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Consumers’ perceptions of chemical household products and the associated risks

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ABSTRACT

Accidents with chemical household products are prevalent worldwide and often involve young children. Previous research has shown that consumers use both analytical factors (e.g., warning symbols) and potentially misleading heuristics to evaluate the riskiness. However, it remains unclear whether consumers intuitively think of the specific risks of these products when handling them. We conducted an online survey with Swiss consumers (N = 1109) aiming to investigate consumer’s spontaneous and prompted risk perception of chemical household products. First, we asked them about their free associations to laundry detergent, descaler, mold remover and essential oils. While participants were aware of the risks when prompted about them, they did not name them intuitively, but mainly thought of the possible uses and attributes of the product. Next, we examined prerequisites to safe handling of chemical household products. This included applied knowledge about the products, but also factors like perceived barriers to safe use. Finally, we assessed the predictors of perceived severity of accidents in order to estimate the potential behavioral changes that these predictors might elicit. For interventions, particular attention should be accorded to personal risk awareness and the perception of potential barriers, which were significantly related to the perceived severity of accidents.

1. Introduction

Chemical household products are widely used in many of the activities associated with daily living, including cleaning tasks, do-it-yourself (DIY) projects, and garden maintenance. While chemical household products may offer many advantages, for example, permitting us to live in a hygienic and healthy environment, they are also associated with certain risks to our health and environment if they are employed in an unsafe way (Garcia-Hidalgo et al., 2017; Tox Info Suisse, 2019). Aside from acute poisonings, chemical household products also lead to other severe health risks, such as chemical burns from corrosive products or hazardous fumes, when bleach is combined with vinegar or drain cleaner (Habib et al., 2006; Swiss Federal Office of Public Health, 2014). Finally, such products often have a negative impact on the environment, especially when recommendations are disregarded (Slack et al., 2004). Risk-decreasing behavior can not only occur when using a product, but also when buying a product (e.g., choosing a lower-risk product rather than a product with a higher risk profile), when deciding how and where to store a product (e.g., out of reach of children and separately from food products), and finally, when disposing of a product.

The present study sought to provide specific insights into consumers’ perceptions of chemical household products and the factors contributing to accidents. For this, a number of factors were investigated that have thus far received insufficient attention in the prior literature (e.g., Bearth et al., 2020; Bearth et al., 2017). Among other factors, general risk awareness, the perception of the severity of risky situations and perceived barriers to the safe handling of chemical household products were investigated.

2. Theoretical background

Toxicological reports from several Western countries (e.g., Switzerland, United Kingdom, United States) show that accidents involving chemical household products represent an important public health issue (Gummin et al., 2018; Tox Info Suisse, 2019; Williams et al., 2012). In Switzerland, for example, the national toxicological helpline reported over 8000 poisonings with chemical household products in 2018 (Tox Info Suisse, 2019). This makes chemical household products the second most commonly involved substance in accidents after medicine and a common risk especially for young children. These numbers are likely to be an underestimation, as there is no legal requirement to report a poisoning, even if medical help is sought. Additionally, health issues other than poisonings, such as burns or eye...
injuries, can result from exposure to chemical household products (Tschopp et al., 2015). Similarly, according to the American Poison Control Centers, household cleaning substances are the second most common cause of unintentional poisonings in the United States (Gummert et al., 2018).

In recent years, the risks associated with chemical household products have changed. While some products are no longer available due to safety reasons (e.g., cleaners and laundry detergents containing environmentally problematic surfactants), certain newly available products pose an additional risk. For example, the introduction of laundry pods has resulted in an increase in poisonings and injuries. These products can be mistaken for sweets, and they are highly concentrated, which renders them more dangerous in cases of exposure (Claudet et al., 2014; Wyke and Desel, 2018).

If chemical household products are to be handled safely, different prerequisites must be met. First and foremost, people must be aware of the potential risks that chemical household products can pose. Second, people must have the knowledge necessary to adopt adequate measures to protect themselves. Third, people must have sufficient motivation to engage in safe behavior (Laughery and Wogalter, 2014). The prior literature regarding these three issues will now be presented and discussed in light of the present study's goals.

