



Household chemicals and pre-schoolers: Caretakers' beliefs and perspectives on risks and responsibilities

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ARTICLE INFO

Keywords:

Household chemicals
Risk perception
Accident prevention
Parenting style

ABSTRACT

Chemical products are present in most households and can endanger the health of humans, particularly toddlers and pre-school children. With a focus on accident prevention, this article investigates parents and other caretakers' beliefs and perspectives on risks and responsibilities. A mixed method approach was applied, combining in-depth qualitative interviews (pre-study, $N = 10$) and a quantitative survey (main study, $N = 688$) with Swiss caretakers of pre-school children. The questionnaire of the main study was developed based on the findings from the pre-study, and measured beliefs, perceptions of product, environmental risks, and responsibilities. The main findings suggest some prevalent misconceptions among parents regarding the risks of products perceived to be natural and the safety of child-protective caps. Furthermore, relationships were uncovered between psychological factors, such as perceived responsibility, trust and risk perception, and caretakers' beliefs about household chemicals and their role in accident prevention. These beliefs highlight the need for preventive efforts focused on caretakers exhibiting pragmatic/trusting beliefs, compared to caretakers exhibiting protective or educational beliefs.

1. Introduction

Chemical products are present in most households, ranging from cleaning products (e.g., toilet cleaner, laundry products) to do-it-yourself products (e.g., glue, paint) to garden chemicals (e.g., fungicides, pesticides). Some of these household chemicals can endanger the health of adults and predominantly, toddlers and small children. In 2018, over half of all accidents with household chemicals concerned pre-school children (Weiler and Kupferschmidt, 2020). Worldwide, acute poisonings lead to an estimated 45'000 deaths in children and young adults per year and children below the age of 5 are particularly at risk of suffering severe consequences and death from accidents with household chemicals (World Health Organization and unicef, 2008). The high number of poisonings in pre-schoolers can partly be explained by children's developmental exploring behaviour that involves grasping for items, manipulating them or ingesting them (World Health Organization and unicef, 2008). With a focus on accident prevention, this article investigates the perspectives of parents and other caretakers on this issue: whether some products appear more attractive to children compared to other products, which environmental aspects contribute to accidents,

and how accidents can be prevented.

Insights regarding the product attributes that reduce or raise children's attention might be a first step towards accident prevention. However, the literature on product attributes that might attract young children's attention is rather limited. Older studies focused primarily on the potential of packaging design and warning labels to signal risk and deter children to prevent accidental poisonings (Fergusson et al., 1982; Schneider, 1977). Schneider (1977) conducted an exploratory observational experiment with children aged 3.5 to 5.5 in the US. In this experiment, the packaging form (round or square), packaging colour (white, black, red), product smell (no smell, pleasant odour, antiseptic odour) and warning label (written, graphic) of a cleaning product were systematically varied. The children were left alone with the packaging, and it was recorded whether they touched or opened the products. The results of the studies by Schneider (1977) and Fergusson et al. (1982) suggested that children were not deterred by warning labels, but rather were attracted by them. Further, certain product attributes attracted children's attention more than others. For example, the children more frequently grabbed the cleaning product in white and quadratic packaging and were attracted by both pleasant and antiseptic odours.

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Generally, [Schneider \(1977\)](#) concluded that packaging with various elements on the label were more attractive to children than packaging with less elements. Because of their lack of experience and knowledge, warning labels are not familiar to children and could even be misinterpreted by them ([Latham et al., 2013](#); [Silk, 2003](#)). For example, children mistook the hazard pictogram ‘Corrosive’ ([United Nations, 2017](#)), which features a substance dripping on a hand, as ‘this is for washing your hands.’ A newer observational study with 1.5- to 3.5-year-olds showed that particularly black or opaque containers, salient symbols (e.g., insects on biocidal products), non-pointed, quadratic forms and metal packaging signal risk to children ([Schwebel et al., 2017](#)). Newer studies have also focused on product innovations, namely laundry capsules, as these have been involved in accidents and can cause particularly severe damage due to their high concentration ([Rigaux-Barry et al., 2017](#); [Settimi et al., 2018](#); [Swain et al., 2016](#); [Valdez et al., 2014](#)). Two studies investigated the effect of colour and size on attractiveness to toddlers ([Richmond et al., 2018](#); [Richmond et al., 2021](#)). The results suggest that toddlers expressed a preference for multi-coloured capsules, but only if presented in an isolated, experimental setting. When presented in a cupboard filled with other household chemicals no differences were found. Similarly, small or large sizes of the capsule did not differ in children’s attention, measured by grasping behaviour ([Richmond et al., 2021](#)).

Of course, whether a product, based on its design, raises the attention of a child is only one factor that might contribute to the accidental poisoning of children. In a literature-based conceptual model, [Schwebel et al. \(2017\)](#) further considered the influence of the person (e.g., child, caretaker or parents, siblings and peers), locations (e.g., safeguarding, storage), as well as community and society (e.g., culture, social class, policy and industry decisions). The attractiveness of a household chemical for children is irrelevant if the products are stored in a safe manner (i.e., in a locked closet, above 160 cm). However, various studies have uncovered a lack of risk awareness or product attributes that mislead adults’ risk perceptions ([Basso et al., 2016](#); [Basso et al., 2014](#); [Bearth et al., 2017b](#); [Bearth and Siegrist, 2019](#); [Wieck et al., 2018](#)). The basic assumption underlying these studies is that inaccurate risk perceptions about a specific product might lead to suboptimal storing, using, or disposing of this product. Children having access to household chemicals in their environment increase the risk of an accident substantially. In a secondary analysis of poisoning data, [Basso et al. \(2016\)](#) showed that household chemicals with food-imitating attributes were frequently involved in accidental poisonings, namely products that are shaped like candy, have a syrupy consistency, smell of fruits or feature pictures of fruits on the packaging.

