-art knowledge on risk communications. Its use is demonstrated in a walkthrough of the model in the context of a medical product and accompanying information about how it might be applied in practice. As the literature lacks both rigorous empirical evidence and evaluation research, this theoretical contribution is a step towards building on the previous work of Waterson and Monk (2014) and Waterson et al. (2012). Theoretically, the integrated model addresses the gaps identified in the literature review in considering children and caregivers. The model integrates methods for behavioural testing with children and caregivers within the process of risk communication design. The basis for the proposed framework is

McLaughlin and Mayhorn's theory of risk communications for older adults, which according to the authors applies to capabilities and limitations of older adults in the interaction between humans and almost any kind of product or system (McLaughlin & Mayhorn, 2014).

8.4.3 Practical application: tools

The toolkit has been mapped out and developed throughout the chapters based on each of the results of the study. Many tool components, such as personas used in the industry, have not been used comprehensively in the context of risk communications aimed at young children aged 5 to 11. An example walkthrough user journey is used in Section 8.5, in the context of a medical product and accompanying risk information, to illustrate how the proposed integrated framework and tools may guide the design and evaluation of risk communications aimed at this group. The tools must be agile enough to allow the user to apply them to different scenarios and in different ways, and to permit the designer or other members of the target community to focus on specific elements of risk communications when required. For example, the tools may be applied with a medical product intended for use by a seven-year-old child, as described in the walkthrough in the user journey from Section 8.5. Another example would be in an environment such as a playground, where the tools need to have the breadth of focus to cover the relevant psychological factors, such as those that underlie the decision to comply with the risk communication. Furthermore, sometimes caregiver interactions need to be reflected in interacting with a risk communication or product, in which case the tools need to allow the designer to control the output appropriately, as discussed in Chapter 6.

The tools described in the resource review in Chapter 4 are the go-to resources for designers; however, the results show that they are lacking in some of the elements required by designers and other groups to design risk communications. Furthermore, the findings also indicate that it is necessary to create a much more holistic and systematic resource to make it easier for designers and other members of the target community to use it. The present study has developed the relevant tools, but live project work would help to further improve them. More time will need to be allocated to build the toolkit and more accurately meet users' requirements. The Risk Management Framework shows how the tools applied throughout the project lifecycle can be both flexible and efficient.

The specific example in Section 8.5 describes the user journey. It details a walkthrough of how the tools might be used in practice to guide the design of a medical device and accompanying instructions for use by children at a specific developmental stage. The walkthrough example demonstrates that different tools can be chosen at each of the major stages, depending on the type of project and the sorts of considerations. Section 8.5 illustrates the user journey and intended interactions of those involved. The final version of the risk management framework presented in Figure 8.1 (Section 8.2.4) is a way to support researchers in coordinating a more structured and considered approach to design for child safety. The framework provides this support by introducing aspects that are relevant for child development, design, and evaluation, and by providing information on the possible impact of each element on the outcome of the child and caregiver interaction. An accurate definition of objectives and selection of techniques, participants, and resources for the session contribute to optimising the benefits of the design practice concerning the invested effort and in line with the results of the interview and observation studies (Chapter 5). Thus, by being supported in the process of defining and organising the process, practitioners can achieve results better aligned with their goals and useful to their design. In the following, a hypothetical scenario illustrates how the framework can be implemented within design practice.

It is essential that all guidelines be organised into a flexible framework that retains the relationship between these guidelines and underlying theory about child-warning interaction. In this way, it is much clearer which existing guidelines can be used, where they need to be made more specific for this type of product, risk communication, and user group, and where possible gaps may be. For designers, the framework also provides an accessible overview of all guidelines. The proposed unifying framework is based on McLaughlin's model of risk communications for older adults. This model is commonly used for the evaluation of risk communications for older adults, but is used in a novel way here to help design and evaluate risk communications for children, and structure the design guidelines. Further evaluation of the tools used in-situ is required, as the intention is for the integrated model to be applied in designers' everyday working practice, allowing practitioners or other professionals in the target community to follow the risk-communication development process to improve communication effectiveness. The framework and tools used in this way will help to implement age and context-appropriate communications and designs that better consider children, caregiver, and environmental components with the potential to reduce the number of unintentional

injuries. The user journey describing the deliberate steps are described below and further illustrated in Figure 8.2.

Outcomes of the research into human-factors integration (HFI), previously discussed in Chapter 5, demonstrate that one barrier to the use of methods is that they are time-consuming and expensive (Waterson & Lemalu-Kolose, 2010). Human-factors integration is not easy to achieve, and the findings show this to be the case in design for child safety too. Approaching risk-communication research from a systems perspective enabled the researcher to include individual, organisational, technological, and environmental factors that might be considered to influence a child's interaction with risk communication at each stage of development. The risk management framework was developed in this study to overcome such barriers by introducing the opportunity for better integration into design practice. The established framework encourages the identification and prioritisation of areas relevant to safe design for children. Prioritisation in this sense may increase efficiency and produce better safety outcomes, as discussed in the following section.

8.5 User journey

This section demonstrates how the tools work in conjunction with the risk management model, and how the tools can be used in the context of design practice. The example presented in this section uses the proposed child-persona card tool, illustrating a seven-year-old female and detailing her cognitive abilities, specifically language and thinking skills (see Figure 8.3). The first step is as follows:

- Stage One: The designer needs information to aid in designing the appropriate risk communication.

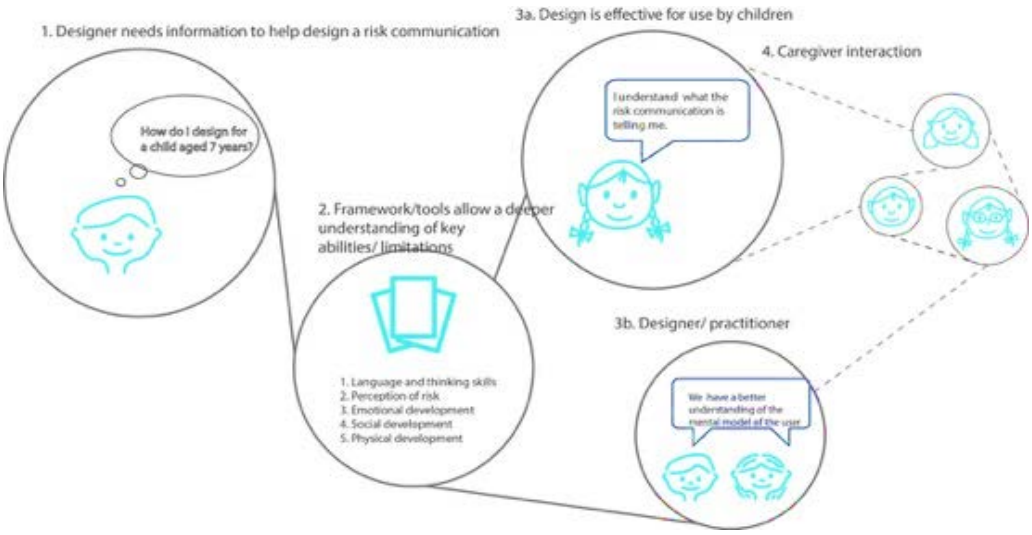


Figure 8.2 Proposed user journey

Findings from the interviews presented in Chapter 5 revealed that at this stage in the process, the designers find current information sources challenging to use, as they are often displayed in large tables and fragmented. Designers are also unsure of where to find these sources. Moreover, there is a lack of common understanding, which creates a barrier between the different groups involved. The tools need to be agile to allow access to information and sharing of this information among other professionals in the target community who are expected to understand children's needs. An example walkthrough has been illustrated in the user journey (Figure 8.2). In this example, the designer requires support for designing for a seven-year-old child.

- Stage 2: The framework and tools allow for a deeper understanding of user characteristics.

Framework: The first part of the model prompts the designer to gather information on child and caregiver characteristics that may interfere with either the child's understanding of or compliance with risk communication. User characteristics of a seven-year-old female have been collated from the research.

Table 8.2: Children's needs (aged 7)

Source	**Characteristic**	**Children's needs**	**Design considerations**
ISO/IEC Guide 50:2014	**Exploration strategies**	In this age group, children are often interested in testing the limits of objects by increasing the risk involved in using them.	This may mean that they are at more risk of breaking the rules.
ISO/IEC Guide 50:2014; CEN/CENELEC Guide 14 (2009)	**Language and thinking** **Familiar pictograms and keywords** **General warning signs**	Can converse at an almost adult level and reading may be a major interest. Very simple pictograms and key words recognised by some children. Children may understand some warning signs.	Keep language and pictograms very simple so that they can be recognised and understood. They may include some simple key words. Children may be able to recognise conventions of warning signs e.g. colour, shape.
CEN/CENELEC Guide 14 (2009)	**Verbal warning, demonstrating or discussing potentially hazardous events**	Demonstration of a potential accident (or explanation of a 'near miss') may convince, but not if it contradicts experience.	Consider previous experience of hazard exposure; if there is limited experience use a realistic demonstration.

