Designing Parental Monitoring and Control Technology: A Systematic Review

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Abstract. An increasing number of children around the world are spending a significant amount of time online today. Unfiltered access to the Internet exposes them to potential harms, which can have detrimental effects in the crucial stages of their life. Parental control tools play a vital role in empowering parents to regulate their children's Internet usage. In this work, we present a systematic review of literature on the design of these tools from the last decade, synthesize design guidelines proposed so far, identify gaps in the literature, as well as highlight future opportunities for the HCI community.

Keywords: Parental control tools· Privacy · HCI · Usable Security · ICT4D

1 Introduction

As the world moves to digital solutions due to the outbreak of the COVID-19 pandemic [32, 43], users including millions of young children are at an increased risk of threats of the online world [10]. As of July 2020, the global Internet penetration rate is 59%, i.e., 4.57 billion people [30]. Approximately 3.6 billion of these users actively use social media today [31]. Children and teenagers form one of the main user groups online, accounting for about one in three Internet users [4]. As the Internet becomes more accessible and affordable, more and more children from various parts of the world are going online, and for longer periods of time.

An estimated 1.5 billion children have access to the digital world today, and participate in a variety of online activities: taking classes online, playing games, and socializing with friends online. The Internet provides great learning and entertainment opportunities for the children, helping them develop an interest in various topics and online social experiences [9]. Children typically access Internet from a variety of devices, including laptops, tablets, gaming consoles, and smartphones. Access to personal devices, especially smartphones, changes when and where children go online, often providing them with a personalized, private, and unsupervised experience [4]. On average, 2 out of 3 children in Europe and Japan own a cellphone with 12 as the average age of acquisition [6]. Similarly, according to one survey conducted in the United States, 95% of the participating teens had access to a smartphone, and 45% of them were online 'almost

constantly'; 92% of them went online daily, and 71% used more than one social networking site [17]. The rate of smartphone usage is also increasing in the developing regions, with teens leading the way in smartphone ownership [71].

Unfortunately, these higher usage numbers also directly lead to higher potential risks ranging from cyberbullying and harassment on social media [1, 16], oversharing of personal information [58], chatting with strangers online, to exposure to inappropriate content online [23]. Parents play a crucial role in the safety of children online, and can employ a variety of strategies to protect their children from these risks [72]. A study involving 1,000 parents in the United States found that 55% monitored their teen's tech usage by limiting when and how they can be online, 39% used parental control tools to block, filter, and monitor their child's online activities on home computers, and 16% used parental tools on their child's mobile phone [15]. Similarly, another study found that half of the the participating parents used parental control tools, content filters, or blockers [5]. The relatively moderate use of parental control tools is not surprising given that this technology can be overwhelming to understand, overly restrictive and highly invasive — creating a rift in parent-child relationship, or can be evaded by children without coming into parents knowledge [7, 33, 38].

This work seeks to understand and systematize the existing body of knowledge around the attitudes and perceptions of parents and children towards parental monitoring and control tools, as well as the existing work on the design of these tools. In the remainder of this section, we first provide background and related work, and then lay out our study aims and research questions.

1.1 Background and Related Work

Parental control technology is a technical mediation strategy employed by parents and caregivers to monitor, restrict, and filter the content their children can access online. Some solutions are moderate, providing filtering of pornographic content, but some tools take extreme forms, giving parents access to their child's SMS and call logs, which can potentially damage the parent-child relationship. Despite the increasing number of children exposed to online risks today, research on the design and analysis of parental control tools is limited. Below we summarize the existing literature reviewing work in this space.

A study conducted in 2015 by Fuertes et al. analysed some state-of-the-art parental control tools and measured their functionality, efficiency, usability, security, and accuracy, commenting little on the design and development of these tools [36]. Through their results, the authors established that parents do not use tools to safeguard their children from online risks and are unaware of the ways they can block content. However, the study reported these findings through a survey, as opposed to parents' interaction with the investigated tools, which can provide a qualitative view and deeper insights into the usability and user feedback on the design of the tools.

Other works, for instance, Pinter et al.'s review focused their research around the stakeholders, methodologies, and conceptual categories that make up the multidisciplinary field of adolescent online risks and safety [66]. The authors

presented a structured review on the topic of adolescent online safety and risks, but did not focus on the existing parental control tools. Similarly, Guerrero et al.'s review on 'Parental Mediation', provided recommendations for parental mediation, such as: careful choice of appropriate content for children, setting time limits on digital media consumption, and constructive use of media instead of passive consumption [44]. Just like [66], the authors analysed the risks and implications of exposure of children to technology but did not review the existing tools and their design.

An overview of the existing adolescent online safety apps, and a study of user reviews of the apps were reported in [77] and [38, 42] respectively, but the studies focused on the analysis of user reviews and did not take stock of the literature studying usability of the tools using an in-person research methodology, thereby missing the user participation view in the tools' evaluation. Further, these studies were limited to apps available on the Android Play store and tested on only one mobile device for the usability testing. Lastly, while Altarturi et al.'s bibliometric study on cyber parental control provided insights regarding the most influential research practices and a taxonomy of parental control tools based on the type of risk, parenting style, content, and filtering approach, the study did not incorporate analysis of underlying design frameworks and in-person research design [14].