### 2.1. Awareness of the risks concerning chemical household products

It is rare for people to knowingly behave in an unsafe way without any reason or incentive (Weegels and Kanis, 2000). Thus, a prerequisite for mitigating a risk is awareness that there is a risk in the first place. While laypeople seem to be cautious of chemicals (Jansen et al., 2019; MacGregor et al., 1999), to date these has been little research as to whether people are generally aware of the potential risks specific to household chemicals. For chemical household products, the research suggests that product attributes might be associated with a higher or lower level of risk awareness. For example, pre-school children find it easier to recognize an unsafe chemical household product if it is in a black, opaque, and square bottle or metal container (Schwebel et al., 2014). It can be assumed that, perhaps to a lesser extent, similar perceptions could apply to adults. Additionally, chemical household products are sometimes packaged in a similar way to food products (so-called food-imitating products) in order to increase their attractiveness (e.g., featuring flowers or berries on the label, or in bottles that resemble soft drinks). This could lead to lower levels of risk awareness (Basso et al., 2010). In line with this, some such products are associated with a higher number of poisonings (e.g., the all-purpose cleaner Fabuloso, which is available on the American market) (Basso et al., 2010, 2014). Basso et al. (2014) found that when their participants looked at soap that was packaged in a similar way to orange juice, the brain activity in the gustatory cortex areas was increased, although the participants were able to verbally differentiate the products. Therefore, it is possible that adults, particularly when tired or drunk, might experience difficulty distinguishing these products, which could lead to unintentional poisonings.

### 2.2. Knowledge regarding chemical household products and their associated risks

Further, if chemical household products are to be handled safely, knowledge of how a particular risk can be reduced is necessary in order to engage in safe behavior. Many European countries introduced the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) between 2010 and 2015. Checking the different pictograms for each class of risk (e.g., corrosive, inflammable, toxic) should enable consumers to easily assess the type of risk associated with a specific product. Additionally, the pictograms are complemented by hazard and precautionary statements that provide information about how to safely handle the product in question (United Nations, 2017).

However, it has been shown that while signal words had an influence on individuals’ risk perception, the presence of a GHS pictogram did not (Boelhouwer and Davis, 2010). It has also been shown that a considerable number of consumers are unaware of the relatively new GHS pictograms, meaning that they instead rely on defunct classification systems. Additionally, some consumers seem to be unfamiliar with part of the GHS pictograms. In fact, in a study conducted in 2018 in eight European countries, 65% of participants indicated never having seen the health hazard pictogram before. Equally, only 42% of participants indicated knowing the meaning of the environmental hazard pictogram (Bearth et al., 2020). In a British study examining the use of pesticides in households with children, nearly half of all parents indicated that they did not understand the label, although at the same time 90% of parents believed in following the warnings featured on the label (Grey et al., 2005). Another study involving British manufacturers, vendors, workers, and consumers used focus groups to explore the safety information featured on chemical products. While the study found that most people seemed to be aware of the labels, many of them did not seem able to understand the labels (Hinks et al., 2009). This finding is also reflected in observational studies showing that most laypeople do not even look at labels, let alone read them (Kovacs et al., 1997). It seems that while the warnings included on the label are appreciated by most consumers, some consumers find it difficult to understand the exact meaning of those warnings.

Thus, people might apply other strategies for judging the risks associated with household chemicals and protecting themselves from harm. Previous research shows that a number of shortcuts can be used by laypeople to determine a potential risk. For example, eco-friendly products are considered by laypeople to be safer than regular products, even when controlling for other factors (e.g., attractive packaging) (Bearth et al., 2020). This probably reflects consumers’ preference for natural products, as they believe that substances of natural origin are not generally harmful to human health or the environment (Bearth et al., 2017; Bearth and Siegrist, 2019; Kahraman and Kazaçoğlu, 2019). Further, many consumers ignore the dose–response relation in terms of the way that a chemical product is considered to be either dangerous or safe (Saleh et al., 2019). This results in consumers not knowing that substances generally considered to be safe can prove to be toxic if they are ingested in a large enough quantity. Additionally, some laypeople include product- and marketing-related factors in their risk assessment. While risk-related aspects (i.e., warning symbols, ingredients) are judged to be important by most laypeople, some people also rate less-informative factors such as perceived effectiveness, previous experience with the product, and place of purchase of the product as being important (Bearth et al., 2020). Thus, consumers might believe that they are using a safe product because, for example, they bought it from a familiar shop, even though it is actually quite dangerous.

### 2.3. Motivation and barriers concerning the safe use of chemical household products

Even when risk awareness and knowledge regarding mitigating factors are given, accidents can still occur. The reasons for this could be the perceived barriers to safe behavior or a lack of motivation in terms of the additional effort required to apply safety measures.