The research suggests that adult characteristics are an essential consideration in the design of products and risk communications. Caregiver characteristics, including the

level of supervision, is a component that may interfere with the child's interaction with a product, for example, his understanding of or compliance with risk communication. Table 8.3 Caregiver interactionTable 8.3 describes caregiver interaction in the process.

Table 8.3 Caregiver interaction

Source	Caregiver interaction	Design considerations
CEN/CENELEC Guide 14 (2009).	Perception of risk-passive state/ active state Children are still developing basic skills but are gradually subject to less supervision.	Although this age group is subject to less supervision, behaviour might still be impulsive and unpredictable. Injuries may be caused in the home environment.

In this scenario, the cards are introduced to the designer and other professionals in the target community at the start of the project. The user looks at the cards showing the design stages and sees that children's physical and cognitive abilities would be useful at this stage to identify the typical internal safety strategies and potential risks for that sub-group, including the stage of development. Theoretical and practical inputs from the risk management framework and advanced tools allow the designer to develop a better knowledge base and a deeper understanding of the key abilities and limitations of young children. The dynamic determents of risk communication displayed on this example persona card show the characteristics relevant to comprehending a seven-year-old child's understanding of risk. This example shows language and thinking skills, indicating that at age seven, children are interested in reading and can converse almost at an adult level.

Figure 8.3: Proposed child-persona card tool

Further cards show other areas relevant to designer understanding, including but not limited to:

- perception of risk;
- emotional development;
- social development; and
- physical development.

- Stage 3a: Design is effective for use by children. Children understand what the risk communication is telling them.

Another consideration for the design of risk communication is the channel of the communication, or how the message is communicated to the target user group. For example, a seven-year-old child may not have access to a mobile phone, whereas older

children have more extensive access to phones. Thus, app-based communications relevant to an older age range may not be appropriate for younger children.

- Stage 3b: Designer understands and better empathises with children's needs.

In applying the tools in practice, the designer (or other professional in the target community) develops empathy for and has a better understanding of the mental model of a seven-year-old female's understanding of risk, and thus her potential interactions with risk communication. In this step, the tools allow the designer to empathise with the characteristics of the users of a product or risk communication that can lead to the presence or absence of a hazard. This requires an understanding of child development, a characteristic that changes rapidly and can vary considerably between children of similar ages.

- Step 4: Caregiver interaction and knowledge of characteristics of children can be integrated into the designer's process.

The final design is now developed. This scenario shows how the use of the cards could provide relevant and appropriate information when developing risk communications aimed at young children and when implementing safe design. The cards facilitate the integration of human-factors knowledge into design and use a common vocabulary to create a shared knowledge base and empathy for the related, yet distinct groups involved.

8.5.1 Which theoretical perspectives are useful for enhancing the user-focused design when designing for children aged 5–11?

The Risk Management Model was developed by the researcher, and components of the model were integrated into a child persona tool for formative evaluation. Rather than being a prescriptive model of the process, this model is presented as a conceptual tool that can be used for both planning and understanding design processes for risk communications and wider considerations of product safety in considering children. User requirements were considered in the design of the persona tool and evaluated using

an online assessment, as presented in Chapter 7. This contribution relates not only to the identification of key theoretically and empirically supported constructs but also, and perhaps most importantly, to offering guidance regarding how such constructs may be used to inform message content writing and subsequent evaluation. Knowledge of the risk communications environment of the intended audience of young children, and further understanding of caregiver interactions allow the message designer to select appropriate communication objectives. Communication objectives may include contextualising the messages correctly, and delivering them through communication channels frequented and preferred by members of the audience.

According to the literature, the interpretation of risk communication aimed at young children is a mutual interaction between a child and his caregiver (Waterson & Monk, 2014). Indeed, supervision has been identified as an essential component in the reduction of the number of unintentional injuries to young children (Morrongiello et al., 2009). A model of caregiver interactions relevant to supervision, presented in

Figure 2.13 in the literature review, is a conceptual model representing caregiver decisions about injury prevention strategies (Saluja et al., 2004). Caregiver interactions are integrated into the framework, such as the effective determents of supervision and the social and cultural context considered significant in the development of relevant risk communications.

As discussed in Section 8.2.1, the additional ergonomic design and evaluation principles in the context of children's characteristics integrated into the framework provide a way to organise the findings into a systems-based model that considers children and provides a means to overcome the lack of knowledge. The holistic risk management framework and tool would be a valuable resource for designers. It builds upon the findings and expanded framework of the systems risk management model presented in Figure 8.1 by incorporating design with ergonomic principles. The updated model adds HF/E design principles with a layer of colour coding that supplements the three categories of risk-communication design and evaluation: children, caregivers, and environment. As shown, a range of interventions include all the HF/E ergonomic design principles, as well as the subcomponents of the physical environment and caregiver interaction. The organisational considerations are marked by a prevalence of decision-making interventions, whether associated with communication, culture, or age. Age-related interventions focus primarily on the child and span a range of the human factors or

ergonomic design principles. Gathering information on children's physiology may also add some value to new methodologies to increase influence of new technologies and the possibilities these afford for presenting information in different ways, for example context-sensitive, sensor-driven, ambient warnings (Wogalter and Mayhorn, 2006).

8.5.2 Development of risk-communication theory in the context of children

The developed risk management model has simplified the research from risk communication design and child development, and combined theory-grounded and audience-centred approaches to safety and risk-communication design, contributing to the steady progress in the field for children in the age range of 5 to 11. McLaughlin and Mayhorn's model (2014) has been developed and verified using both the resource review and interviews with designers. To date, it is not easy to determine how theory relates to the realities of the practitioner's world (Maibach & Parrott, 1995). Besides a lack of research examining children, there is an over-abundance of useless and confusing information in the environment, much of which lacks evaluation. This information lacks any concrete guidance to accomplish communication objectives for practitioners. The present studies contained in this thesis have demonstrated a need to develop much more holistic guidance, mostly due to uncertainty surrounding who the users of the tools would be, with results revealing a highly diverse user group involved in developing risk communications for young children.

8.5.3 Considering children in previous models of risk communication

The key aim of the framework is to highlight the relationship between the variables in predicting interactions of risk communications in the context of young children. Some of the literature on source credibility, risk communication, and children constituting the building blocks of this model is discussed as the starting point for the general framework for the tools. However, the evidence-based research behind the toolkit development needs to be evident to users, as it was generally reported in Chapter 7 that users would like to know the evidence-based process behind developing the child-based personas.

This section discusses the relationships between variables and proposes an integrated model of the conceptual framework between the variables to fill in the gaps identified in the literature and resource review. The three empirical studies outlined in this thesis aimed to establish a new context of design for child safety by filling in the gaps and implementing something that will be usable in everyday practice.

The difference between existing techniques for creating adult personas and the proposed method for developing the child personas is the use of a framework. The framework integrates previously developed guidelines and research to make them more efficient for the designer to use. Traditionally, a framework is derived from a theory or set of assumptions about a phenomenon. In design, frameworks have recently been based on design experience and generalisations from user studies (Rogers et al. 2006). The child-persona framework results from theories (about children and adults) and practical experience (about what is essential to know about children in design). It can be used to help designers understand children and provide a structured and responsive way to inform, and to better document the creation of age-appropriate risk communications. The three dimensions of the framework are:

1. Childhood needs (developmental abilities);
2. Environment; and
3. Caregiver.

These dimensions are reusable for multiple projects. They are based on theoretical understandings and empirical findings taken from children's developmental psychology. Children's developmental abilities and limitations are included in the framework to ensure that the risk communication is matched to the capabilities and limitations (cognitive requirements) of its intended audience. The second dimension is project-specific and explores experiential risk-communication goals dependent upon the environment.

8.6 Holistic (360 view)

This section discusses the framework's purpose with regard to both research and theory. The theoretical approach of the thesis advances HF/E through a participative framework. Chapter 6 reported the core theme of the findings in the literature to use and develop design tools, to address gaps in the existing design culture, and to use the

evidence base. Translation of theory across to design practice was understood by identifying the need for a child persona tool to integrate safety into designing for children. Understanding the user is widely recognised in design, and an interdisciplinary design team is commonly used in designing for children meaning there is often a lack of definition of terminology between stakeholder groups and thus inadequate guidance. Therefore, an additional literature review was conducted to explore design guidance and evaluation techniques concerning children.