It has been suggested that psychological factors, such as personal beliefs, risk perceptions or perceived responsibilities, would impact people’s interactions with environmental risks or household chemicals ([Bearth et al., 2020](#); [Bianco et al., 2008](#); [Buchmuller et al., 2020](#)). Low risk awareness and the underestimation of children’s developmental speed and mobility might contribute to accidental poisonings of children by encouraging incorrect storage ([Beirens et al., 2006](#); [Gibbs et al., 2005](#); [Patel et al., 2008](#)). [Gibbs et al. \(2005\)](#) further uncovered that child-safety caps, which are designed to only be opened by a minority of children of a certain age, can signal absolute safety to caretakers and lead to sub-optimal storage. It also has been suggested that caretakers neglecting the risks of household chemicals might lead to children’s frequent contact and interaction with household chemicals, which in turn might facilitate accidents ([Schmertmann et al., 2013](#); [Schwebel et al., 2017](#)). However, to our knowledge no prior study explicitly investigated caretakers’ beliefs, despite their likely importance for caretakers’ storage and handling behaviour. Generally, there is an insufficient evidence base on how product design and caretakers’ risk perception, perceived responsibility and beliefs might contribute to accidents with household chemicals. Due to this lack of research, regulatory decisions are largely based on anecdotes and the individual preferences of the involved stakeholders. Thus, studying caretakers

perspective might contribute to the much needed evidence base.

2. Pre-study: Qualitative interviews with caretakers of pre-schoolers

2.1. Research goal

The goal of the pre-study was to interview caretakers of pre-schoolers to get their perspective on various attributes of household chemicals (i. e., packaging, colour of product, smell of product) and their role as caretakers in the prevention of accidents. These insights served as the basis for the study design and development of the questionnaire for the main study.

2.2. Method

A semi-structured interview guideline was prepared and pretested. For the pre-study, 10 parents of children between the ages of 1.5 and 5 years were interviewed. Recruiting was supported by a professional recruiter company (<https://www.testingtime.com>) and the participants provided informed consent. All interviewees were based in the canton of Zurich (Switzerland), their ages ranged from 29 to 41 years and 9 out of the 10 were female. The interviewees varied according to educational background (vocational training, university), as well as number of children in the household (1 to 3 children). The interviews took place in the interviewees’ homes, which allowed to combine the interviews with an observation of the household chemicals present in the household. If the interviewee agreed, pictures were taken of the storage situation. The interview guideline comprised a series of open-ended questions that were complemented with follow-up questions based on interviewees’ responses (cf. Appendix A). Core of the interviews were the open exploration and subsequent sorting of product attributes (e.g., colour of packaging, smell of product, packaging form). Furthermore, interviewees were asked about their prior experiences (e.g., prior accidents or near misses), risk awareness and various preventive measures when shopping, storing, and using household chemicals (e.g., safety caps, warning labels). The interviews were recorded, transcribed, and analysed by coding the interviewees’ responses in a previously established coding system. The coding system (Appendix B) was developed based on the literature reviewed in the previous section and was continuously extended based on the input of the interviewees. Additional insights regarding the risk perception, storage and preventive measures were also gathered from the interviews.

2.3. Results and implications for main study

The majority of interviewees were aware of the risk that household chemicals might pose to their children and took precautions (e.g., storing the household chemicals outside of children’s reach). However, in all households, exceptions were uncovered that could mostly be attributed to a lack of risk awareness for specific products (i.e., keeping a fragrance lamp with aetheric oil on a coffee table) or convenience (e.g., storing laundry detergent on the floor next to the washing machine). Generally, interviewees were more risk averse for products that they perceived as effective and strong (e.g., drain cleaner, medicine), while they were more risk tolerant for products that they perceived as natural (e.g., aetheric oils, cleaning vinegar). This was evident from their storage strategies and explicit statements regarding various types of household chemicals. The interviewees also expressed knowledge gaps regarding the meaning of various warning symbols and what should be done in case of emergency. Some interviewees expressed a very high trust in safety caps by giving the household chemicals with these locks to their children to play with.

The interviewees mentioned different beliefs regarding their children’s interactions with household chemicals. These beliefs are strongly shaped by prior experiences, experienced, or reported accidents and

near misses with their own children. Some beliefs focused on the need to keep children strictly away from household chemicals and comprised protective intentions (e.g., 'I lock away all household chemicals and my children are forbidden to touch any of them.'). Other beliefs involved educational intentions (e.g., 'I neutrally explain to my children that the household chemicals can be dangerous, but also let them make their own experiences.'). Many parents also mentioned more pragmatic beliefs that neglect the risk of accidents with household chemicals (e.g., 'I do not think that children are interested in household chemicals.') and beliefs characterised by a high trust in the child (e.g., 'I have a well-behaved child and trust that it does not touch something that it should not.'). Table 1 presents a list of product attributes of household chemicals that might attract children's according to the interviewees. This list, as well as the additional insights gained above, served as a basis for the development of the questionnaire for the main study.