1.2 Study Aims

Although researchers have explored adolescent online risks, children and parental perspectives on online risks and safety, and parental tech mediation, no prior work provides a holistic view of research on parental control tools: the users involved, the frameworks employed in designing them, and user feedback on these tools.

In our work, we systematize the body of knowledge around user perceptions and existing parental control tools, and attempt to understand the challenges and future research directions. In particular, we answer the following research questions:

- What are the user (both parents' and childrens') attitudes towards online risks and parental mediation strategies?
- What are the underlying frameworks and study designs employed in the design of existing parental control tools?
- What parental control tools have been designed in the context of HCI4D? (Human-Computer Interaction for Development (HCI4D) refers to research that focuses on maximising the usability of interactive tools designed specifically for under-served, under-resourced, and under-represented populations [21]).

Based on the above research objectives, we seek to develop an understanding of how parental control tools have been approached in HCI research on children's safety. We synthesize the existing literature and present guidelines on how researchers and designers can conduct their studies and design the emerging

parental control tools, while valuing both stakeholders (i.e. parents and children). We cover both stakeholder's perceptions (i.e. parents and children) in our work to study whether the current practices have been reflective of the needs of both population groups.

2 Literature Search Methodology

For the literature search, we followed the process proposed by Webster and Watson [76] (shown in Figure 1). Our review focused on identifying studies focusing on parental control tools' design, usability, or impact, as well as studies covering behaviors and attitudes towards online/tech parental control, online/tech child safety or online/tech parental mediation.