The researcher developed the framework based on existing theories related to risk communications and warnings. Furthermore, the framework used McLaughlin and Mayhorn's theory of risk communications for older adults, which applies to the capabilities and limitations of older adults in the interaction between humans and almost any kind of product or system. Instead of being a prescriptive model of the process, the risk management framework developed by the researcher is presented as a conceptual tool that can be used for both planning and understanding design processes in relation to risk communications. Section 9.4 in Chapter 9, discusses recommendations for other applications. The risk management process is outlined in a systematic format to fit with the usability engineering process:

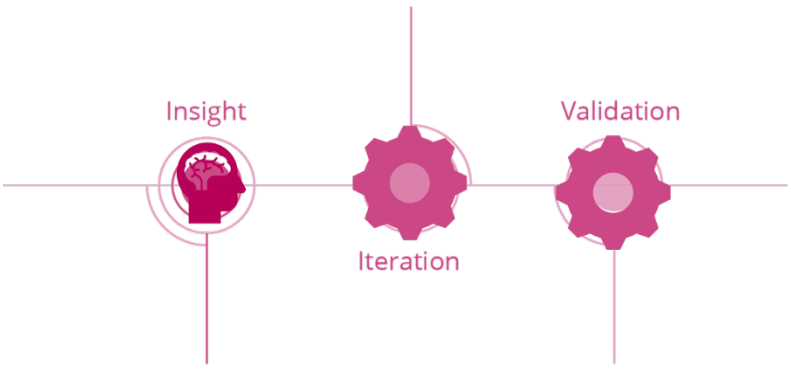


Figure 8.4 Development process

It is a multi-perspective approach that requires the consideration of all product life cycle environmental impacts. This means that safety is the responsibility not only of child-safety professionals, but also of designers, engineers, marketers, and all those responsible for new product development. The risk management model should prompt these groups to think about the following questions:

- Is the product safe?
- What potential hazards are associated with this kind of product? (i.e. bath seats, drowning)

- How does this product address the hazard?
- If not, what types of safety information and labelling are needed to address the hazard?
- How could it fail, and could a failure mode cause injury?
- How will it be used?
- How will children/caregivers interact with it?
- What is the size/shape/strength of the user, and what is the environment?
- Can it be designed better?

The last stage of the model suggests that the organisation should develop procedures to review and improve design and evaluation and testing, with the aim of improving the overall safety of children. Each phase of the approach uses specific tools to make safety issues more visible. Furthermore, each phase helps designers make trade-offs and choose specific actions when addressing safety issues. In addition, other appropriate tools can be adapted to accomplish each phase's purpose. Thus, the approach becomes flexible enough to support the designer in practice.

8.7 Summary of contributions

The framework offers a significant contribution to risk-communication design and practice. This contribution concerns not only the framework's identification of key theoretically and empirically supported constructs, but also, most importantly, the guidance the framework offers on how such constructs may be used to inform message content design and subsequent evaluation. The following chapter concludes the thesis and outlines a roadmap for future work in the field with the potential to build on the findings and further advance research and practice in this area.

Chapter 9: Future work

9.1 Introduction

This final chapter details the general conclusions of this thesis and outlines a roadmap for future work.

9.2 Overall conclusions

Through qualitative data collection and analysis, this thesis identified a number of important criteria for design tools. In conclusion, the importance of developing holistic tools for industrial designers is recognised. This study has shown that a combination of integrated knowledge from warning theory, available guidance, education, and information, along with considered content, appropriate presentation, and easy access, are all critical to the success of such tools. Furthermore, this study explored the requirements for designers and other professionals in the target community for an improved form of support, and to potentially reduce the number of accidental injuries among young children. The findings of this thesis make several contributions to the area of risk communications to young children and design from the viewpoint of child safety. The development of 'working tools' explored the need for an industry-academic partnership as a way of catalysing future collaborative work within the wider area of 'evidence-based design' to translate the work into a suitable form that will support the implementation of inclusive design within the industry, i.e. promoting knowledge transfer regarding design for child safety. This study has shown that designers encounter obstacles in finding the relevant information, and lack sufficient support when designing safety communications for children aged 5 to 11. The main conclusions of this thesis are the following:

- Theories of human behaviour and communication processes provide half of the necessary information for the effective design of a health communication message. The other half is thorough knowledge of the target audience.
- The literature shows that children and safety-risk communications are complex issues with a lack of empirical grounding.
- In considering the target audience of children, understanding their capabilities, limitations, and caregiver interaction is a step towards helping designers to

apply some of the developed and new knowledge into practice when developing safety information.

- There is a lack of support for translating theory into practice. The tools developed in this thesis integrate the knowledge about children, caregivers, and other environmental considerations.

Evaluation is needed with designers on a live project to test and further develop the tools. Due to the lack of empirical grounding, methods that work to efficiently support designers in practice are limited. Many practicing designers are unaware of certain resources or fail to see value in them as they are outdated. Otherwise, these resources may also simply be too costly for the company to buy updated or newer versions as they are released. This thesis identified a distinct lack of research and theoretical inputs pertaining to young children. Thus, several gaps in knowledge were found, and the research activities in the present study sought to address them. The field of risk communication has developed comprehensive theories; however, it had proved difficult to translate this theory into practice. While answering each of the research questions discussed in Chapter 8, the researcher tested the sub-arguments that make up this thesis and form the base of this investigation. Using the results, the researcher formulated the proposed set of guidelines and concept tools.

To answer the questions outlined in Chapter 8, it is possible to derive credible, dependable, and useful guidelines for the design of risk communications for children using psychological theories of child development and existing risk communication theory from the literature on adults, as well as existing guidelines and usability principles. The integrated framework organises the resulting guidelines and supports the conclusion that it is possible to integrate design-related factors from different theoretical fields and research disciplines into one coherent and useful structure.

9.2.1 New knowledge

The distinctive product of this thesis is the concept of support tools and a framework of guidelines, collected from different knowledge domains, for the design of risk communications for young children aged 5 to 11. New research results on risk communications are continuously being published in academic journals or conference proceedings. These have recently focused upon new methodologies to examine warnings. There is value in this, but from a general design point of view there are usually many aspects to consider, and few designers will take the time to search for and study

all academic publications that are relevant to their design. In addition, no other researchers in the field of risk communications have attempted to do what the present study has achieved: namely, to draw together a broad range of research topics such as children's cognitive development and acquisition of specific cognitive skills relevant to risk-communication design in the context of young children. When considering the existing guidance and previous knowledge in the area, this thesis contributes several elements:

- With regard to the research process, this thesis demonstrates that a systemic review of resources provides a useful source of knowledge relevant to developing tools.
- The thesis provides a theoretical grounding of age-related guidelines.
- From a scientific point of view, the most important contribution lies in the integration of different fields of research, namely psychology, risk communication, and warnings.

9.2.2 Practical implications

The proposed models from this research and guidelines from previous research within the literature were the foundation for the evidence-based persona tools, resulting in a much more practical application for designers. By applying these tools, developmental stages and theoretical knowledge in the field become much more accessible to designers for children and to researchers in the field. Chapter 8 demonstrated a practical application of the results, with an example consisting of a walkthrough of how the tools could be applied to a live project. This demonstration proved that the results could be applied to design and evaluation. In terms of the design for risk communications to young children, the framework can be used as follows:

1. To provide a practical and systematic risk management process in the planning stages of design or when choosing between options any stage of design.
2. As a checklist for designers of risk communications for children aged 5 to 11, to ensure that their designs are developmentally appropriate.
3. To stimulate design ideas.
4. To evaluate and develop prototypes.

The proposed tools are not this thesis's only contribution to knowledge. It has also succeeded in providing designers of risk communications aimed at young children aged

5 to 11 with a solid basis for design in a wider context, and a practical way to apply theory.

9.2.1 Limitations

This study has clear limitations. The first concerns gaining access to a sample of designers and other people involved in design for longer periods of time, and even bringing the groups together. Furthermore, there was no clear starting point for the resources, and it was difficult to identify the varying needs and requirements for such diverse groups of designers through an online evaluation of the tools. The online evaluation only yielded some feedback on the tools, and it would be more beneficial to gain richer in-depth qualitative feedback from designers using the tools in design practice. Nevertheless, the comments allowed for richer insights into fit with design practice and opportunities for a wider application of the research and toolkit. Still, more in-depth evaluation would be useful. A further limitation of this study is that designers and evaluators are not necessarily the same people with the same background or the same working process. Therefore, more research on the best way to present the information for different purposes and further evaluation of the framework is necessary. To proceed in developing this framework, it is essential to describe the combination of findings gathered on children in relation to risk communication design, with a structured method for usability experts to evaluate risk communications for children.

9.2.1 Conformability

Miles and Huberman (1994) describe conformability as a means for testing or confirming findings. The research questions compelled the researcher to collect the data across a wide range of theoretical fields and research areas. Therefore, notes and logs were kept throughout the research process. Furthermore, as much as possible, the researcher ensured that the findings reflected the experiences and ideas of the informants and the participants, rather than the characteristics and preferences of the researcher herself. The methods and procedures followed in this research were explained in detail in the methodology sections in Chapter 3, and the research background was fully described in Chapters 1 and 2. Thus, there is a visible trail throughout the thesis showing how data were collected.