Consumers who report their previous experience with a specific product to be a reason for their risk perception (Bearth et al., 2020) may be buying the same products out of habit, and thus, not see a reason for checking the product in detail every time they use it. For everyday household items, for example, cleaning products, consumers tend to choose the same product repeatedly without investing too many resources (e.g., attention, time) in making the choice. This phenomenon is strengthened when consumers are in a well-known shop (Park et al., 1989; Wood and Neal, 2009). Although habit is not bad per se, it may result in a lack of attention. In this case, changes in the market situation, for example, the appearance of a safer product alternative or the
addition of a warning label, might go unnoticed.

Another aspect of relevance is whether the users of chemical household products believe that their own actions have an impact on safety. In an earlier study, we found that consumers with positive outcome expectations, e.g., the belief that acting in a safe way results in the risk being decreased, exhibited safer behavior than consumers with negative outcome expectations (Bearth et al., 2020). Further, consumers may opt to avoid taking safety precautions if they perceive them to involve a too high burden in everyday life. For instance, the parents of young children were found to prefer storing dangerous products within reach of their children because storing them in a safer place would have been inconvenient (Gibbs et al., 2005). Equally, when consumers believed that sufficient precautionary measures had already been taken, for example, if the product comes in a child-resistant container, they were less likely to follow the storage recommendations (Gibbs et al., 2005). Lastly, when consumers perceived themselves to be familiar with the product in question, they felt less inclined to take the time and read the safety recommendations on its packaging (Grey et al., 2005).

2.4. Study goals and research questions

The intuitive perception of chemical household products in general, without prompting the participants with regard to the potential risks, has not previously been examined. People will likely not associate everyday household products that they habitually use with risk, unless prompted to think about this. Thus, investigating intuitive perceptions might reflect their actual risk perception in a more valid way. Prior studies have investigated the handling of chemical household products, although it has proved challenging to measure behavior due to retrospective and social desirability biases (Basso et al., 2010; Bearth et al., 2017; Habib et al., 2006; Wieck et al., 2018). In the present study, we attempt to tackle this issue by studying both the intuitive perception of chemical household products and the perceived severity of risky situations involving chemical household products, rather than studying self-reported behavior. This approach is based on the assumption that consumers need to perceive accidents involving chemical household products as being severe to develop an intention to adjust their behavior (Floyd et al., 2000). It is likely that consumers will go to greater lengths to prevent a severe health risk than to prevent a minor health risk. Thus, the perceived severity of potentially risky situations involving chemical household products might inhibit or prompt behavioral change.

Based on prior literature, we suggest that there are a number of factors that contribute to the perceived severity of potentially risky situations. First, awareness of the risk is necessary if laypeople are to start the process of thinking about both the severity and possible mitigating factors with respect to chemical household products. Therefore, we sought to answer the following research question:

1. How are different chemical household products perceived, and are consumers aware of the potential risks associated with such products?

Second, a high level of risk awareness alone is not sufficient to change behavior (Scolobig et al., 2012). People need the resources necessary to change their behavior. This includes applied knowledge of how the safe handling of chemical household products can be attained, and an understanding of how motivational factors can potentially hinder this behavior. Thus, we formulated the following questions:

2. How much knowledge concerning the use of chemical household products do consumers have?

3. How do consumers perceive possible motivational factors for safe behavior?

It has previously been shown that people's risk perception is conditional: when evaluating a risk, laypeople consider the protective measures that they have taken to evaluate the severity and thus, the personal relevance of a given risk. Therefore, a comparison between oneself and others with regard to safety measures will take place during the evaluation of a risk (Boehmert et al., 2016; Brewer et al., 2007). This leads to the next research question:

4. How safe do consumers perceive their own behavior to be with regard to chemical household products when comparing themselves to their peers?

These points are prerequisites for the safe handling of chemical household products, and they could explain unsafe behavior in situations in which consumers perceive a high degree of severity and exhibit the willingness to change their behavior. Therefore, we examined whether these factors predict the perceived severity of potentially risky situations.

5. Which individual and situational factors are relevant to the perceived severity of potentially risky situations involving chemical household products?