2.1 Systematic Literature Search

Four digital libraries were identified for the search, namely: ACM Digital Library, IEEE Xplore, SpringerLink, and ScienceDirect, since they host a plenitude of interdisciplinary research on human factors in computing and technology, relevant to and reflecting our review scope. Search strings were formed for identifying publications relevant to our domain respective to each database. The following search string was used for the ACM Digital Library; slightly tweaked versions were used for the rest of the libraries respective to their search constraints:

```
(Parent* OR Teen* OR Adolescent* OR Child* OR Family) AND
(Security OR Privacy OR Risk OR Safety OR Usability OR Protection
OR Control OR Value* OR Ethic* OR Monitor* OR Mediate*) AND
(Online OR Internet OR App*)
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The additional criteria (i.e., including terms on safety and privacy in the search string) was crucial to make the search results correspond to the review scope. Publication dates were limited to Jan 2010 - Jun 2020. This filter was added so that the included studies capture research from the last decade and are reflective of recent trends in this area. Also, the online risks today are paradigmatically similar to risks post-2010 [8, 51]. We then proceeded to the next two steps proposed by Webster and Watson [76] for literature search.

2.2 Going Backward and Forward

After getting an initial pool of papers by applying the inclusion and exclusion criteria, we checked all the papers cited by the papers in our initial pool. We then identified relevant papers from this set, and added the ones not already present in the initial pool. This cycle was repeated until we stopped encountering newer relevant papers from the cited papers. Once we covered the backward search, we turned to identifying the papers which cited the papers in our initial pool. Here again, we added all the relevant papers which were not in the initial pool. This cycle was similarly repeated until we stopped encountering newer relevant papers.

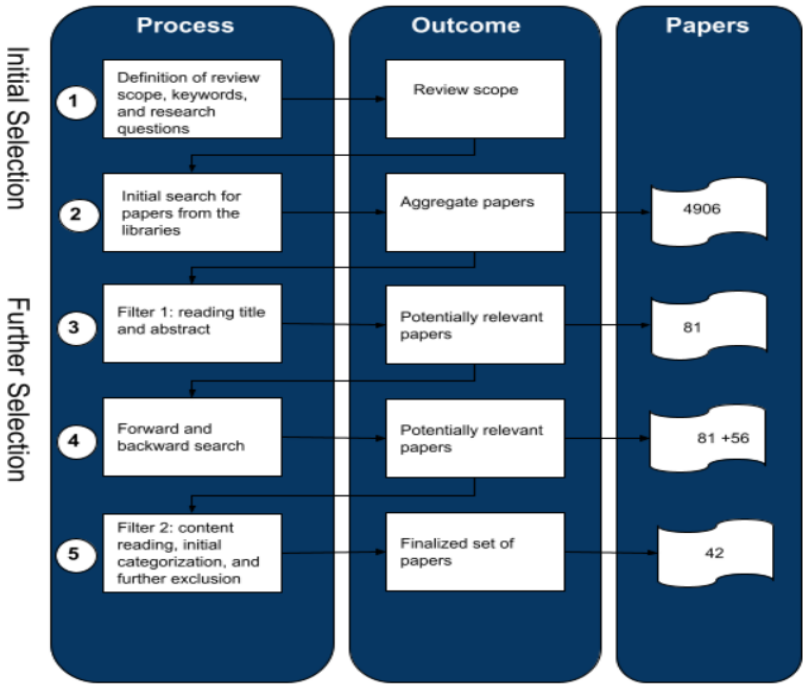

Fig. 1. Literature Search Process

2.3 Categorization of Literature

After classifying papers around study aims, methodology, and user groups, we identified a final set of 42 papers for analysis that aimed to inform the community about any aspect of parental control. Papers having common aims were further clustered into the following categories and sub-categories (n below represents the paper count in the respective category):

- Perceptions and attitudes towards online risks and parental control tools (n = 27)
  - What do parents think, want, and do about parental control tools?
  - What do children know, ask, and do about online risks and safety?
  - Predictors and effects of parental tech mediation
- Designing tools for online child safety (n = 15)

Each paper was then coded according to the study's aims, design, methodology, findings, limitations, and implications for the HCI community if any. The papers in the first category were coded by authors 3, 4, and 5 collaboratively, whereas authors 1 and 2 coded the second category. Authors 6 and 7 were consulted if there was any ambiguity in the relevance of the category or the relevance

of the publication. The materials were studied in an iterative manner to identify the content of the publications reflective of our categories. After the coding process, the results were summarized in a tabular form.

As the final set of publications (n = 42) is relatively small, we did not perform a quantitative analysis, and instead proceeded with a narrative-based synthesis to systematize the current knowledge and highlight directions for future research.

3 Perceptions and Attitudes Towards Online Risks and Parental Control Tools

The literature contains 27 papers that study the perceptions and attitudes of different user groups (parents and children) towards parental control tools, and how they affect the parental mediation employed for online child safety. These papers along with main study characteristics are listed in Table 1. We provide a review of the main findings of these papers, as they provide the background crucial to the design of parental control tools.

3.1 What do parents think, want, and do about parental control?

As parents want to get a view into their children's online activities to keep them safe [56], Ghosh et al. found more than half of the participants in their study used at least some kind of technical mediation on mobile phones of their teens [40]. Badillo et al.'s work corroborated this, and found that parents would rather prefer their child's safety over completely preserving their privacy [18]. Other works suggest that the needs and concerns of parents about their child's online safety are highly influenced by their parenting style [24, 82].

A spectrum of parental mediation strategies exist, from active mediation (i.e. parents engaging in discussions with their children about their online activities) to deference (i.e. parents purposefully doing nothing to avoid conflict with their children) [62]. Therefore, 'safety' in the online context is an evolving concept, which requires a nuanced response from the parents to ensure a balance between risk prevention and child autonomy [47, 68]. Some parents use restrictive strategies by setting rules for time, frequency, and location of use [46], while others deem open communication as the best strategy to mediate their child's Internet use [47, 74]. Parents also feel that content control/monitoring tools are not very effective, as there will remain some part of children's online activities which they might not be able to monitor due to lower tech-literacy in comparison to their children [13, 46, 80]. Some parents also do not trust these applications as they think children can easily evade them [67, 70]. Badillo et al. found that most parents in their interview-based study were also not aware that these solutions exist [18].

3.2 What do children know, ask, and do about online risks and safety?

Parents and children differ in their perceptions, such as on social media, where parents tend to oversimplify teen's online experience, and children tend to hide certain aspects of their online lives from their parents. Studies found that for parents, privacy in the online and physical world was an identical concept; whereas children thought of privacy as different in these two environments [22, 33].

According to Goh et al., children prefer that parents do not set up rules regarding the usage of devices; at maximum they would like to ask their parents before they use the devices [75]. While navigating the digital world, children also develop some strategies to manage privacy and security risks, but still like to rely on parents for support. However, per Kumar et al.'s study some parents only employ passive strategies to control their children and fail to adequately address the privacy and security risks [55]. Children also do not feel good when parents use strategies that at times hinder and jeopardize their privacy [81]. They fear privacy invasion more likely from household members, instead of strangers that they encounter on the Internet [81]. This should raise some concerns as Kumar et al. pointed out that children rely heavily on their parents for protection [55]. Children realise the need and significance of independence and parental trust in their online experiences for countering any threats [33]. They prefer applications which provide them with control and a secure, wholesome experience rather than ones that outright give complete control to their parents [19].