9.2.1 Credibility

The nature of the study and the thesis naturally involved triangulation of data sources. The data sources included a diverse collection, ranging from developmental theories to empirical results in the field of risk communications. The emerging categories of guidelines and tools are well linked to the related theory and to existing frameworks and guidelines (Waterson & Monk, 2014).

This study has integrated the findings from interviews with designers and an early stage (online) evaluation that collected feedback on the initial concept persona as an idea for the tools. Lastly, the thesis presents conclusions and a roadmap for future work, including the further evaluation and development of the tools detailing the steps for an in-situ evaluation with designers.

9.3 Roadmap for future work

Continued development of resources is required to better educate design practitioners and other groups involved on aspects relevant to developing appropriate communications. Since the focus of this thesis was on design research rather than product development, future work could use the concepts defined in this work and further evaluate the concept tools for the purpose of creating a functional tool with which all groups involved in designing for children can interact. This could take the form of card tools (Bekker and Antle, 2011) booklets or web applications (Bevan, 2009). In this instance, the effectiveness of the tool would depend on how the contents of the framework have been implemented to the layout and format of the toolkit to facilitate the user's interaction. The discussion in Chapter 8 addressed the fundamental gaps in both research and practice. However, a number of additional suggestions for further research were highlighted by the three studies undertaken for this thesis. These are discussed in the following sections. The evaluation of the three studies indicates possibilities and challenges for designers to be aware of when designing risk communications for children. Identified gaps include the need for further investigation of the developed concept for the framework and tools. Further work is needed to test their application for designers, since some indication of how reliable or realistic the use of the tools will be in future applications is important for further development. Using this approach, additional knowledge could be gained by choosing more than one suitable project, and comparing the difference between them in applying the tools. Furthermore,

this thesis has highlighted a number of other topics on which further research would be beneficial. The following Sections describe a roadmap for future usability evaluation, consisting of a detailed description of the formative research methodology and detailed methods to use in future evaluation, including *in vivo* naturalistic cases. Moreover, the literature review and table 8 outlined several areas where information is lacking. Table 8 also detailed the development of the risk management framework in relation to the literature. In particular, there is a lack of empirical research, fragmented information, and difficulties in applying theoretical knowledge in practice. The present thesis's contributions to research represent a step forward, but much remains to be considered in further advancing the emerging evidence base. Further studies might for example look to further develop the tools with design practitioners and other groups. Therefore, an ongoing roadmap for toolkit implementation and support is mapped out in the following sections. The main areas for future work identified in the research include further evaluation of the framework, with the opportunity to test the tools with designers in-vitro.

9.3.1 Procedure

A systematic evaluation of the tools will need to be conducted with designers during a live project, from concept creation through to the outputs of design for age-appropriate risk communication. The aim should be to assess the toolkits' impact on everyday practice and design activity. The case study should involve an industry project, for example the design of a product or a medicine bottle and accompanying packaging and information. Another area for future work and evaluation is the toolkit's potential for application to other areas of risk management when designing for children. Phases include tool development and evaluation of the prototype, with feedback from designers about using the toolset with the case studies, and further liaison with researchers, developers, and users.

9.3.2 Usability evaluation

As designing risk communications aimed at young children is a relatively new area, a combination of different techniques that compliment and strengthen the evaluation of the tools should preferably be used. This should ensure that their collective application is more powerful than if they were applied in isolation (Jaspers., 2009).

9.3.3 Sampling strategy

This thesis presents the findings from a research project that aimed to understand the type of requirements that industrial designers have for persona tools. To this end, an online survey was conducted containing the concept prototype of the tools. Through qualitative data collection and analysis, it is intended that a number of additional important criteria for the tools will be identified. The importance of developing holistic tools for industrial designers is recognised. Furthermore, this thesis has identified that a combination of guidance, education, and information, along with well-considered content, appropriate presentation, and easy access are all critical to the tools' success.

9.3.4 Evaluation phases

The usability evaluation should include the impacts of time, costs, ratings of usefulness by designers, and manufacturers' evaluation of any changes in designer's attitudes and behaviour. Furthermore, it would be advantageous throughout the study to consult with external experts from the studies detailed in the present thesis, for example a child psychologist. The roadmap for future work can be broken down into the following phases.

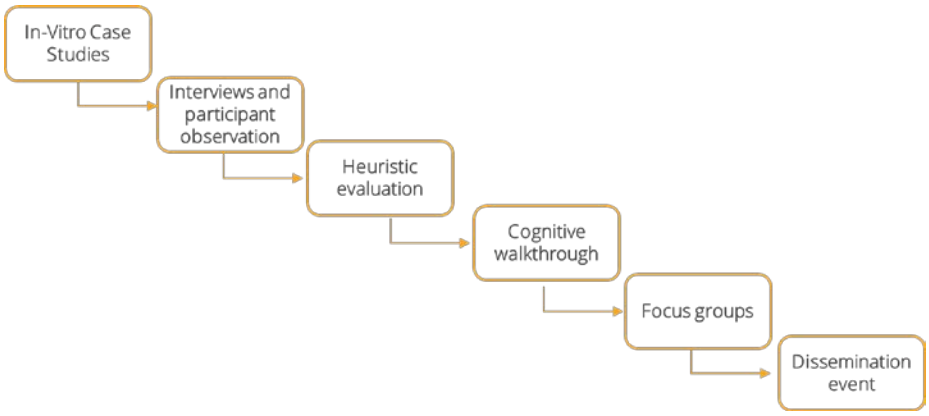


Figure 9.1. Example methods: Roadmap for future work

9.3.4.1 In-vitro case studies

This thesis has shown that there is not one clear starting point for the tools, and that these tools are required to be flexible enough to fit designers' needs and daily working

practice. The developed tools should be further validated in-situ with the relevant sample of stakeholders to observe direct experience in design projects. The aim would be to list the lessons learned in applying the tools, and to review the techniques applied in the field. An appropriate method for evaluating the tools would be to test them with designers who would apply them in a live project. Evaluation of the concept tools *in vivo*, in which the formative evaluation of the risk management framework and tools is done during its application, would follow a case study approach (Yin, 1994). The idea would be to further develop and consolidate the final ideas for the tools in-situ while the design practitioners work on a live project. In-vitro case studies are an appropriate method of evaluating the tools with industry experts. Methods to support a formative evaluation would include protocol analysis. By allowing designers to talk out loud while using the tools, the researcher would gain insight into their thought process and feedback when designing and meeting the requirements of the project brief. For instance, it may be appropriate to determine a child's capabilities and limitations in interacting with a product at each stage of development, and it would be useful to know how the designer is able to consider this when using the tools with limited time to complete the project deliverables.

9.3.4.2 Interviews and participant observation

It may be less obtrusive for designers to use observation during various design activities, and post-task interviews during which the designers could describe their experiences with the tools after completing a set of tasks. Video data of designers using the tools could also be reviewed to provoke comments on the various stages of the process.

9.3.4.3 Heuristic evaluation

Heuristic evaluation is an example of a usability evaluation method that could be applied by the researcher, as it requires the relevant skills and usability experience of the evaluators to produce reliable results (Jaspers., 2009). It has a high benefit-cost ratio (Monique and Jaspers, 2009).

9.3.4.4 Cognitive walkthrough

A cognitive walkthrough is a method in which one or more evaluators work through a series of tasks and ask a set of questions from the perspective of the user (Robson, 2011). The purpose is to find various usability problems. This is a much more structured approach than the heuristic evaluation, with a stronger focus on the learnability of applying the tools to a project. Major drawbacks of the cognitive walkthrough concern the project to which the tools may be applied, the determined level of task detail, and user background descriptions. Allowing designers to think aloud (Ericsson & Simon, 1993) is another direct method suitable for use with the design team to gain deeper insight into the problems that end users encounter when interacting with the tools and designing for child safety. One drawback of using this method is that data analysis is often time-consuming and expensive (Jaspers., 2009). It also requires a high level of expertise in the area of cognitive ergonomics and design for child safety.

Figure 9.2 Evaluation of tools in a live project

Verbal protocol analysis is a method that is extensively used. It has been used to study the cognitive process of engineering students and design activity (Dorst et al., 1995). In carrying out a protocol analysis of a live design process, the developed prototype tools would first be distributed to design companies, with a request for a designer on a live project to trial them in the presence of the researcher. The researcher would ask the designer to talk out loud throughout the process while applying the tools at the set stages of the design. This is a rigorous methodology that would quickly elicit the designer's

thought process in the form of verbal reports. The designer's thought sequences would become a valid source of data on thinking in everyday practice while designing for child safety. Hence, the researcher would be able to analyse aspects of the tools that meet the requirements during the process, and determine which aspects would need to be changed. The problem-solving behaviour of people in design activities is considered an important research theme and has been studied for decades. Given the complexities of design for the user group of young children, verbal reports collected from various experts are a method to explore the ways of thinking of the various groups of designers involved throughout the process of designing on a live project. Studies use the protocol analysis to reveal the problem-solving behaviour of designers, which would prove to be beneficial in attempting to better integrate the various experts involved in considering a complex user group of children. However, limitations of cognitive walkthroughs are that they could discourage exploration, limiting the evaluators' ability to find problems not directly related to the tasks being performed. It may also limit users' experience when they learn to accomplish tasks. Heuristic walkthroughs incorporate a list of user tasks and a list of questions that highlight important parts of the interaction process, in addition to a detailed description of how designers accomplish their tasks.