3. Main study: Research questions and hypotheses

Based on prior literature and the pre-study, the main study had two main aims. The first aim was to investigate caretakers' risk perception of specific product and environmental attributes. Within this aim, the following descriptive research questions were investigated to strengthen the qualitative findings of the pre-study and investigate potential misconceptions that the caretakers might have:

- 1) Do the caretakers differentiate the severity of exposure for different household chemicals?
- 2) Do the caretakers overestimate the protection offered by safety caps?

The second aim was to investigate, which individual and psychological variables (sociodemographics, risk perception, perceived responsibility, trust in child, general parenting style) determine to what extent the caretakers of pre-schoolers exhibit different beliefs regarding household chemicals and their role in protecting children from accidents. We decided to focus on caretakers' beliefs for two reasons. First, these beliefs held by caretakers will likely impact decisions regarding the storage and handling of household chemicals, which in turn might contribute to or prevent accidents in households with pre-schoolers (Beirens et al., 2006; Buchmüller et al., 2020). Second, compared to directly asking about behaviour and behavioural intentions (e.g., 'I store

Table 1

List of product attributes of household chemicals that might attract children's attention (based on qualitative interviews with parents of pre-schoolers, N = 10).

Product attribute	Quote from interviews ¹
Overall packaging design	'This toilet duck, it has a safety lock, but it also is shaped like a duck and has a duck on the label. Maybe that would be interesting for children.'
Colour of packaging or product	'The colour [of the detergent] makes him think that it is something sweet. He is currently quite into sweet drinks.'
Smell of the product	'If it has a citrus smell or smells sweet, then it is certainly more tempting [to children compared to a strong chemical smell].'
Size and shape of the packaging	'...if they can hold the product, then it is more attractive and fun to carry around.'
Foam	'The descaler comes out foamy, they like that and ask me if they can spray it too. That seems to be fascinating to children without us [adults] noticing it, because it seems so normal to us.'
Spray	'My daughter loves spray bottles, really anything that can be sprayed, is more interesting than a normal lid.'
Similarities to familiar products	'I had just bought painkillers and put them on the sideboard. His vitamin pills are also packaged like this. He already had it open when I came back but had not eaten any yet.'
Pods and tabs	'I would think that if he licks or bites it once, it is done and he would never touch it again.'

¹ Translated from Swiss German.

all dangerous household chemicals out of reach of my preschool children'), these beliefs might be less prone to the social desirability bias and thus, might deliver less biased responses from caretakers in a quantitative setting.

4. Main study: Method

4.1. Study design

Caretakers from three of the four language regions of Switzerland were recruited for this study, namely German-, French- and Italian-speaking adults living with pre-school children (roughly 3 to 6 years of age). The participants from the German- and French-speaking regions were recruited with the support of a market research company (respondi AG) and filled out the questionnaire online. Quota sampling was applied for the two language regions. As it was not possible to achieve a sufficient sample size of Italian-speaking participants with this recruitment method, the participants from the Italian-speaking region were recruited by purchasing postal addresses from another market research company (AZ Direct AG) and sending an invitation letter, paper-and-pencil questionnaire, and a prepaid response envelope. Additionally, the participants were able to access the questionnaire online via link or QR-code. Of the 700 invitations sent out, N = 188 were returned, which corresponds to a response rate of 27%. These additional recruiting measures resulted in a sample size of 746 respondents. This initial sample was screened, and speeders (time to fill out questionnaire in less than 5 min; n = 20), participants that did not indicate to live with a pre-schooler (n = 35), and underage participants (n = 3) were removed from the final data set.

4.2. Questionnaire

The questionnaire was created in German and was translated to Italian and French by native speakers (and backtranslated to German to check for translation accuracy). The questionnaire was pretested on a convenience sample of caretakers of pre-schoolers to ensure comprehensibility and appropriateness of questions (N = 10). Part of the questionnaire was also a short questionnaire comprising pictures of household chemicals that were used in a follow-up laboratory experiment with pre-schoolers. These materials are not presented in this article but are available upon request from the corresponding author.

To measure *beliefs*, 12 items were developed based on the pre-study with three items each for protective, educational, pragmatic and trusting beliefs. The items were introduced with the following sentence: 'Please indicate to what extent you agree with the following statements about household chemicals and children. Think especially of pre-school children (3 to 6 years of age). There are no right or wrong answers.' The response options ranged from 1 'do not agree at all' to 5 'strongly agree.' A Principal Component Analysis (rotation: Varimax) suggested three factors as the items from the pragmatic and trusting subscale loaded on the same factor. The three sub-scales were labelled 1) pragmatic/trusting, 2) protective, and 3) educational. Table 2 presents the descriptives of the 12 items and the results of the scale analysis.

Based on the findings of the qualitative interviews, two scales were developed to measure *Risk Perception*. The first scale focuses on the potential of product attributes to attract children's attention ('Risk Perception: Product Attributes'), while the second scale focuses on the risk of various storage situations ('Risk Perception: Environmental Attributes'). The *Risk Perception: Product Attributes* scale comprised the 10 items presented in Table 3. The items were introduced with the following text: 'Depending on their design (e.g., colour, pictures on packaging), household chemicals can attract the attention of pre-schoolers (approx. 3 to 6 years), which can lead to them being more likely to reach for them and play with them. Please indicate to what extent you think the following designs of household chemicals might attract the interest of pre-schoolers.' The response options ranged from 1

Table 2Mean values (M), standard deviations (SD) and corrected item-total correlations (r_i) for 'Beliefs' subscales (N = 683).