3.3 Predictors and effects of Parental Tech Mediation

Low autonomy granting parents are more prone to opt for parental control tools [39]. This happens due to the scarcity of knowledge and expertise among parents to perform active mediation; hence they either go for stern restrictive measures or no measures at all. [65, 79] support this notion. Studies emphasize that it is essential to educate parents about the latest applications and the Internet, their inherent risks, as well as proven strategies for online safety, in order to equip them to better handle the posed risks [45, 78]. Moreover, studies recommend that restricting and limiting online experience is not the best way to protect children online as it has adverse effects and is less effective [78, 79].

Active mediation might be the way forward in order to protect children from these risks [52, 78]. Most parental monitoring tools promote the authoritarian parenting style where parents strictly monitor their children [39, 78, 79]. Authoritarian parenting is a parenting style characterized as low in responsiveness but high in demanding-ness [20]. These parents have exceedingly high expectations of their children and they may monitor almost every aspect of their child's life and behavior [28]. Unlike authoritarian parents, some parents adopt an authoritative parenting style where children are encouraged to explore and navigate their lives in an independent manner [28]. This parenting style is characterized

Table 1. Study Design: *User Attitudes and Perceptions* category

Study	Sample Size	Study Design	Population	Age	Location
Yardi et al. [80]	16	Interviews	Parents	-	US
Broekman et al. [24]	591	Survey Interviews	Parents	Mean = 41	Netherlands
Zimmer et al. [82]	60	Interviews Questionnaire	Parents	-	Germany
Hartikainen et al. [47]	-	Discourses Survey	Parents Children Teachers	-	Finland
Symons et al. [74]	34	Interviews	Parents	Mean = 44	Belgium
Ghosh et al. [40]	215	Survey	Parent-teen pairs		US
Kuzminykh et al. [56]	10	Self-reports Semi-structured Interviews	Parents	32-50	Canada
Nouwen et al. [62]	20	Interviews Workshops	Parents Corporate Stakeholders	-	Belgium
Hamade et al. [46]	152	Questionnaire	Parents	-	Kuwait
Alqahtani et al. [13]	60	Survey	Parent-child pairs	-	Saudia Arabia
Badillo-Urquiola et al. [18]	29	Interviews	Parents	-	US
Ringland et al. [68]	-	Digital Ethnography Semi-structured interviews	-	-	US
Schiano et al. [70]	472	Survey Follow Up Interviews	Parents	Median = 41	US
Nouwen et al. [63]	11	Interviews	Parents	-	Belgium
Prasad et al. [67]	29	Interviews Focus Groups	Parents	Parents (31-60)	US
Zhang-Kennedy et al. [81]	14	Interviews	Parent-Child pairs	Children (8-11) Parents (21 - 50)	Canada
Kumar et al. [55]	18	Interviews	Parents and children	Children (5-11)	US
Cranor et al. [33]	10	Semi-structured Interviews	Parents and teenagers	Children(14-18)	US
Blackwell [22]	42	Semi-structured Interviews	Parent and children	Children (10-17)	US
Badillo-Urquiola et al. [19]	12	Semi-structured Interviews	Children	Children (7-11)	US
Ghosh et al. [39]	215	Survey	Parent-Child Pair	Children(13-17) Parents(>25)	US
Padilla-Walker et al. [65]	276	Interviews	Mother-child pairs	-	US
Wisniewski et al. [79]	12	Semi-structured interviews	Parent-Child pairs	Children (13-17)	US
Wisniewski et al. [78]	588	Survey	Parent-Child pairs	Teens(Mean = 15) Parents(Mean = 47)	US
Gomez et al. [45]	39K	Survey	Children	Children (12-17)	Spain
Khurana et al. [52]	629	Survey	Parents and children	Children (12-17)	US
Padilla-Walker et al. [64]	478	Interviews Questionnaires	Families	Children (11-15)	US

by high in responsiveness and demanding-ness [28]. Studies advise that applications built on the idea of authoritative parenting should replace the current apps which cater to the authoritarian style [39, 78, 79]. In fact, these applications might have a far higher user base and would push parents towards using an authoritative parenting style, which brings positive reinforcements in children while being more effective [39, 64].

4 Designing Tools for Online Child Safety

A set of fifteen papers propose parental control and monitoring tools or their technical components. We further categorize these into two classes based on whether they include a user study. The first set, i.e., publications with tool design and no user study, shown in Table 2, contains eight papers and suggests that developers tend to focus on direct parental monitoring or automatic content control when developing a tool. Most tools such as [11, 29, 34, 54, 59, 61] enhance monitored or automatic content control of children's online activities, taking little account of children's agency and perceptions around online threats

Table 2. Study Characteristics: *Tool Design with No User Study* category

Author (year)	Study Purpose	Tool Name	Tool Purpose	Target Audience	Target Threat
Mugni (2019)	To determine basic information about sites that are most frequently visited by children and implement an internet screening program	DNSBL	Content filtering on social networks	Children	Exposure to inappropriate content
Suchaad (2018)	To apply blockchain as a form of disciplining children	-	Encourage good behavior and discourage bad behavior	Children	Online risks and third party privacy issues
Fahrnberger (2014)	To propose a framework for protecting children's communication channel for obnoxious sources	SafeChat	Content	Children	Exposure to inappropriate content
Noor (2012)	To propose a parental mobile control system for monitoring children's online activities	Parental Mobile Control	Capture, detect and block harmful content	Children	Exposure to inappropriate content
Kumar (2016)	To propose a real-time software against pornography by MATLAB and SQL queries	Protection Against Pornography	To protect against pornographic content	Parents	Exposure to pornographic content
Majchrowicz (2018)	To demonstrate that it is possible to build a parental control system by rooting a Samsung Smart TV	Prototype	To control a TV remotely and apply parental controls to it	Parents	Children watching TV without permission or viewing inappropriate content
Chiu (2019)	To propose a reliable defensive architecture against inappropriate websites	Network Guardian Angels (NGA)	Identify and block inappropriate websites. The tool also puts time limit on internet use	Taiwanese students	Exposure to inappropriate content
Buzzi (2011)	To discuss the effectiveness of Youtube user interface for signaling inappropriate content	-	-	Children	Accessing inappropriate content by accident