3. Method

3.1. Participants

Participants from three of the four language areas of Switzerland (German-, French-, and Italian-speaking areas) were recruited for the present study. The questionnaire was administered online via a market research company operating in all three language areas (N = 1109 participants). For this, quota sampling based on age and gender was applied. Both the French-speaking part (n = 295) and the Italian-speaking part of Switzerland (n = 41) were oversampled in order to have sufficient power for the statistical analyses. To increase the sample size in the Italian-speaking part of the country, the addresses of 600 people living in that part were purchased from another market research company. Thus, the Italian version of the questionnaire was also sent out via mail as a paper-and-pencil questionnaire (N = 146 participants). This resulted in a final sample size of N = 1255 for the Italian-speaking part. Some 49% of participants were male (n = 614), while the mean age was 50 years (SD = 17, range: 18–85). One participant preferred not to indicate their gender and age. When compared to the general Swiss population aged 18 years and older, our sample was comparable (M = 49 years for the Swiss population over 18). In terms of the gender distribution, our sample was equally comparable to the general Swiss population (50% of the Swiss population is male) (Bundesamt für Statistik, 2019).

3.2. Questionnaire and measures

This study comprised part of a larger research project funded by the Swiss Federal Office of Public Health. In the present article, we focus on only certain parts of the questionnaire, although the full questionnaire is available from the corresponding author on request. The questionnaire was translated from German to French and to Italian by native speakers and then pretested in all three languages. Any irregularities that were revealed during the translation process were resolved by the first author. Additionally, toxicologists checked and provided input regarding the correctness of the questionnaire. A variety of measures were applied to investigate consumers' risk perceptions, attitudes, and behavior. These measures will be presented in more detail later in the article. Additionally, the following socio-demographic and control variables were assessed: age, gender, education level, language area (German-, French-, or Italian-speaking part), location (town, agglomeration, or countryside), household type, presence of children within
the household, participation in household chores, and professional occupation dealing with chemicals.

3.2.1. Perception of chemical household products and risk awareness

For the first question, the participants were asked about their spontaneous associations concerning four specific chemical household products, namely laundry detergent, mold remover, descaler, and essential oil. Care was taken to choose a variety of products with regard to consumer familiarity, product attributes, and objective riskiness (based on annual poisoning and toxicity reports) (Tox Info Suisse, 2019). To ensure the clarity of the question, the participants were presented with pictures of the specific products. The participants were asked to indicate the first three things that came to their mind in relation to the four different chemical household products (“If you hear the term laundry detergent/mold remover/descaler/essential oils, what are the first words, images or thoughts that come to your mind spontaneously?”). For the analysis, a coding scheme was developed and the participants’ answers were coded by the main author depending on whether a health or environmental risk was explicitly mentioned (e.g., toxic, harmful, dangerous, environmental problem) or whether other associations were mentioned (e.g., purpose, product use, evaluation). Associations that implied a risk but did not explicitly express that risk (e.g., health, aggressive, phosphates) were not coded as a risk. Empty fields or meaningless answers (e.g. answers like “ylsfnm”), were not considered for the analysis. In the case of descaler, a total of 2253 associations could be analyzed (with 1187 participants naming at least one valid association), while for laundry detergent there were 2484 associations (with 1192 participants naming at least one valid association), for essential oil there were 2239 associations (with 1150 participants naming at least one association), and for mold remover there were 2103 associations (with 1128 participants naming at least one association).

Next, the participants were presented with seven common household accident scenarios (Basso et al., 2014; Tox Info Suisse, 2019) in order to investigate the perceived severity of potentially risky situations. This measure was the main variable of interest in the present study, as it is indicative of the perceived consequences and perceived threat of chemical household products for consumers. For this, they were asked to judge the severity of the situation on a scale ranging from 1 = not severe at all (no intervention necessary) to 6 = extremely severe (life threatening). Scenarios concerning both severe and less severe situations, as previously judged by toxicologists, were included (cf. Fig. 2).

Then, the participants’ personal risk awareness, that is, the degree to which they felt personally concerned by the risks associated with chemical household products, was measured using five items on a scale ranging from 1 = do not agree at all to 6 = totally agree (cf. Table 1). The participants were asked to consider the way they store and handle which they felt personally concerned by the risks associated with chemical household products (Fig. 2).

3.2.2. Knowledge regarding the safe handling of chemical household products

Aside from a lack of risk awareness, a number of other factors might develop chemophobia, was measured using a scale adapted from the one developed by Saleh et al. (2019) and used in a similar context by Bearth et al. (2019). For this study, only those items that showed erroneous beliefs and irrational fears were included (c.f. Table 2). Therefore, seven items were considered, and the participants’ responses ranged from 1 = do not agree at all to 6 = totally agree.