9.3.4.5 Focus groups

Focus groups provide a fast method of data collection. Using them yields further insights into how and what members of these groups think (Robson., 2011). The present study explored the diverse knowledge needs of multiple groups involved in the process of designing for children. Due to time and cost constraints and differences in views encountered in conducting research with the target groups, a focus group would allow the researcher to ask multiple subjects the same question in the exact same way, making it possible to observe verbal and non-verbal triggers. Where typically a survey may have closed questions, and be conducted individually with subjects, focus groups allow more insights to be gained by simulating a multi-dimensional conversation between the researcher and multiple subjects. Furthermore, focus groups generally provide greater insights than other methods as they allow subjects to provide deeper insights and greater explanation of their answers (Gill et al., 2008). Due to the conversational style of this method, the questions can lead to unplanned topics, thereby providing insights that were not previously predicted or planned. The disadvantage of this is that the focus group can quickly go off topic and be difficult to continually focus specifically on the area of the research question.

9.3.4.6 Dissemination event

A dissemination event would be the final stage of evaluating the final design for the tools, involving a wide range of safety experts and stakeholders from various fields. An invitation would be sent out to the various groups, including safety experts who were involved in the studies reported in this thesis from the Child Accident and Prevention Trust (CAPT), the Royal Society for the Prevention of Accidents (RoSPA), and Trading Standards. The idea of the dissemination event would be to facilitate tool production and finalisation.

9.4 Recommendations for other applications

It is important to note that some of the findings in this work can be applied in other contexts. The thesis explored examples of child safety in the environment (e.g. warning signs on trains) and product design. It may be relevant to consider applying the framework and tools to a wider context or group of design fields when considering young children, for example to improve the safety of products, services, or environments. Furthermore, the framework could also be applied in designing appropriate websites and applications. Finally, it would be valuable when considering standards development to bear in mind generational changes in the way that children interact with technology today. In sum, further applications could include aspects described in the following sections.

9.4.1 Risk management for a wider set of products, services, or environments

The way in which children communicate is changing; for example, children are using computer technology at increasingly younger ages and have become a potential end-user group for tablet applications (Bertou and Shahid., 2014). Environmental changes are also occurring, meaning that design for safety is a moving target and channels of communication are rapidly altering. Changes are not always accounted for due to time and cost constraints. Therefore, the flexibility of the tools for different applications becomes extremely important. Theoretical inputs to design provide guidance for

additional kinds of learning and human development, and these may be applied to different kinds of situations, including the use of new information technologies as tools.

The risk management framework, may be applicable to a wider set of products as the framework is strongly grounded in theories pertaining to developmental stages which considers internal the cognitive process of young children for the purposes of considering the outcomes of a design. The tools could be used for a wider application, in standards development and design to prompt thinking regarding children's needs and abilities. The tools developed from this study aim to act as a navigation aid for designers, as standards are often difficult to understand.

9.4.2 Application for inclusive populations

The impact of the new tools will be societal. Namely, they will increase the awareness and ability of the various stakeholders involved to design safer products for young children. Furthermore, application of the tools will also be relevant for inclusive populations, as the tools offer a range of benefits in evaluating capabilities and limitations of the user group to make products and services easier to use. Longer term, the tools may contribute to reductions in the number of accidents among young children in the UK.

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Appendences

Appendix A - Guidelines (Waterson & Monk.,2014)

A1 Table 1: Summary of the design guidelines developed by Waterson et al. (2012)

A2 Table 2: Summary of the evaluation guidelines developed by Waterson et al. (2012)

A3 Table 3: Modifications and additions to the design guidelines

A4 Table 4: Modifications and additions to the evaluation guidelines

Appendix B - Interview Information

B1: Participant Information Sheet & Informed Consent

B2: (Consent form) Gathering the Requirements for Design Tools aimed at Safer Design for Children (Aged 5- 11 years)

B3: Risk Management Framework and Interview Schedule

B4: Example Interview Transcription [S2-01: Ergonomist]

Appendix C – Online Questionnaire Survey

Appendix A – Guidelines (Waterson & Monk.,2014)

Appendix A1

Table 1: Summary of the design guidelines developed by Waterson et al. (2012)

GUIDELINE	SUB-COMPONENT	DETAILS
Design Prototyping	Preparation	Pilot, test and evaluate your methods thoroughly
	Design and Evaluation	Be prepared to be surprised by what you find (they may contradict your assumptions)
General format	Type of signs	Design the sign with objectives and context of use in mind
Textual aspects	Language	Keep the language used in signage as simple as possible.
	Number of words	Use a minimum of words
	Use of Terminology, Concepts	Avoid 'abstract' concepts or terminology
	Fonts and Lettering	Use large font sizes and consider the use of upper-case lettering
Visual aspects	Pictograms	Use pictograms where possible to reinforce the safety message
	Examples	Use examples of pictograms that demonstrate 'good' and 'bad' behaviour
	Symbology	Use symbology that appeals to children
	Characters	Use safety characters to help convey the safety message

GUIDELINE	SUB-COMPONENT	DETAILS
	Colours	Use colours to reinforce the safety message

Appendix A.2:

Table 2: Summary of the evaluation guidelines developed by Waterson et al. (2012)

GUIDELINE	DETAILS
Preparation	Working with children can be challenging and it is essential to pilot materials and activities with small groups before using them to carry out design or testing. A process of iteration and refinement of the content and format of materials/activities and obtaining feedback from children, parents/carers and teachers is strongly recommended. Time spent gathering ideas and trying out activities with parents and teachers is very likely to be well spent.
Setting	A setting which places the children at ease and the activity can be integrated into normal, daily life is recommended. We found that a familiar setting such as the classroom worked well within our study. In other cases, playgroups or afterschool clubs may also be worthwhile considerations for design/testing activities.
Participants	Children, particularly young children are likely to be shy when in the presence of other adults they do not know. It is worthwhile including a parent or teacher in the study group. The presence of an 'authority' figure can be reassuring for the children and reduce any anxieties they may have. It can also help to maintain discipline when children find it hard to focus on a particular task or when individual children dominate group tasks and the views of quieter children are not allowed to be heard.
Methods	We found that the children in our study responded well to classroom discussions rather than a focus-group format. They found the discussions to be fun and interesting. Small focus groups may be useful with older children, particularly when prototype designs are well advanced and more specific aspects of the design need to be tested. The use of open-ended questions

Appendix A.2:

Table 2: Summary of the evaluation guidelines developed by Waterson et al. (2012)

GUIDELINE	DETAILS
	also helps to stimulate discussion amongst children and may help to generate useful, sometime unexpected design suggestions.
Activities	For younger children it is worthwhile integrating design/testing into a story-like format. Younger children often think in terms of stories and enjoy them. Stories also may facilitate their understanding of the task and help them to generate ideas.

Appendix A.3:

Table 3: Modifications and additions to the design guidelines (additional guidelines in grey, other changes in italics)

GUIDELINE	SUB-COMPONENT	DETAILS
Working with children	Preparation	Pilot, test and evaluate your methods thoroughly
	Design and Evaluation	Working with children can be challenging, be prepared to be surprised by what you find (they may contradict your assumptions)
	Safety campaigns	If the sign within a larger safety campaign, how would the sign complement or fit into other aspects of the campaign (e.g., consistency in terms of colours, characters etc)?
	Additional supporting materials	Consider the use of other media to support safety signs (e.g., leaflets, websites, TV programmes)
Target audience	Age	What age range does target audience fall into? What are their reading levels (very young children (<7 years) will have low levels of reading comprehension)?
	Cultural, national factors	Cultural and national factors may impact the comprehension of signs (e.g., interpretation of characters, symbols; language comprehension – e.g., children learning English as a second language)
	Special needs and disabilities	Some children may have learning disabilities which may need to be taken into account; a significant proportion of children are colour blind