and parental monitoring. One study mentions incentive based parental control model and suggests blockchain technology to implement it [73]. Another study discovered flaws in the YouTube interface and suggested some features to counter the existing vulnerabilities that allow access to inappropriate content [25].

The second set of studies includes publications with a tool design and a corresponding user interaction study. We review this sub-category in detail to present a picture of which user populations have been represented in the literature for designing tools and studying their usability. We summarize the user samples and tool characteristics in Table 3, and discuss them below:

User Study Characteristics: All seven studies involved the end-users in either the design or evaluation of a parental control tool. This involvement was either in the form of in-person research where authors conducted interviews and surveys, or they held design sessions with participants for consistent feedback on prototypes and updated requirements. The studies incorporated value-sensitive design, iterative design, and general feedback to guide the development and/or evaluation of the tool. Out of the 7 studies, 2 were based in Canada, 2 in the USA, 1 in Korea, and 1 in Thailand. Our systematic search revealed only one study that was based in the third world [69]. The participants in all the studies, except for one, involved parents and children whereas McNally et al. [60] conducted their study only with children. All of the studies had a sample of fewer than 100 participants. Six of the studies designed a tool whereas one study evaluated an existing tool. Six studies involved parents and children in their user study whereas one study only included children to guide the design of the tool. One study tested three in-sequence prototypes for their tools.

Table 3. Study Characteristics: *Tool Design with User Study* category

Author (year)	Study Purpose	Sample Characteristics	Tool Design	Main findings
Yasmeen (2014)	To introduce a new approach towards content filtering by involving children and focusing on child involvement and education rather than control	**Sample size**: N = 13 sets of family **Population type**: Parents and children **Age**: Parents of 6-8 year olds **Location**: Canada Data collection: In-person research (interviews) **Type of data collected**: Participants impressions of the We Choose prototype **Incentive**: Parents received a $10 gift card and children received a toy	**Tool name**: We-Choose **Purpose**: Facilitates an educational approach to control by involving children in the filtering process **OS**: Android **Accessibility**: Android app **Target population**: 6-8 year old age group **Target threat**: Exposure to inappropriate content **Design Framework**: -	**Usability**: Participants' perspectives: Parents found the collaborative approach as an effective way to engage in conversations with their children. Children were not as vocal as their parents but overall, they enjoyed working with their parents in setting the content control. **Design guidelines**: Visual indicators for content types and their appropriateness can help the parents in setting filters. Child friendly representations such as color schemes should also be explored
Ghosh (2020)	To design a new approach to mobile online safety and evaluate its strengths and weaknesses	**Sample size**: N = 17 parent-child pairs **Population type**: Parents and children **Age**: Parents of teens 9-17 **Location**: USA Data collection: In-person research (interviews), surveys, observational notes **Type of data collected**: Likert scale survey, how parents and children interact with one another and the app **Incentive**: $20 gift card for a pair for stage 1, $30 for stage 2	**Tool name**: Circle of Trust **Purpose**: Lets parents and children co-mediate the text messaging (i.e., SMS and MMS) activity that takes place via the child's phone **OS**: Android **Accessibility**: Android app **Target population**: Parents and children **Target threat**: Exposure to risky messages and strangers **Design Framework**: Value sensitive design	**Usability**: Participants' perspectives: Parents and children preferred Circle of Trust as compared to baseline app since it was designed for the values of teen privacy, trust and parental control. Participants found the app less privacy invasive and beneficial for parent-child relationship **Design guidelines**: Value sensitive design and Participatory design sessions need to be employed for designing mobile online safety
McNally (2018)	To understand children's perceptions by analysing their feedback on an existing parental mobile monitoring application	**Sample size**: N (1) = 12 for tool evaluation, N (2) = 8 for feature design **Population type**: Children **Age**: 7-12 **Location**: University of Maryland's KidsTeam Data collection: Co-design sessions: 1. Survey and Feature redesign 2. Paper prototyping **Type of data collected**: The extent to which children find parental tools appropriate and what features do they desire **Incentive**: -	**Tool name**: TeenSafe **Purpose**: Monitor and restrict what children can do on their phones **OS**: - **Accessibility**: - **Target population**: Parents and teenagers **Target threat**: Exposure to harmful places, strangers, inappropriate content **Design Framework**: -	**Usability**: Participants' perspectives: Children accepted some parental controls. Monitoring location was accepted by 84% (10/12) and search history was accepted by 75% (9/12). However, after the second stage of design session, it was showed that while children accept some parental controls, they have a desire of privacy in their digital activities
Ko (2015)	To discuss how participatory parental mediation can overcome restrictive and invasive approaches	**Sample size**: N (1) = 4 families for design testing, N (2) = 12 families (17 parents and 18 teenagers) for app evaluation **Population type**: Families **Age**: Parents (40-60), Children (Average: 16.39) **Location**: Korea Data collection: Group interview for Stage 1, Within-subject experiment for Stage 2 **Type of data collected**: Usage experience for Stage 1, Changes in parental mediation of smartphone use after introducing FamiLync for Stage 2 **Incentive**: $50 card for Stage 1	**Tool name**: FamiLync **Purpose**: Considers use-limiting as a family activity and provides a public space for parents and teens to have social awareness and improve self-regulation **OS**: - **Accessibility**: - **Target population**: Families **Target threat**: Excessive usage of smartphones **Design Framework**: Persuasive System Design	**Usability**: Participants' perspectives: Members of the family became aware of their usage patterns with FamiLync's self-monitoring support. Smartphone usage were significantly reduced improving parent-child interactions **Design guidelines**: Study adopts iterative prototyping with field evaluations for their parental control service. Designing for abstraction of content and hiding private details would assist in participatory parenting