	M	SD	r_i	Factor 1: pragmatic/ trusting ($\alpha = 0.80$)	Factor 2: protective($\alpha =$ 0.64)	Factor 3: educational($\alpha =$ 0.71)
Response range: 1: do not agree at all – 5: strongly agree						
Children are smart enough not to play with dangerous household chemicals.	2.07	1.07	0.70	0.69	−0.03	0.09
Good children do not touch household chemicals.	1.86	1.11	0.59	0.59	−0.01	0.01
I trust that children do not put themselves in danger.	2.07	1.07	0.62	0.62	−0.13	0.15
Children tend not to be interested in household chemicals.	2.53	1.09	0.58	0.58	−0.06	−0.09
Children prefer to play with other things in the household than with household chemicals.	3.10	1.20	0.45	0.46	0.04	−0.06
Even if children play with a household chemical once, this does not pose a danger to them (e.g. child-resistant caps).	2.06	1.12	0.42	0.40	−0.18	0.23
Children should strictly be kept away from all household chemicals.	3.97	1.13	0.56	−0.11	0.83	−0.12
All household chemicals should be kept out of reach of children (e.g. on high shelves, in lockable cupboards).	4.45	0.89	0.43	−0.17	0.75	0.09
Children must not be allowed to touch household chemicals.	3.72	1.19	0.40	0.11	0.69	−0.20
Children should be taught how household chemicals should be used.	3.21	1.30	0.51	0.13	−0.18	0.78
Under supervision, children can also try out how to use household chemicals.	2.91	1.33	0.48	0.21	−0.21	0.74
If you forbid children to touch household chemicals, you only make them more interesting for them.*	3.22	1.15	0.22	−0.15	0.11	0.62

Note. *: removed from final scale due to low Cronbach's Alpha ($\alpha = 0.59$).**Table 3**Mean values (M), standard deviations (SD) and corrected item-total correlation (r_i) for the items in the 'Risk Perception: Product Attributes' scale (N = 683).

	M	SD	r_i
Risk Perception: Product Attributes ($\alpha = 0.89$)			
(1: not interesting at all for pre-schoolers – 5: very interesting for pre-schoolers)			
Packaging of household chemicals with cartoon characters on it (e.g., animals, people).	4.22	1.03	0.62
Packaging of household chemicals with fruit or other food on it (e.g., berries, coconut).	3.86	1.05	0.64
Household chemicals that smell like food (e.g., fruit, milk).	3.80	1.13	0.68
Colourful liquid household chemicals.	3.60	1.13	0.73
Colourful toilet blocks or toilet fresh discs.	3.53	1.15	0.68
Household chemicals that foam when you use them.	3.44	1.15	0.65
Laundry detergent pods (gel pads for the washing machine).	3.38	1.21	0.73
Laundry detergent tabs or dishwasher tabs.	3.27	1.22	0.70
Household chemicals in spray bottles (sprays).	3.19	1.14	0.60
Household chemicals that smell unpleasant (e.g., strong chemical odour).	1.88	1.01	0.33

'not interesting at all for pre-schoolers' to 5 'very interesting for pre-schoolers.' The *Risk Perception: Environmental Attributes* scale was measured with a list of 15 storage situations involving various commonly available household chemicals. The items are presented in Table 4. The following text preceded the items: 'Please indicate whether you consider the following situations involving household chemicals to be a risk for pre-schoolers. Keep in mind that children might sometimes be unsupervised for a moment (e.g., because the caregiver is distracted or leaves the room).' The response scale ranged from 1 'no risk at all' to 5 'a very high risk.'

Four separate items measured perceived responsibility. The four items were introduced with the sentence 'Please imagine the following situation: A child drinks a small sip of washing-up liquid. How do you judge the responsibility for this event?' This was followed by four items: 1) 'The manufacturers should have equipped the product with a child-resistant cap,' 2) 'The retailer should have warned of the dangers of handling this product at the time of purchase,' 3) 'The caretakers should have kept the product out of reach of their child' and 4) 'The child should have known not to touch cleaning products.' The response options ranged from 1 'do not agree at all' to 5 'strongly agree.' The scale for *Trust in child* was introduced in the following way: 'Please indicate to what extent you agree with the following statements regarding your pre-school child or children. If you have more than one pre-school child, please think of the child whose birthday is next.' Subsequently, the following three items were presented: 'My child is able to recognise

Table 4Mean values (M), standard deviations (SD) and corrected item-total correlation (r_i) for the items in the 'Risk Perception: Environmental Attributes' scale (N = 684).

	M	SD	r_i
Risk Perception: Environmental Attributes ($\alpha = 0.93$)			
1: no risk at all – 5: very high risk			
Transferring household chemicals (e.g., cleaning products, antifreeze) into PET bottles.	4.08	1.13	0.53
Lamps operated with lamp oil in the living room (paraffin).	3.83	1.19	0.65
Use of slug pellets in the garden.	3.78	1.13	0.67
Dishwasher tabs that are stored at ground level next to the dishwasher.	3.76	1.14	0.73
Laundry detergent pods or tabs stored on the floor next to the washing machine.	3.77	1.09	0.68
A cleaning cupboard that cannot be locked.	3.73	1.17	0.67
Toilet cleaner that is stored next to the toilet.	3.73	1.14	0.74
A spray bottle of bathroom cleaner that stands around.	3.70	1.09	0.73
Laundry detergent (powder or liquid) stored on the floor next to the washing machine.	3.61	1.16	0.76
Essential oils in fragrance lamps on the table.	3.61	1.12	0.65
Essential oils for external use (e.g. massage oil, aromatherapy) on the bedside table.	3.49	1.15	0.69
Toilet blocks or fresh discs in the toilet.	3.42	1.16	0.61
Cleaning vinegar standing on the floor while being used for cleaning.	3.30	1.18	0.70
Disinfectant for hands in a handbag in the entrance area of the apartment.	3.26	1.13	0.62
Dishwashing detergent for hand washing dishes that is stored in the kitchen next to the sink.	2.95	1.14	0.54