3.2.3. Motivation and barriers to safe behavior regarding chemical household products

The barriers to safe behavior were examined by five items (“Official recommendations for storage, use and disposal of chemical household products are not always respected. It is important to us to know in which situations this happens. Please indicate how pertinent the following reasons are for you.”, cf. Table 3). The participants were asked to indicate how pertinent different reasons for unsafe handling were on a scale ranging from 1 = do not agree at all to 6 = totally agree.

Additionally, after completing the questionnaire, the participants who answered the online version were asked to upload up to three pictures of their cleaning cabinet in order to investigate their adherence to storage guidelines. As a high dropout rate was expected for this task, it was clearly stated to be voluntary. A total of n = 92 participants (7%) uploaded at least one image. Due to the poor image quality, only n = 88 of these images could be coded and analyzed. The subsample that uploaded pictures was comparable to the original sample in terms of both gender, X² (1) = 0.20, p = .66, and age, U = 48146.00, z = −1.59, p = .11, r = −0.04. The images were coded according to the official guidelines for the safe handling of household chemicals (https://www.cheminfo.ch). More specifically, this meant that chemicals should be stored separately from food, in their original container with the original label, at a height of at least 1 m 60 cm, and ideally, in a cupboard that can be locked.

4. Results

4.1. Perception of chemical household products and risk awareness

Only a minority of participants expressed risk-related associations concerning the four specific chemical household products (cf. Fig. 1). Over all three associations, risks were mentioned most frequently with regard to the mold remover (14% of participants who gave valid answers named a risk at least once), followed by the descaler (6% of participants who gave valid answers named a risk at least once), the laundry detergent (5% of participants who gave valid answers named a risk at least once), the掇序乱序-tubulations, as previously judged by toxicologists, were included (cf. Table 2). Therefore, seven items were considered, and the participants’ responses ranged from 1 = do not agree at all to 6 = totally agree.

Then, the participants were asked to evaluate their own behavior when compared with the behavior of the rest of the Swiss population (“If you compare yourself with other people in Switzerland, how safe do you estimate your own handling of chemical household products to be?”) on a scale ranging from 1 = less safe than others to 6 = safer than others.

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Table 1

<table>
<thead>
<tr>
<th>Personal risk awareness: Corrected item-total correlations, means (M), and standard deviations (SD) (N = 1254–1255).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected item-total correlation</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>1 I often find the danger and safety recommendations on chemical household products exaggerated.</td>
</tr>
<tr>
<td>2 I have the feeling that chemical household products could endanger my health.</td>
</tr>
<tr>
<td>3 In my daily life, I do not think a lot about whether chemical household products endanger my health.</td>
</tr>
<tr>
<td>4 The dangers associated with chemical household products preoccupy me.</td>
</tr>
<tr>
<td>5 I am worried that I could endanger other people with chemical household products.</td>
</tr>
</tbody>
</table>

Note. Reversed items; 1: do not agree at all – 6: totally agree.
The most frequent associations comprised the reasons for using the product, the place the product is used, and the product attributes (e.g., color of the product). For all the products combined, just 19% of participants named a risk-related thought at least once.

In terms of the items intended to measure the perceived severity of potentially risky situations, the seven items (cf. Fig. 2) were analyzed by means of a principal component analysis (PCA), which exhibited one dimension. The Cronbach’s alpha (α = .80) was also found to be good. The items were combined into a scale measuring the perceived severity of potentially risky situations by taking the mean over all the items.

Further, the participants were asked to rate their personal risk awareness. The scale analysis of these items (PCA) suggested one dimension and a good Cronbach’s alpha (α = .69). Thus, the items were combined into one scale measuring personal risk awareness by taking the mean over all the items.

### Table 2

Chemophobia: Item-total correlations, means (M), and standard deviations (SD) (N = 1253–1255).

<table>
<thead>
<tr>
<th>Corrected item-total correlation</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.40</td>
</tr>
<tr>
<td>2</td>
<td>0.56</td>
</tr>
<tr>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>4</td>
<td>0.59</td>
</tr>
<tr>
<td>5</td>
<td>0.69</td>
</tr>
<tr>
<td>6</td>
<td>0.56</td>
</tr>
<tr>
<td>7</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Note. 95: reversed items; 1: do not agree at all – 6: totally agree.