Hundlani (2017)	To design, develop and explore the feasibility of a parent-child authentication mechanism	**Sample size**: N (1) = 20 for prototype 1, N (2) = 20 for prototype 2, N(3) = 30 for prototype 3 **Population type**: Parents and children **Age**: Children aged 7-11 **Location**: Canada Data collection: Pre-test interview, Prototype testing, Post-test interview **Type of data collected**: User feedback on current online practices, and their experience with the prototypes **Incentive**: -	**Tool name**: KinderSurf **Purpose**: To allow children to log in to website without requiring a password and enabling parents to authorize the login request **OS**: - **Accessibility**: - **Target population**: Children aged 7-11 **Target threat**: Exposure to non-permissive websites **Design Framework**: Iterative design	**Usability**: Participants' perspectives: Participants thought that such a tool is necessary, however many parents wanted additional parental control features, beyond the scope of an authentication mechanism while others thought that even this mechanism is too invasive for a child's privacy **Design guidelines**: Iterative design can help developers with recognizing and correcting flaws in their prototypes, gather additional requirements making the system more usable. Children are more likely to give feedback on a prototype rather than in an interview
Belanger (2011)	To describe the design of an automated tool for protecting children's online privacy	**Sample size**: N = 25 user responses **Population type**: Parents and children **Age**: Parents with children under the age of 13 **Location**: - Data collection: Online survey **Type of data collected**: Measures of ease of use, perceived behavioral control, cost benefits **Incentive**: -	**Tool name**: POCKET **Purpose**: Allows parent to control access **OS**: Windows XP **Accessibility**: Microsoft IE **Target population**: Parents, merchant website owners **Target threat**: Exposure of personal information **Design Framework**: Multiple design frameworks researched in Decision Support System	**Usability**: The tool developed after acquiring requirements from parents through focus group was evaluated using white and black box testing. The system was easy to use and met the needs of the parents **Design guidelines**: The study follows the design methodologies from decision science literature, not explicitly naming any
Santisarun (2015)	To design and implement a mobile application that will enable parents in monitoring their children's activities on social networks	**Sample size**: N = 20 **Population type**: Parents and children **Age**: - **Location**: Thailand Data collection: - **Type of data collected**: Application's experiences **Incentive**: -	**Tool name**: - **Purpose**: Helps parents monitor their child's activities on social networks to foresee threats **OS**: Android **Accessibility**: Android app **Target population**: Parents **Target threat**: Inappropriate activity on social media **Design Framework**: -	**Usability**: Participants' perspectives: 18/20 parents were satisfied with the application and its ease of use for generation X and early generation Y.

Parental Control Features: Of the 7 studies reviewed, 4 involved tools for participatory mediation between parents and their children suggesting alternative approaches to restrictive parental control whereas 3 studies delegated all monitoring authority to parents. The studies focusing on participatory mediation valued child privacy, trust between parents and their children, education, and self-awareness. 5 out of the 7 papers proposed an Android application for regulating children's Internet usage. One study focused on website login safety. None of the studies catered to the development of a cross-platform tool.

Features Supporting Parent-Child Collaboration: Hashish et al. designed an Android application that included children in the design process for giving them more authority in setting content control filters [48]. The application was designed aligning with the Positive Youth Development framework [27] to demonstrate that educating youth about the opportunities, norms, and risks can help them in making good decisions about their safety as compared to restricting them. This is also beneficial for parents as the novel approach encourages healthy communication between parents and children. Through interviewing parents, the authors found out that parents did not employ software-based control solutions, except using passwords, due to their difficulty of use, a finding also supported by Ko et al. [53].

Based on these findings, the authors in [48] designed an application to facilitate an educational parent-child session on the appropriateness of the content, opening opportunities for dialog between the parties. Just as Hashish et al. [48], Ghosh et al. [41] conducted a within-subjects experimental design with parents and children to evaluate their novel approach to online mobile safety. Through the Value Sensitive Design framework – a framework to design systems accounting for human values [35], they aimed for designing an Android application empowering teen privacy, trust, and parental involvement. For keeping their application teen-centric, they employed: (i) less granular activity monitoring, (ii) avoiding features that restrict teens' online behavior, (iii) self-monitoring techniques to increase the self-awareness of teens, and (iv) appraisals for teens and parents to work together towards risk identification and how to respond to them.

Similarly, Ko et al. [53] also centered their application on family values developing a participatory parental control service. By conducting an online survey, they found that 77.14% participants had concerns with their children's smartphone usage which led them to mediate their child's phone (78.10%). Most of these parents relied on restrictive rule-setting to regulate usage. A substantial fraction of parents (27.95%) complained that they found parental controls effective but had difficulties in installation and maintenance. This led the authors to design for self-regulation and goal-based use-limiting, encouraging both populations to understand each other's behaviors. The tool lets family members share their smartphone usage but abstracts the representation of content hiding private details assisting in participatory parenting.

Features Supporting Parental Authority and Control: In contrast to the above studies, McNally et al. conducted design sessions with children on an existing app called TeenSafe [60]. Participants surveyed 10 features of this application, of

which 7 were based on monitoring while the rest of the 3 were based on restriction. A trend was noticed where children's acceptance decreased as the features became more privacy invasive. Another thing noticed was that the redesigned features by children incorporated active mediation although no surveyed features had any sort of active mediation. Supporting the previous studies' findings, children in this study also wanted the applications to support parent-child communication.