dangers independently,' 'Generally, my child does not expose itself to any dangers,' and 'My child protects itself from danger.' The response options varied from 1 'do not agree at all' to 5 'strongly agree' and the final scale was created by taking the mean over all three items ($\alpha = 0.76$). Two subscales of the Parenting Styles Inventory (Satow, 2013) were used to measure *Parenting Style*. The two subscales that measured educational styles 'Authority' and 'Autonomy' were chosen, as they were more relevant for the topic at hand than other subscales (e.g., 'Love' or 'Religiosity').

Additionally, participants were asked in three separate items, how severe it would be for the health of a pre-schoolers to take a little sip of one of three different types of household chemicals (*Severity of Exposure*). The sip was quantified as 'not more than a teaspoonful.' First, they were asked about washing-up liquid (low severity, low risk perception). Second, they were asked about a chemical descaler (high severity, high risk perception based on perceived naturalness). Third, they were asked about a vinegar cleaner (high severity, low risk perception based on

perceived naturalness). Assumptions regarding the severity and people's responses to these products were based on the pre-study and previous literature (Bearth et al., 2020; Bearth et al., 2017b; Scott and Rozin, 2020). The response options were: 1 'not dangerous at all (no measures necessary),' 2 'not dangerous (observe child),' 3 'rather not dangerous (call the poisoning hotline),' 4 'dangerous (call a doctor)' and 5 'very dangerous (call an ambulance, go to hospital).' Alternatively, participants could indicate that they did not know. Participants were further asked about their expectations regarding child-resistant caps ('What expectations do you have when a household chemical is labelled as child-resistant?'). The following four response options were provided: Option 1: 'The packaging cannot be opened by pre-school children.' Options 2-3: 'The packaging can only be opened by [very few pre-school children/a handful pre-school children]' and option 4: 'The packaging can be opened by most pre-school children.' Lastly, participants were asked about their sociodemographics, household composition and whether they had ever called the emergency number of Tox Info Suisse (145).

4.3. Data analysis

All newly developed multi-item scales were subjected to a Principal Component Analysis (PCA) and all scales' internal consistency was estimated with Cronbach's Alpha. Descriptive analyses were conducted to investigate the first aim on product and environmental attributes. Bivariate correlation and linear regression analyses were conducted for the second aims focusing on the beliefs. All data analyses were conducted with SPSS 26 (IBM Corp., 2017).

5. Main study: Results

5.1. Sample description

The final sample comprised $N = 688$ participants, with $n = 376$ German-speaking (55%), 143 French-speaking (21%) and 169 Italian-speaking participants (25%). Comparing the sample to the national distributions (70% German-speaking, 24% French-speaking, 6% Italian-speaking) exhibits that Italian-speaking participants were oversampled. There were more female participants ($n = 462$, 67%) than male participants ($n = 223$, 32%), and 3 participants did not indicate their sex. The mean age of the participants was $M = 38$ (age range: 20–78) with one person not indicating their age. Most adults indicated to live with one pre-schooler ($n = 533$, 78%, range: 1–4 pre-schoolers per household). Most participants were primarily responsible for the household ($n = 380$, 55%), followed by partly responsible ($n = 277$, 40%) and not responsible ($n = 30$, 4%). A total of 96 participants (14%) indicated to work in a field that produces, imports, trades, or uses chemical products. The participants reported varying levels of education with 461 (67%) indicating high school or vocational training and 226 (33%) indicating a higher education (university, applied university).

5.2. First aim: Risk perception of product and environmental attributes

Tables 3 and 4 exhibit the separate items included in the risk perception scales. Overall, risk perception for both product and environmental attributes were high with means ranging mostly between 3 and 4 (maximum: 5). The quantitative findings regarding the product attributes confirm the qualitative findings. The caretakers exhibited the highest risk perception for colourful household chemicals with pictures on them or food imitating products. Responses were more mixed for other product attributes or specific products, such as pods and tabs. A lower risk perception was uncovered for products with unpleasant smells. Regarding environmental attributes, caretakers exhibited the highest risk perception for transferring the household chemicals into PET bottles. The lowest risk perception was observed for dishwashing detergent and household chemicals perceived to be natural (i.e.,

essential oils, cleaning vinegar) or disinfectant.

Fig. 1 presents the response distribution for the severity of exposure to three household chemicals. The results confirm the finding from the pre-study that caretakers differentiate the potential severity of exposure to different household chemicals. For the washing-up liquid, the most frequent responses were either 'rather not dangerous' and 'dangerous' and caretakers would call the poisoning hotline or a doctor. For the chemical descaler, the most frequent response was 'very dangerous' and caretakers would call an ambulance or go straight to the hospital. For the vinegar cleaner, the most frequent response was 'dangerous' and caretakers would call a doctor.

The main study confirmed the high trust in child-resistant caps uncovered in the pre-study. Most caretakers indicated that household chemicals with child-resistant caps cannot be opened by pre-school children ($n = 496$ 72%) or only very few pre-school children $n = 118$ (17%). A total of $n = 38$ (6%) and $n = 35$ (5%) thought that packaging with child-resistant caps can be opened by a handful or most pre-school children respectively.