	Gender	What is the gender mix of the target group? Gender may influence the degree to which characters, colour and symbols are interpreted and comprehended
General format	Type of signs	Design the sign with objectives and context of use in mind
Textual aspects	Language	Avoid the use of text in signs where possible; where this is not possible, keep the language used in signage as simple as possible.
Textual aspects	Number of words	Use a minimum of words
	Use of Terminology	Avoid 'abstract' concepts or terminology
	Fonts and Lettering	Use lowercase lettering and consider the use of uppercase for important (signal) works (e.g., STOP); consider the use of fonts which children find easy to read (e.g., Comic Sans); consider the size of the text to be used
Visual aspects	Pictograms	Use pictograms where possible to reinforce the safety message; keep these simple
	Examples	Use examples of pictograms which primarily demonstrate 'good' (i.e., safe and correct) behaviour; examples of 'bad' behaviour may also be appropriate, but be aware that they may encourage children to copy the behaviour shown
	Symbology	Use symbology that appeals to children; consider the use of symbols which are easy to comprehend (e.g., Makaton symbols)
	Characters	Use safety characters to help convey the safety message; consider the use of characters which may be topical and popular with children (e.g., TV characters); avoid the use of characters which may

		be perceived as frightening to very young children (e.g., monsters)
	Colours	Use bright colours to reinforce the safety message; consider some of the association young children may have with colour (e.g., 'red' for 'danger'); be aware that some children may be colour blind
Location	Height	Position the sign in the line of child's line of sight
	Positioning	Position the size where it is likely to be noticed by the child and not obscured or easily confused with other objects; consider the positioning of the components of the sign (e.g., pictograms, text)
	Size	Make the sign large enough to be noticed within its location

Appendix A.4:

Table 4: Modifications and additions to the evaluation guidelines (additional guidelines in grey, other changes in italics)

GUIDELINE	DETAILS
Working with children	Working with children can be challenging – thorough evaluation and testing are imperative. Designing for children is very different from designing for adults. Treat children with respect as they are easily offended.
Preparation	Working with children can be challenging and it is essential to pilot materials and activities with small groups before using them to carry out design or testing. A process of iteration and refinement of the content and format of materials/activities and obtaining feedback from children, parents/carers and teachers is strongly recommended. Time spent gathering ideas and trying out activities with parents and teachers is very likely to be well spent.
Setting	A setting which places the children at ease and the activity can be integrated into normal, daily life is recommended. We found that a familiar setting such as the classroom worked well within our study. In other cases, playgroups or afterschool clubs may also be worthwhile considerations for design/testing activities.
Participants	Children, particularly young children are likely to be shy when in the presence of other adults they do not know. It is worthwhile including a parent or teacher in the study group. The presence of an 'authority' figure can be reassuring for the children and reduce any anxieties they may have. It can also help to maintain discipline when children find it hard to focus on a particular task or when individual children dominate group tasks and the views of quieter children are not allowed to be heard.
Methods	A variety of methods for testing and evaluation are possible, some of these will depend on the age of the target group, as well as other concerns such as the time available for testing/evaluation. One way to

Appendix A.4:

Table 4: Modifications and additions to the evaluation guidelines (additional guidelines in grey, other changes in italics)

GUIDELINE	DETAILS
	test signs is to attempt to mock-up or simulate the environment in which the sign will be situated (e.g., the interior of a train, a leisure centre or playground). Alternatively, it may be worthwhile carrying out a role-playing exercise, where a parent or teacher may be able to act out some of adult the roles alongside children. Young children also respond well to classroom discussions rather than a focus-group format. They found the discussions to be fun and interesting. Small focus groups and interviews (accompanied by a parent, guardian or teacher) may be useful with older children, particularly when prototype designs are well advanced and more specific aspects of the design need to be tested. The use of open-ended questions also helps to stimulate discussion amongst children and may help to generate useful, sometime unexpected design suggestions.
Activities	For younger children, it is worthwhile integrating design/testing into a storytelling format. Younger children often think in terms of stories and enjoy them. Stories also may facilitate their understanding of the task and help them to generate ideas.

Appendix B: Interview Information

Appendix B.1: Participant Information Sheet & Informed Consent

The section below describes the Project Background, Participant Information Sheet & Informed Consent used in Chapter 5 (Study 2).

My name is Suzanne O'Connor and I am a doctoral researcher from Loughborough University, UK. We are carrying out a project to investigate safe design for young children aged 5-11 years. One of the things we have found during our investigation is there is a general lack of up-to-date or accessible Human Factors and Ergonomics methods and resources available, which support safe design for young children. We would like to find out what makes a product safe and if we can create a form of guidance or tool to help product designers and design for child safety.

<Expand if understanding is unclear>

This will be conducted as a series of semi structured questions. It is my responsibility to inform you that you can withdraw from this study at any time without giving a reason, confidentiality will be kept at all time and you will never be named unless you wish. Finally, is it okay to record this and make notes?

Appendix B2: (Consent form) Gathering the Requirements for Design Tools aimed at Safer Design for Children (Aged 5- 11 years)

INFORMED CONSENT FORM

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethics Approvals (Human Participants) Sub-Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about my participation.

I understand that I am under no obligation to take part in the study.

I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.

I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.

I agree to participate in this study.

Your name……..

Your signature……

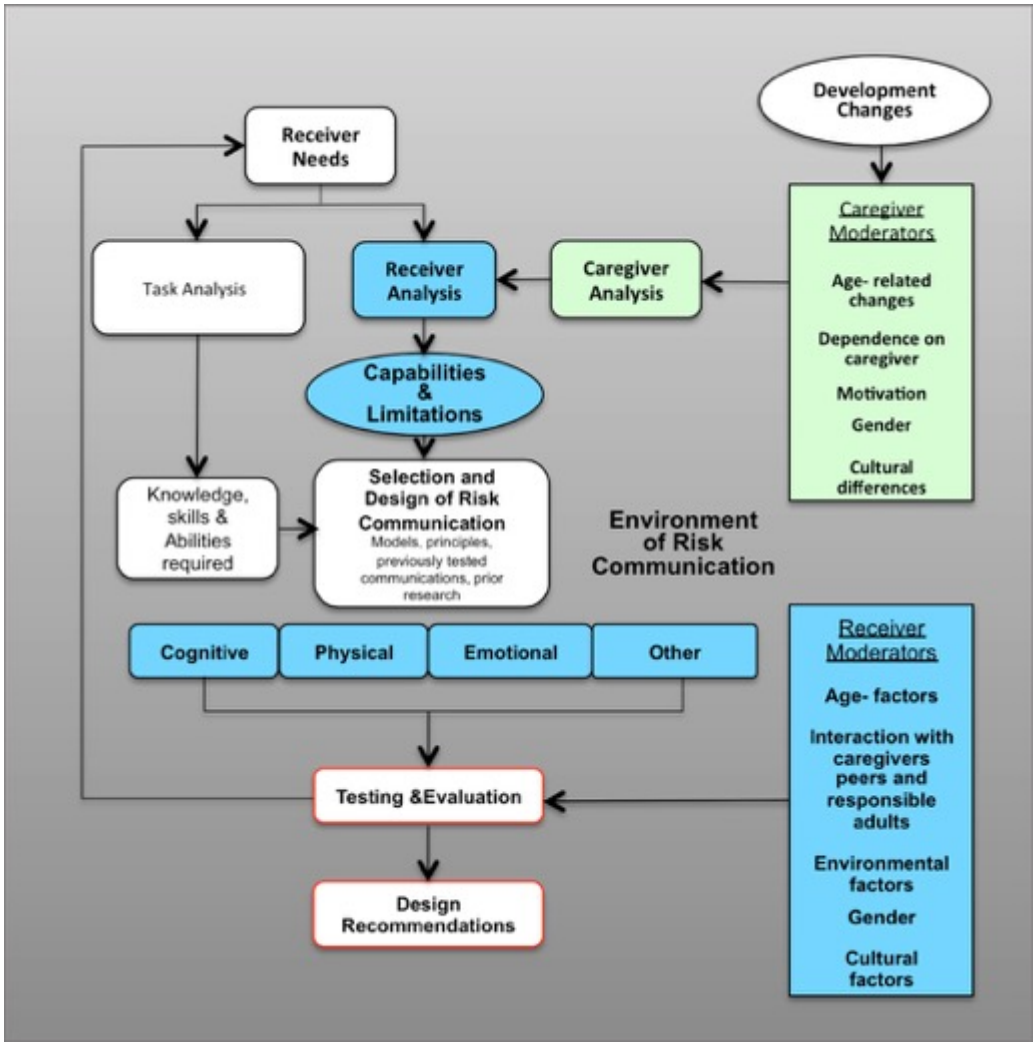
Signature of investigator……

Date……

Appendix B.3: Risk Management Framework and Interview Schedule

The section below describes the interview protocol and model used in Chapter 5 (Study 2) in Gathering the Requirements of the Toolkit Components from Designers and other experts in the Target Community.

Model: A Systems model of Risk Communication for Young Children Based on McLaughlin & Mayhorn (2014).



[Part 1: Background, role, involvement in design for children]

a. What is your background?

b. Position in company/charity

c. What does your current role involve, (job title)?

d. Years of experience

e. Number of employees in company

[Part 2: Sources of Information]

a. How is Design and Evaluation carried out?

b. What sources of information/ resources do you currently use when designing – If any?

Prompts:

- Tables?
- Other resources?
- What stages of the process do you use the different types of information?
- How do you insure that your designs address the needs and desires of users?
- What are the main user research tools and methods you use – If any?
- What do you think is the most beneficial research technique and why?

a. What sources of information would be useful?

c. What methods/ resources (if any) are used?