### Table 3

Perceived barriers to safe behavior: Item-total correlations, PCA with direct oblimin rotation (pattern matrix), means (M), and standard deviations (SD) (N = 1249–1253).

<table>
<thead>
<tr>
<th>Attitudinal barriers</th>
<th>Behavioral barriers</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Not enough time and time pressure</td>
<td>0.11</td>
<td>−0.81</td>
</tr>
<tr>
<td>2 Distractions (e.g., other tasks, children, domestic animals)</td>
<td>−0.08</td>
<td>−0.90</td>
</tr>
<tr>
<td>3 Safety recommendations are exaggerated</td>
<td>0.85</td>
<td>0.20</td>
</tr>
<tr>
<td>4 Safety recommendations are too complicated</td>
<td>0.79</td>
<td>−0.12</td>
</tr>
<tr>
<td>5 Safety recommendations are not known</td>
<td>0.54</td>
<td>−0.29</td>
</tr>
</tbody>
</table>

Note. 1: do not agree at all – 6: totally agree.

### 4.2. Knowledge regarding the safe handling of chemical household products

Generally speaking, the participants exhibited a high level of applied knowledge (cf. Fig. 3). However, some items proved more difficult to answer than others. Most participants (82%) were aware that products without danger symbols could potentially also be dangerous. Equally, a high number of participants (73%) knew that dangerous chemical household products do not necessarily have an unpleasant scent, and further, that essential oils are highly flammable (61%). Not quite half of all participants (44%) knew that the type of laundry detergent has an influence on the level of toxicity due to the different concentrations of liquid, powder, or tab laundry detergent.

Finally, with regard to chemophobia, a PCA was run for the seven relevant items, which resulted in one dimension and a good Cronbach’s alpha (α = .83). Therefore, we computed a scale by taking the mean over all the items (M = 3.45, SD = 1.07). All the items and their means can be found in Table 2.

![Fig. 1. Free associations: Type of associations regarding the four chemical household products.](image-url)
Fig. 2. Perceived severity of potentially risky situations: Frequencies ($N = 1254–1255$).

Note. (s): judged to be severe by toxicologists, (ls): judged to be less severe by toxicologists; participants responded on a scale ranging from $1 = \text{not severe at all}$ to $6 = \text{extremely severe}$; responses $1 + 2$, $3 + 4$, and $5 + 6$ are combined in the figure.

Fig. 3. Applied knowledge: Percentages ($N = 1253–1255$).

Note. (f): false statements.
4.3. Motivation and barriers to safe behavior regarding chemical household products

In terms of the perceived barriers, a PCA with direct oblimin rotation was run to determine the dimensionality of the items. Based on the eigenvalues and the scree plot, two components were retained. One scale was composed of two behavioral barriers (distractions and lack of time; \( \alpha = .70 \)), while the other scale consisted of three attitudinal barriers due to issues regarding official guidelines (\( \alpha = .62 \); cf. Table 3). The two scales were created by taking the mean over the respective items.

Next, the participants were asked to compare their behavior to the behavior of other people living in Switzerland (e.g., Fig. 4). Some 85% of participants considered their behavior to be safer than the behavior of the average consumer (\( M = 4.44, SD = 1.06 \)).

With regard to the subsample of participants who provided images of their cleaning cabinets, a considerable number of participants did not fully comply with safety guidelines. A minority of two participants (2% of \( n = 87 \)) stored their cleaning products together with food. Only seven participants (8% of \( n = 84 \)) did not store their products in the original packaging (e.g., transferred into a syrup bottle). A majority of participants (55 participants, 71% of \( n = 77 \)) stored their products under a height of 1 m and 60 cm, meaning that they were potentially accessible to children. Finally, 29 participants (36% of \( n = 81 \)) did not store their products in a closed cabinet.

4.4. Predictors of the perceived severity of potentially risky situations

The correlations between the various scales were computed, and they are presented in Table 4. The participants who reported a higher perceived severity in relation to potentially risky situations also reported higher personal risk awareness, safer behavior according to their own comparative evaluation, higher chemophobia, and more perceived behavioral barriers. However, they perceived less attitudinal barriers. Furthermore, the strongest correlation was observed between chemophobia and personal risk awareness. Thus, the participants who perceived higher personal risk awareness also exhibited higher levels of chemophobia. No significant correlations were observed between personal risk awareness and behavioral barriers, peoples cooarative evaluation of their own behavior and chemophobia or behavioral barriers and finally between chemophobia and attitudinal barriers.