5.3. Second aim: Individual and psychological variables that determine beliefs

Table 5 exhibits the Pearson correlation coefficients and Table 6 the linear regression analyses for the beliefs and individual and psychological variables. The caretakers that indicated higher levels of pragmatic/trusting beliefs had less children in the household and were less frequently single caretakers (i.e., one adult in the household). Further, they expressed lower risk perception, perceived more responsibility for retailers and less responsibility for parents, expressed higher trust in the children, and had higher values on the authority parenting style scale. The caretakers that indicated higher levels of protective beliefs expressed higher risk perception, perceived higher responsibility for parents, and had higher values on the authority parenting style scale. Lastly, the caretakers with higher levels of educational beliefs expressed higher trust in children and higher values on the autonomy parenting style scale.

6. Overall discussion

Accidents with household chemicals happen when a variety of safety measures fail. Naturally, the availability of hazardous household chemicals in the household increases the likelihood of an accident. As many hazardous household chemicals are omnipresent in households due to their purpose and convenience, this is unavoidable. It highlights the importance of caretaker's risk awareness and perceptions for hazard (due to a household chemical's hazardousness) and risk (due to a child's interest in the household chemical due to its attributes and design), which in this study was found to be high. Particularly, cartoons, colour, and foodstuff on the packaging or appetising smells were identified by the caretakers as raising children's attention. Furthermore, risk perception based on the presence and unsafe storage of household chemicals was high. However, the following anecdote from the pre-study highlights a common misconception among caretakers: a caretaker stated that their household was free of hazardous chemicals, while the observatory data showed the presence of predominantly ecological household chemicals with similar risk profiles as regular household chemicals. The misconception that certain products, perceived to be natural or weak, pose a lower risk to children was also found to be prevalent in the quantitative main study. Most notably in the direct comparison of the severity of exposure to chemical descaler compared to vinegar cleaner. Another misconception, previously rereferred to as the lulling effect (Morronegiello and Major, 2002; Viscusi, 1984), suggests a high reliance on child-resistant caps, as roughly 70% of the caretakers were convinced that pre-school children were not able to open them.

These findings mostly confirm what other studies have previously suggested regarding adults' risk perceptions of household chemicals

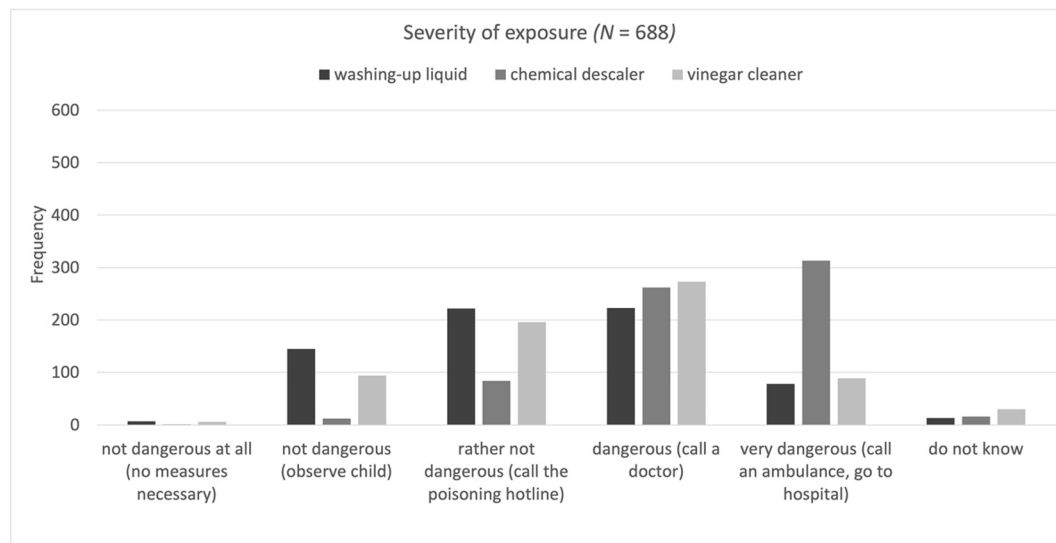


Fig. 1. Perceived severity of exposure for three different household chemicals.

(Basso et al., 2016; Bearth et al., 2020; Bearth et al., 2017a; Beirens et al., 2006; Buchmuller et al., 2020). It stresses the importance of continued awareness-raising campaigns, particularly among parents and other caretakers. It is assumed that informational campaigns are more successful in raising awareness and impacting behaviour if focused on novel information and existing misconceptions (Morgan et al., 2002). Thus, future awareness-raising campaigns should highlight the potential risks of the incorrect storage of household chemicals that are mistakenly perceived as safe (e.g., cleaning vinegar, essential oils, eco products or products in biodegradable containers) and the limitations of child-resistant caps. Warning labels, such as the GHS pictograms and warning statements, might play a role here, although the impact of these warnings have been disputed (e.g., lack of awareness or attention) (Bearth and Siegrist, 2019; Dalvie et al., 2014; Riley, 2014; Su and Hsu, 2008).