Prompts: age factors; interaction with caregivers, peers and responsible adults; environmental factors; gender; and cultural factors affect / influence testing and evaluation?

The Model & Components: Show model and explain workings]

After researching literature an initial framework has been created to gather the requirements for the design and evaluation guidelines. This could be further developed and used when in the design phase to evaluate concepts, or later when assessing products for safe design for young children.

[Part 3a: Capabilities and Limitations

Appendix B.3: Risk Management Framework and Interview Schedule

a. What developmental changes are considered – If Any?

b. How do you design/evaluate taking into consideration individual differences?

c. How do you consider/ evaluate young children's capabilities?

d. How do you design with caregivers in mind? Prompt: Caregiver moderators: age-related changes, dependence on caregiver, motivation, gender, cultural differences.

5. Is it possible to walk a design scenario through my model?

- Do you have your own models?

6. What sort of resources/ format/ content/ presentation would be useful?

[Part 3b: Design Recommendations]

a. What is your opinion on the model? How could it be improved?

b. Is there anything missing that the framework doesn't cover?

c. What would you like to see changed/added/removed?

d. What sort of format do designers (evaluators, testers) want the information in?

Prompt: different stages of the lifecycle rather than focusing on single issues (prompt) purpose, the time they take to complete, their format, their nature and their focus.

[Part 4: Further Issues]

a. Do you have any general comments or concerns that we have not discussed

b. Do you have anything else to add to improve the usability/ wording

Finnish: Thank you (Provide contact for follow-up if they have questions or further comments.)

Appendix B.4: Example Interview Transcription [S2-01: Ergonomist]

Researcher	What is your background and previous involvement in design for children?
Participant	I'm an ergonomist by training and an ergonomist in the department and at the moment I'm head of ergonomics at the Furniture Industry Research Association and my background, I have a degree in engineering followed by a masters in ergonomics and I've been working with a number of companies helping to design products, evaluate products and also sit on standards committees, chair committees writing standards for children.
Researcher	How many years' experience do you have?
Participant	I've worked for FIRA (Furniture Industry Research Association) for 25 years, but as an ergonomist 35 years.
Researcher	Number of employees in the company?
Participant	At the moment, there are 60-70 employees and we are even part of a bigger group
Researcher	Sources of information you use when designing for example standards and thing like that I mean these examples are more for child safety?
Participant	Yes I see ISO Gude50, of course I use that and em well depending on which age group especially for children. For children anthropometric data is the key one that you need to use and Fira has been doing anthropometric surveys and so many in 1971 did one and in 2001 I did another one and there is a lot of other data in 2001 we found that children have been growing by 1 cm per every decade so its not stopping its still going on so for that we will use our own data source and also we look at tor other populations we look at is child data which is the only other one and some of DTI, I can't remember the full reference, the strength of children and we use that one as well bec we allow them to turn or operate or not to turn or operate depending on what the design

	issue is so we use those eh there's no other guides basically. Em there is going to be a Europe wide anthropometric study of children in Europe they are just starting and im in part of the steering group so we are looking at all existing data and also find new data and also talk to the standard makers exactly the same thing – what kind of information do they want when they are writing standards so when we are writing standards I know where many of these sources exist from but most manufacturers of course do not even know those things exist or do not even look into it, it its very rare. Yes, so those are the sources I would look.
Researcher	How is design and evaluation carried out with young children? How do you evaluate products?
Participant	So the initial thing we would do is we would check a dimensional find out what age group and what purpose it was designed for and then we do immediately, based on that population group we do a dimensional analysis if it will fit to see whatever the purpose of it is it suitable for that age group you know weight, height and all that sort of thing and then we do what we call a fitness for purpose so what is the invented purpose and we try to evaluate that and we have well its not exactly a user trial but we have children in that actually use the products that they are supposed to use and then we talk to them, we question them and based on that we do a checklist there are no ready-made ones we make it depending on the product and we evaluate based on that our opinion and of course we refer to the standards for safety issues, and if there are no standards them we will make our own guidance.
	Is it easy to involve children in user trials?
Participant	Yes if you don't involve them then it's almost impossible to know because the best thing to do is just let them loose with a product and you

	can see. I mean one time we had a rocking horse that was a high chair so we got some children to come here and we also went to the parents' house to get them to do with the photograph we did questions and get the parents to answer there are no set questionnaires or anything it just depends on what the product is so once we understand what the purpose of the product is then we write a checklist but I guess if there was a guidance of what designers should know, none of the designers know any of that - they just assume, as to how we ask the questions and I guess if there is guidance around that because none of the designers know any of this they just assume – it wasn't high enough there were a lot of issues I'm mean it was a good rocking horse but the minute you take it away from a rocking horse she hadn't really thought about it there's other issues there were a lot of things like you know children will fall off but you know the intention is if it's a highchair you can leave them alone and be ensure that they won't fall of it but this one did not fulfill that quality and so we looked at it and she still hasn't come back with that yet right she still hasn't managed to get it to work.
	It's a difficult process. Yes so I was going to ask you about design, testing and evaluation so I have brought some prompt cards here that are hazards that are relevant to young children. Some of them are not always obvious, so it's things like entrapment, choking hazards, chemical hazards, some of them are more obvious like sharp edges and things like that.
Participant	Yep, those definitely we do because they are covered under, there is a number of standard, I can't remember what it is but you look at for any children's product, there is European directive for these things that asks you to look at entrapment issues, choking issues, thermal issues what else is there ? sharp edges chemical hazards and flammability, which is thermal properties, so there all when you write a standard you have to sort of assess the product based on this, so when we do our own assessment obviously, we check for all those, and say for chemical hazards we don't test everything, we just ask, well there is a toy standard EN 71 which tests for a whole load of list of chemicals anyway, so we say well you aught to get that tested so, but we don't test those but

	entrapment, and sheer and squeeze points and all that information, warnings, we have the biggest business in warnings. I mean I have a problem with warnings that a lot of designers and or manufacturers, I mean this is off the record, try to hide behind it if they can't solve something cover it with a warning and to me that's a cop out you get rid of it as much as you can but on the certain thing that is almost impossible to do, then you use warning and warnings have got to be explicit and visible but what do they do ? they hide the warning to comply with the standard you have to use a warning but its not there, or you have to many, in the case of pushchairs half the book is warnings like 20 pages of warning after warning so im nit going to read all that skip all that straight to the other bit if they ever read it so warnings need to be carefuly worded so it needs to be careful worded and mustn't use too many warnings as too many people ignore the real ones and tell them how it is, this can kill your child
	Who would the blame be put onto as such if the warning was there but was not sufficient or
Participant	Lots of the standards we have lots of warning things in there but im saying that we do not make them strong enough so in a Cretan way certain things are so dangerous that you have to really tell people that it could hurt a child so but we do all times look at all those issues if the design can't overcome it automatically, then we work with the designers to write the warning's - most warnings are specified in the standards, so you have to write exactly what the standard says- if there are no warnings then we try to deliver our own in line with all the other standards.
	How are capabilities of children taken into account when you are designing?

ParticipantV	Em there is no information, I mean even as an ergonomist there is only data, we have the strength of children, not much more than that em and designers don't even have that, I guess you do need to know that, how well, I mean your PhD wont look at young babies but the issue when you design products for babies you need to know when they can stand up or when they can lift themselves up because that defines the product they can use and what they can't use but that again is not available, its easy for 5-11 but they still want to know what dexterity, maybe they but as the strength of what actually they can and can't do and mental ability no one knows what each other is capable of doing there is no point in 11:44 putting a warning that the child is not going to read I think age 5-11, even if they read it they would not know what it really meant so it is difficult.
	Do you use task analysis?
Participant	Ye it is a kind of task analysis we use its called fitness for purpose what is the purpose of what they are trying to achieve, how they are trying to achieve it- it's a kind of task analysis and we do do that yes that's they key part of it that's how we assess it or when we design in it we just write those and then aim to fulfill that yes.
	How do u consider the caregiver in interacting with the product as well?
Participant	It depends on the product, if it involves the caregivers as well, say we do a lot of work on highchairs, you look at the child's point of view and plus the caregiver if it's a product it's who uses it and how, so we were looking at the heights and we put a child in relation to the table and the height of the chair so your looking at the height adjustment of the relationship of the person who is sitting on the chair feeding them. When there's more than one user you think of all those.