In contrast, Hundlani et al.'s proposed mechanism puts everything in the hands of the parents [49]. Their mechanism takes the burden of creating and managing passwords from children and puts this responsibility upon parents. They offered features such as parents receiving a request to grant approval each time the child decides to log in. It was up to the parents whether they wanted to configure the app in a way where it would automatically perform the action according to the predefined rules or whether they want to approve it manually every time. It also provides parents with the power to register new devices on behalf of their children and manage and register new accounts. Parents also have access to the login history of their children. Additionally, they can set up rules on both per child and per website basis. It is also the choice of parents if they want to create a master password for children.

Another approach along these lines was proposed by Santisarun et al. [69]. They designed an application which gives parents the power to observe and control what children do on social media. They aimed to let parents monitor all the activity, and edit or delete the comments and photographs they did not deem fit to be posted. They built a mock up social media application closely mirroring Facebook's functionalities.

Just as Santisarun et al. [69] and Hundlani et al. [49], Belanger et al. also created an application centered around parental authority [26] . Their tool, POCKET, was created to enforce COPPA (Children's Online Privacy Protection Act) while being easy to use simultaneously, so that parents are able to set up their controls. The app also maintained a log for each website it interacted with. Initially a mock up was designed and then opinion was sought from parents about the design. These opinions were then synthesized to come up with requirements.

User Acceptability: Most of the studies reported positive feedback from parents. Findings from Hashish et al. [48] and Ghosh et al. [41] demonstrated that parents like the teen-centric approach for parental control measures as well. They were aware of their children's needs for privacy and trust and encouraged tools that highlighted these values. Hundlani et al [49] had a similar finding where although most parents wanted monitoring features beyond simple authentication, some thought that even this is too invasive for their teens. Belanger et al.'s [26] designed tool POCKET is the only app which mentions that it was found to be user friendly and this is an important decisive factor for choosing an app when it comes to parents who are not tech savvy. This study also highlighted that designing is as important as the end product.

Children also seemed to like applications designed for online safety with features of monitoring and autonomy. For instance, McNally et al.'s findings revealed that participants acknowledged that they faced risks while being online and accepted that there is a need for involvement of parents [60]. However, they maintained that parents should only be able to control to a certain degree and privacy of children should not be invaded, at least directly. They only found certain kinds of monitoring to be acceptable and argued for the need of privacy to carry out their activities. The findings from all studies highlights that although there are differences between the views of parents regarding how much to control and the ways to control, the demand of children is almost always to acknowledge their need for privacy and adopt strategies which invade their privacy as passively as possible.

5 Discussion

5.1 Designing tools for online child safety

Our research resulted in very few studies that have involved users in the design, development, and evaluation of a tool. To the best of our knowledge, this systematic review is the first one to provide an index for existing literature on parental control tools and user perceptions. It also serves as a guide to help with the design, development, and analysis of these tools. This guide is based on an in-depth analysis of design practices and in-person researches described in the included studies.

Designing for users: Children mostly find parental control tools invasive and damaging to their relationship with their parents [12, 53].

Authoritative measures also hinder their personal growth and self-resilience. Our findings suggest that although the risks and threats online are immense and dangerous, authoritative and restrictive measures are not the best option for keeping the children safe. Adults will have to strike a balance between trust, involvement, and control. Instead of restricting and stalking their children, they will have to use active measures of educating their child about the security and privacy threats online. This can be achieved by designing tools that strike a balance between self-regulation and parental control. Findings from Hashish et al. [48] and Ghosh et al. [41] demonstrated that parents like the teen-centric approach for parental control measures as well. They were aware of their children's needs for privacy and trust and encouraged tools that highlighted these values. Hundlani et al. had a similar finding where although most parents wanted monitoring features beyond simple authentication, some thought that even this is too invasive for their children [49].

Studies also showed that although parents are aware of these tools, they do not use them, as they find them hard to understand and operate. Through their explanatory study, Hashish et al. showed that although parents are aware of software-assisted control, they seldom use it because of their difficulty in

operation and the overhead of configuration [48]. Ko et al. also conducted a survey where they found that parents find it difficult to install and maintain parental control apps on their children's smartphones [53]. This opens room for approaching parental control tools with participatory design by involving all stakeholders.

Designing for usability and effectiveness: Even though these tools have a low adoption rate and parents seldom use and operate them [15], little to no researchers have opted for usability testing in their studies as guided by a previous systematic review [50]. Almost no information is present on the user experience and effectiveness of these tools. None of the user studies reviewed were conducted in the field, which could have provided more accurate results on the usability and effectiveness of the developed tools.

We recommend that future work needs to be conducted that develops a parental control tool by following certain criteria: (i) user-friendly, i.e., the tool must be easy-to-use for the target population, (ii) usability, i.e., the tool must cater to the needs of the end-users: children (iii) privacy, i.e., the tool should be non-intrusive towards the child's privacy, and (iv) content and functionality, i.e., the tool should explore features of teen self-regulation and awareness. Although we identified studies that dealt with the tool's functionality and content in-depth [11, 29, 34, 54], the studies did not present information about the design framework that was adopted or shed light on user experiences. A testing framework needs to be conducted to provide quantitative data on the usability of the tool.