Three beliefs were identified in the main study: pragmatic/trusting, protective and educational beliefs. These beliefs should not be seen as strictly distinct and mutually exclusive. Rather, different beliefs might apply during the lifespan of children (e.g., more protective in younger children, more pragmatic/trusting in older children) or for different children in the family (e.g., depending on a child's temperament and adventurousness). These open questions regarding the stability and coexistence of these beliefs cannot be fully addressed with this study, but the results of the bivariate correlation analysis suggest that caretakers might be less prone to protective beliefs, if they are more prone to pragmatic/trusting or educational beliefs. Furthermore, links were uncovered between general parenting style (Authority vs. Autonomy) (Satow, 2013) and these beliefs, as well as other individual and psychological variables, as outlined subsequently. These links offer insights for risk communication and prevention, as it is plausible that these beliefs impact decision making in the storage, handling, and disposing of household chemicals.

The pragmatic/trusting belief is characterised by a risk-neglecting, laid-back attitude regarding household chemicals due to the trust placed in their children and the perception that children are not that interested in household chemicals. This belief has been shown to be less prevalent in households with more children and in households with a single caretaker. This suggests that this belief might be more widespread in households with lower workload and where less potential attention diversions from the child might occur. Caretakers with higher scores on this scale indicated higher trust in the children and lower risk perceptions (product and environment). A precondition to increase protective measures, therefore, would be to increase caretakers risk awareness, as

these pragmatic/trusting beliefs might otherwise be resistant to change. Moreover, caretakers high in the pragmatic/trusting belief perceived a higher responsibility of retailers and the child and a lower responsibility for parents, which further might contribute to resistance to change these beliefs. Lastly, a higher pragmatic/trusting belief was associated with a more authoritative parenting style. This was somewhat surprising but might be related to the trust aspect of this belief scale (i.e., 'My child would not disobey me and interact with household chemicals'). To prevent accidents, it might be worthwhile to better understand what encourages pragmatic/trusting beliefs in caretakers to design specific intervention measures.

The protective belief is characterised by strict rules for children not to touch household chemicals and by locking these chemicals safely away and out of reach of children. Caretakers scoring high on this scale indicated higher perceived responsibility for parents and manufacturers and higher risk perception for various environmental attributes. This suggests that there exists less need for communication and intervention, as these beliefs would suggest adequate protection for the children. Also, caretakers scoring high on protective belief, scored higher on the authoritative parenting style, yet to a lesser degree compared to the prior belief. This belief might be accompanied by the perception that authoritative parenting might be necessary to protect children from harm. The educational belief is characterised by the perceived need to educate children on the usefulness and the potential risks of household chemicals. Caretakers scoring high on educational belief expressed an autonomy-focused parenting style and high levels of trust in their children.

Little is known about the effectiveness of either keeping children strictly away from household chemicals vs. educating them about the potential risks. It has been suggested that both, protective and educational beliefs, would offer protection from accidents in households, while pragmatic/trusting beliefs would offer potential opportunities for accidents to occur (Schmertmann et al., 2013; Schwebel et al., 2017). While a direct relationship between beliefs and decision making is plausible, this study did not explicitly show this. In the qualitative study some links between the interviewees' beliefs and their storage situation were uncovered (e.g., more unsafe storage in interviewees' households with more pragmatic beliefs). However, due to the biasing effect of social desirability in a quantitative setting, no data was collected on decision making and behaviour. In the future, these beliefs should be explicitly linked to caretakers' decision making, as this offers additional insights for risk communication and accident prevention.

Table 5
Pearson correlation coefficients for beliefs (B) and risk perception (RP), perceived responsibility (PR), trust in child, and parenting style (PS).

	B: pragmat./trusting	B: protet.	B: educat.	RP: product attribute	RP: environ. attrib.	PR: manu-facturer	PR: retailer	PR: parents	PR: child	Trust	PS: Author.	PS: Autono.
B: pragmatic/trusting	–											
B: protective	–0.16***	–										
B: educational	0.24***	–0.29***	–									
RP: product attribute	–0.30***	0.12**	0.02	–								
RP: environment attrib.	–0.25***	0.31***	–0.05	0.49***	–							
PR: manufacturer	0.06	0.24***	–0.08*	0.06	0.16***	–						
PR: retailer	0.18***	0.16***	< 0.01	–0.01	0.17***	0.55***	–					
PR: parents	–0.20***	0.36***	–0.05	0.18***	0.26***	0.21***	0.12**	–				
RP: child	0.29***	< –0.01	0.10*	–0.12**	–0.05	0.12***	0.18***	–0.02	–			
Trust in child	0.51***	< 0.01	0.17***	–0.14***	–0.09*	0.05	0.13***	0.03	0.36***	–		
PS: Authority	0.26***	0.09*	0.07	–0.03	0.01	0.07	0.13***	–0.01	0.14***	0.13**	–	
PS: Autonomy	0.05	0.01	0.26***	0.11**	0.08*	–0.08*	–0.02	0.14***	0.04	0.12**	0.20***	–

Note. ***: $p < .001$, **: $p < .01$, *: $p < .05$.