Researcher/ Participant	Things like cultural considerations, does this change things, things or the gender of the child? Response: It hasn't been an issue, you know in that age group young 5-11 there isn't that great deal of a difference em probably dimensionally, you would probably need to consider the girls been the taller group and slightly more developed more mentally so we do that but there isn't a great deal of difference but above 11 and of course, Cultural (pause) its very difficult I mean you are aware of it if the product is being sold here or somewhere else then that's almost impossible on this if we all get children from that culture to do it, you kind of get to know things, what's accepted, suitable for different cultures, but there is no information.
Researcher/ Participant	Do you use any models when your designing do you have any process models? We don't design but of course when we work with designers, we start with the sketches, we call this our rooters, people give us the sketch, then we look at the sketch, then we have mock ups and prototypes, then if were happy with the prototype, then it goes into user trials so we do ask them to do the different stages if they work with us, but if they only come at the last minute, an ideal way, you know in most design guides we promote that u start as early as possible so you track the ergonomist and you get them incorporated in the design, rather than modifying it afterwards it works as early as possible in all those stages
Researcher	Which format do you think that designers and evaluators would want a resource in that would help them to understand all this information. What stages of the design process would they require this information. Would any of these help you?
	Em information on children's sizes and abilities where does that go.

Researcher	How do we get this information over to designers without over complicating it?
	Yep they don't want to be told how to design because clearly that's their job, it's the tools, that was the toolkit we toyed with the idea, we did have a project at Brunell university, a card idea, so you just picked up various things depending on the product type, so that's fine, but then all of the designers when we talked to them said well then we would loose them, maby it's a book with just short sharp key things, telling them where to get the information, not so much how to use the information, this is most important, and then you go and find out where that is, or if there is absolute key things, I mean its interesting that they don't know anything about that and what's the other one RAPEX system, which I think for children's products you should do a risk assessment immediately, you know once you've designed it, even if it complied with all the standards, you still need to do a risk assessment but u do need to make sure that there are other risks that the standards may not cover, so you do need RAPEX in there, they wouldn't know what RAPEX is at all.
Researcher	To designer: Do you know RAPEX? It's a free resource from the EU that you actually do your risk assessment online and it gives you answers and its very useful, it's a good risk assessor structure.
	Yes ok then it will work because then they decide how they're going to use it and say ok well that's fine that will work and shouldn't that be before? The design recommendations should feed back into the system em and then this thing evaluation I would have thought it comes after that and then just re do if there are any issues go back to it that's what I would do really switch it around really because your kind of testing well its basically you saying this is what you need to do and then having incorporated that, you check it and whether they have done it, and if the

	designer hasn't, then go back to wherever it needs to go back to and one thing you always need to consider and designers need to know, which is a difficult area, is sustainability, it's the biggest thing that people are talking about and it's the future, and they have no idea where they get the information from so I think its whatever it is that your providing again it will have to at least make them aware of sustainability issues and what is currently available on them. we don't have the answer because there are so many different ways of looking at sustainability, one thing is I guess sustainability is keeping the product for longer periods, if it lasts 20 years its sustainable, so nothing and energy consumption and recyclability, recyclable content and all that, so they need to be because that's becoming more and more of an issue and carers' will eventually buy something that's more sustainable if they are switched on and I think that's the future of it, they really need to know about that At the end of life of the product? How it can be disposed of Exactly yes How it's been disposed of? So what concentration do they think and the choice of materials would be part of that you know if u want something…u use wood and if u want something,, you use paper or whatever so it is the kind of thing that u need to think about how that is going to impact the environment in the end which is all part of a good design as well, and there is another thing as well ok this is not to do with ergonomists but If designers didn't understand the manufacturing technologies of how it can be manufactured they then, the product doesn't get the full idea that the persons had, you know it cannot be realized because they are not capable of understanding it, how it could be manufactured they might say ok well I want to do this but its impossible to manufacture, then uve got to make compromises then u could ruin the product so it is good to know that they at least look for how it could be manufactured or considered at the design process and also materials, what materials they could use and impact on the design, they may have designed it for leather, but u turn it into plastic, it doesn't work, so its that sort of thing

	we said think about what your going to make it out of in the end rather than design with that in mind but just think about your design well how can it be manufactured, what materials you are going to use and will they achieve what you are trying to do that is a big question that we put to them maby that's beyond the scope of yours but that's the scope of ours it's a full scope for designers coming out of college I don't think we've done any standards for eleven year olds we are just doing a new standard its called children's seating, we have to because the European commission has asked us to produce a standard on seating for children from 3-14 years old so we need to write those, we are looking at all those things you've said so that we can assess those and actually identify the risks and see if the product is safe or not so that is going to be compulsory, anyone who produces seating for children in that age group must comply with that standard so
	Things to consider about the age group when interacting with products - forms of risk / misuse – child appealing- accident data- risks-types of accidents that are RELEVANT TO THAT AGE GROUP 2. content – types of information/ data needed on children: motor skills anthropometrics – 3 format the designers would need the information to be in of the information
	It's a more formalized way of doing it yes em do you envisage there's always caregiver in that age group, children aged 5-11 for children's products, yes there will be children 5-11 I think a lot of the products are kind of marketed to adults as well I'm just thinking a younger group then there's always a carer, but as u get older then the carers involvement drops quite a lot Do you think that's less important for this age group?

	Yes pretty much once they're at school they are pretty much independent, they go where they want they sit where they want I mean you're not trying to entrap them, you know put them in cots and things so once they are at school all those things stop I mean yes fine if there are user needs that need to be considered then fine, but I think it is less important for that age group. It is kind of the idea that if u write standards then you know what the issues are and how your going to test to those risks so basically things like chalking so ok if a bit does come off measure how big it is if its small piece or If it's a llarge piece its ok so we ended up with those pushcairs the other day didn't we they had a bar a bumper bar and we have a bite test if its smaller than that then But your age group then its probably not relevant bec there are no choking hazards if they know they will choke on something then they prob wont do it. End Thank you for your time.

Appendix C: Online Questionnaire Survey Screenshots

Feedback on the Persona Tool Concept

This appendix contains screenshots of the online questionnaire in Chapter 7.

Development of an Evidence- Based Toolkit for Designing for Children Aged (5-11 years)

Prototype Toolkit

Firstly, take a look at the prototype of the possible tools (Example: Persona 1), shown below. Please have a look at this and then click on the 'Next' button to begin answering the survey questions based on the toolkit example.

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Appendix C: Online Questionnaire Survey Screenshots

Q 1-2: Background Information

Development of an Evidence- Based Toolkit for Designing for Children Aged (5-11 years)

*** 1. What is your age?**

- 18 to 24
- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 or older

*** 2. How many years of experience (if any) do you have in design for children (aged 5- 11 years only)?**

- None
- 1-3
- 3-5
- 5-10
- 10 -15
- 20 - 30
- 30 +

Occupation Role

Question. 3-4: Coverage & Format

*** 3. To what extent do you think that the proposed child persona is useful in conveying the following information to the designer ?**

Developmental stages (Defined as knowledge of what children are capable of at a certain age i.e. Age- Related Changes)

	Unsatisfactory				Satisfactory
Cognitive Abilities	○	○	○	○	○
Behavioural attributes	○	○	○	○	○
Physical development	○	○	○	○	○
Emotional development	○	○	○	○	○
Role of the caregiver	○	○	○	○	○

*** 4. In the development of a toolkit, what is your preferred format? Preferences of the tools format (select all that apply)**

- ☐ Checklist Matrix
- ☐ Table of Instructions
- ☐ Webpage
- ☐ CD-ROM
- ☐ Online
- ☐ App
- ☐ Mini-booklet
- ☐ Cards
- ☐ Software for laptops

Other (please specify)

Appendix C: Online Questionnaire Survey Screenshots

Q. 5-7: Usability & Compatibility with Design Standards

*** 5. Usability**

	Strongly disagree				Strongly agree
If this toolkit were available today, how likely is it that you would you use this toolkit frequently ?	○	○	○	○	○
I think the tool appears easy to use	○	○	○	○	○
I found the various functions of the toolkit were well integrated	○	○	○	○	○
I would imagine that most people would learn to use this toolkit very quickly	○	○	○	○	○
If these tools were available, I would feel very confident using these tools in a project	○	○	○	○	○
To what extent do you need to know other information when using the tool ?	○	○	○	○	○

What type of additional support ?

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Development of an Evidence- Based Toolkit for Designing for Children Aged (5-11 years)

*** 6. To what extent is the tool too simple / complex ?**

Complex				Simple
○	○	○	○	○

*** 7. To what degree do you feel that the tool works well with current design standards?**

Little effort				Much effort
○	○	○	○	○

Prev Next

Appendix C: Online Questionnaire Survey Screenshots

Q 8-9: Fit with Working Practice

Development of an Evidence- Based Toolkit for Designing for Children Aged (5-11 years)

*** 8. Fit with working practices**

	Inefficient				Efficient
To what extent would the toolkit fit into general working practices?	○	○	○	○	○
To what extent would it help you to design more efficiently?	○	○	○	○	○
To what degree do you think using the tool would speed up / assist with your working process?	○	○	○	○	○

Comments:

*** 9. How well would the information provided in this tool support the tasks you need to achieve?**

Little Support				Good Support
○	○	○	○	○

Is there anything else that you would like to change/add to the content of the toolkit that you would consider useful?

Prev Done