Designing for inclusion: Our search for relevant tools and user interaction revealed scarce research in low literate countries. The existing literature did not highlight the needs and requirements of a low literate user population group when it comes to designing for teen's online safety. Although Belanger's application, POCKET, was designed for technologically unsophisticated parents, more research is needed in the area of designing and developing parental control tools to cater to the needs of a non-tech savvy and low literate population, which will likely not adopt these tools if they involve configuration and maintenance overheads [26]. In addition to this, tools need to be designed for children in third world countries as well. Statistics show that more and more children, estimated to be around 100 million from Africa and South-East Asia, and 2 million from developing countries worldwide are connecting to the Internet for the first time. Without adequate parental control measures exploring educational and safety approaches for the less literate, the world's most disadvantaged children will face greater risks when exposed to the risks online [4].

5.2 Design Implications and Future Research:

Another aim of our systematic review was to provide design insights for future parental control tools from the perspectives of both end-users: parents and

children. We discovered that parents face multiple but interlinked challenges regarding parental control tools. These ranged from a lack of awareness about these tools [63] to difficulty in keeping up with rapidly changing technological trends [33, 70], to lack of ease in using the tools [48], to installation and maintenance problems [53]. Children found these tools are useless, invasive, easy to evade [47], and damage their relationship with their parents. Our literature synthesis helped us identify the following design guidelines that researchers and designers can incorporate to cater to both user populations as one unit of family instead of individuals with different values.

- **Flexibility for Different Parenting Styles, Age, and Context:** Parental control applications need to be flexible and support different styles of parenting so that parents are able to alter the restrictions and strictness according to different factors such as age, context, and parenting styles [39, 41, 47, 53, 57].
- **Education of Children about Online Dangers:** Parental control applications need to facilitate the education of children in regards to the risks posed as well as dangerous behaviors which could potentially put them in the harm's way [19, 47, 48, 60, 67]. Along these lines, interfaces should be designed to visually emphasize situations of risk so that users may be warned [19].
- **Children as Design and Communication Partners:** Children need to be included in the designing and decision-making process of the applications built for their safety, and parents need to talk to their children and negotiate and discuss the online activities and the restrictions being placed along with the reasons [19, 47, 48, 63, 79].
- **Teen Privacy and Self-Regulation:** Parental control applications need to be more respectful of children's privacy and incorporate features that empower teens to self regulate themselves, or the application itself is able to automatically monitor children while parents only get the data which is abstract and does not invade the privacy of children [19, 41, 47, 53, 60, 67, 79].
- **Usability and Education of Parents on Tool Use:** Parental control applications should be built keeping in mind the ease of use and capabilities of parents as well as their desires, and should work towards educating parents about how to configure these tools as well as about the online risks posed to their children [19, 53, 63, 74, 79].

Future design must take into account the variables for effective parental control tools, which would not disturb the parent-child relationship. However, the present insights are guided by studies conducted in developed world, as shown in Table 3. Our research for existing literature on the design of parental control tools in the low-literate world produced only two studies [36, 69], which implies that even though Internet usage is increasing in these regions [2, 3], little to no studies are focusing on the population's needs for children's safety in the low literate world. The design insights mentioned above might not be applicable to the low literate world where one in four people is unable to read a sentence [37]. Future research should specifically explore the user requirements and needs of this

population group. In addition to this, the design insight *Flexibility for Different Parenting Styles, Age, and Context* highlights a contradiction in literature on the design of parental control tools. Despite the current research discouraging the design of tools based on authoritarian parenting style, some studies have advocated for customization of parental controls that can address different parenting styles [39, 57]. Further work needs to be conducted, especially in different cultural contexts, in order to resolve this conflict and identify a concrete guideline for designers.

Our systematic literature search also revealed little to no studies on cross-platform tools designed for online safety. We were unable to find any work that studies or designs a cross-platform tool with a user study. As stated in Table 3, five of the of the seven studies involving user interaction with a parental control proposed an Android application whereas one study designed a mechanism for permission to website login. This opens room for future designers to include end-population as design partners for cross platform tools, as parents tend to manage multiple devices of their children: laptops, smartphones, and gaming consoles.

6 Conclusion

In this study, we conducted a systematic review including 42 publications analyzing parents' and children's perceptions, as well as the design of parental control tools. Through our review, we found that the low adoption rate of parental control tools is because parents find these tools difficult to install, use, and maintain. Studies on children's perspective show that they find these tools to be invasive and damaging to the parent-child relationship, and can be evaded if tried. Little to few studies employ any usability framework to quantify their tool's usability. Existing parental control tools focus on automatic content control or direct parental monitoring. Even though studies have confirmed that parents find existing parental control tools hard to operate, hardly any works cater to the needs of the non-tech savvy population, especially in the low literate world. Our review identified such gaps in the literature, and also presented guidelines for future researchers and designers on the design of parental control tools.

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