6.1. Implications for further research and limitations

Aside from the novel insights discussed above, it is important to address this study's limitations in light of ideas for future research. Regarding the product attributes, it is important to note that this study measured caretakers' perspectives on product attributes and environmental factors, not actual behaviour by preschoolers. It is logical that caretakers are aware of the product attributes that might raise their children's attention, but it is also possible that their judgments are biased or clouded by their own preferences. For example, [Schneider \(1977\)](#) found that children are attracted to all kinds of olfactory stimuli (pleasant, as well as unpleasant smells), while the caretakers in our study did not perceive high levels of attractiveness for unpleasant smells. Among other goals, this study aimed at generating evidence for regulatory decisions on which product attributes or designs should be avoided in hazardous household chemicals. Future studies should strive to strengthen this evidence with studies focusing on children, instead of their caretakers. Children are not simply "small adults," and unexpected product attributes and designs might raise their attention. Similarly, robust, and valid designs are needed to investigate this in laboratory or observational experiments, as has been applied and suggested in prior studies ([Richmond et al., 2018](#); [Richmond et al., 2021](#)). An aspect that has received insufficient attention, particularly in the quantitative survey, is the impact of prior or occurring experiences on beliefs. In the qualitative interviews, this aspect received more attention and stressed the importance of specific occurrences and experiences for the caretakers' beliefs. For example, a caretaker that previously exhibited pragmatic/trusting beliefs might shift to more protective beliefs after catching their child playing with a hazardous household chemical or after experiencing or hearing about an accident. It is important to state that these beliefs are continuously impacted by these experiences and might therefore, change dynamically.

6.2. Conclusion

This study contributes to the current literature on the risk of household chemicals to pre-schoolers in two ways. First, it provides insights into caretakers' perceptions of household chemicals and attributes that might increase their attractiveness to children. Most importantly, some major misconceptions could be identified that might contribute to the incorrect storage of household chemicals and thus, potential exposure to children. Second, it showed that caretakers express a variety of beliefs to keep children from harm in the household and that various demographic, individual and psychological factors relate to these beliefs. These insights offer ideas and starting points for the development of measures to prevent accidents with chemical household products in households with young children.

7. Data availability statement

The data that support the findings of this study will be available upon publication.

CRediT authorship contribution statement

Angela Bearth: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Noah Bosshart:** Conceptualization, Writing – review & editing. **Stephanie Wermelinger:** Conceptualization, Writing – review & editing. **Moritz Daum:** Conceptualization, Writing – review & editing. **Michael Siegrist:** Conceptualization, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial

Table 6

Linear regression analyses with beliefs (B) as dependent variables and sociodemographics and individual variables as independent variables.

	B: pragmatic/trusting			B: protective			B: educational		
	B (SE)	β	t	B (SE)	β	t	B (SE)	β	t
Constant	1.74 (0.31)		5.70***	1.37 (0.38)		3.64***	0.79 (0.57)		1.40
Age	<0.01 (0.00)	<0.01	0.14	0.01 (0.00)	0.04	1.20	<0.00 (0.01)	0.02	0.60
Sex (0: male, 1: female)	-0.06 (0.05)	-0.04	-1.10	0.09 (0.07)	0.05	1.35	-0.08 (0.10)	-0.03	-0.81
Education (0: low, 1: high)	-0.02 (0.05)	-0.01	-0.33	0.04 (0.06)	0.03	0.72	0.03 (0.09)	0.01	0.33
Number of children in household	-0.08 (0.02)	-0.10	-3.20**	-0.01 (0.03)	-0.01	-0.17	-0.03 (0.05)	-0.02	-0.62
Single caretaker (0: no, 1: yes)	-0.18 (0.05)	-0.10	-3.39**	0.08 (0.07)	0.04	1.16	-0.03 (0.10)	-0.01	-0.35
Called emergency number (0: no, 1: yes)	-0.01 (0.06)	-0.01	-0.22	-0.07 (0.08)	-0.03	-0.91	0.07 (0.11)	0.02	0.59
RP: product attribute	-0.13 (0.03)	-0.14	-3.88***	-0.04 (0.04)	-0.04	-0.99	0.11 (0.06)	0.08	1.73
RP: environment attribute	-0.12 (0.03)	-0.12	-3.42**	0.25 (0.04)	0.25	6.09***	-0.09 (0.06)	-0.06	-1.45
PR: manufacturer	0.01 (0.02)	0.02	0.46	0.08 (0.03)	0.12	2.89**	-0.07 (0.04)	-0.08	-1.68
PR: retailer	0.07 (0.02)	0.12	3.22**	<0.00 (0.03)	0.00	0.03	0.03 (0.04)	0.04	0.89
PR: parents	-0.16 (0.03)	-0.16	-5.06***	0.29 (0.04)	0.28	7.66***	-0.10 (0.06)	-0.07	-1.68
PR: child	0.04 (0.02)	0.07	2.02*	-0.01 (0.02)	-0.02	-0.65	0.05 (0.03)	0.05	1.32
Trust in child	0.38 (0.03)	0.41	12.72***	0.01 (0.04)	0.01	0.29	0.18 (0.05)	0.13	3.23***
PS: Authority	0.31 (0.05)	0.17	5.57***	0.18 (0.07)	0.09	2.59*	<0.00 (0.10)	0.00	0.02
PS: Autonomy	0.05 (0.06)	0.02	0.80	-0.12 (0.07)	-0.06	-1.62	0.66 (0.11)	0.23	6.00***

Note. B: pragmatic/trusting: $R^2 = 0.42$, $F(15, 665) = 32.5$, $p < .001$. B: protective: $R^2 = 0.22$, $F(15, 665) = 12.7$, $p < .001$. B: educational: $R^2 = 10.$, $F(15, 665) = 5.11$, $p < .001$; ***, $p < .001$, **, $p < .01$, *, $p < .05$.

interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to extend our gratitude to Patrizia Eicher for conducting a preparatory systematic literature review and conducting the qualitative interviews for the pre-study. We would also like to thank Heribert Bürgy and Peter Krähenbühl for providing valuable inputs to this study. This study was partially funded by the Federal Office of Public Health in Switzerland (FOPH).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssci.2022.105864>.

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