We conducted a linear regression analysis to determine which factors are related to the perceived severity of potentially risky situations. We included the socio-demographic variables of gender, age, language, the regular presence of children within the household, and education level, as well as the psychological variables of personal risk awareness, comparative evaluation of own behavior, chemophobia, behavioral barriers, and attitudinal barriers. Table 5 presents the results of this linear regression analysis. The model was found to be significant, \( F(11, 1237) = 32.07, p < .001 \), and it explained 22.2% of the variance in the perceived severity of potentially risky situations. In terms of the socio-demographic variables, the most important factor concerning the perceived severity of potentially risky situations was gender, with female participants perceiving higher severity than male participants. Younger participants reported lower perceived severity when compared with older participants. Further, participants with children who are regularly present within their household perceived lower severity. The variables of education level and language area were not related to the perceived severity of potentially risky situations. With regard to the psychological factors, high personal risk awareness and high chemophobia were both related to the higher perceived severity of potentially risky situations. Participants who considered their own behavior to be safer also reported higher perceived severity of potentially risky situations. Participants who perceived that their behavior was more dangerous also reported higher levels of chemophobia and personal risk awareness.

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**Table 4**

<table>
<thead>
<tr>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</thead>
<tbody>
<tr>
<td>1 Perceived severity of potentially risky situations</td>
<td>–</td>
<td></td>
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<td></td>
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<tr>
<td>2 Personal risk awareness</td>
<td></td>
<td>0.39***</td>
<td>–</td>
<td></td>
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<td></td>
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<tr>
<td>3 Comparative evaluation of own behavior</td>
<td>0.18***</td>
<td></td>
<td>0.10***</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Chemophobia</td>
<td>0.30***</td>
<td>0.49***</td>
<td>–</td>
<td>0.01</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>5 Behavioral barriers</td>
<td>0.09**</td>
<td>–</td>
<td>0.05</td>
<td>0.01</td>
<td>0.06*</td>
<td>–</td>
</tr>
<tr>
<td>6 Attitudinal barriers</td>
<td>–</td>
<td>0.11***</td>
<td>–</td>
<td>0.25***</td>
<td>–</td>
<td>0.08**</td>
</tr>
</tbody>
</table>

Note: *: \( p < .05 \), **: \( p < .01 \), ***: \( p < .001 \).
safer than the behavior of others perceived a higher severity. Further, participants who acknowledged more behavioral barriers (e.g., time pressure, distractions) perceived a higher severity in relation to potentially risky situations.

5. Discussion

This study had five key aims: (i) to examine consumers’ unprompted and prompted perceptions of chemical household products, (ii) to determine consumers’ applied knowledge regarding the handling of chemical household products, (iii) to determine the motivational factors to safe behavior perceived by consumers themselves, (iv) to measure how safe consumers’ behavior is with regard to chemical household products, and (v) to identify the individual and situational factors that predict the perceived severity of potentially risky situations in order to assess the perceived consequences and threats associated with chemical household products.

5.1. Lack of risk awareness with regard to chemical household products

We asked the participants about the first three things that came to mind when thinking about four specific chemical household products (e.g., laundry detergent, mold remover, descaler, and essential oil). This technique allowed us to determine the free associations laypeople have in relation to these specific products (Schnabel and Asendorpf, 2013). Risk-related thoughts were only mentioned by a very few participants. Most participants responded by naming the reason for using the product, where the product is used, or the product attributes (e.g., nice smell). However, when asked specifically about problematic situations involving chemical household products, the participants were aware of the risks, and for most situations, they were able to correctly differentiate between hazardous and less hazardous situations. While the participants knew about the potential risks, they did not think of themselves and so had to be reminded of the risks. Therefore, we suggest that attempts to increase safe behavior should focus on activating the available awareness of the potential risks of chemical household products rather than on creating new awareness. This suggestion is in line with prior research regarding food-imitating products (Basso et al., 2010, 2014). Such studies have shown that laypeople have to be reminded of the potential risks if they are to correctly categorize a product and then adopt appropriate safety measures. We suggest that this could be achieved using distinctive packaging. Research concerning young children has shown that, for example, this could involve the use of the color black or the use of square bottles (Schwebel et al., 2014).

A special case is essential oils. These can not only be used for cleaning as well as for cooking and as medicine. However, the different products should not be used for applications other than their intended use. For instance, essential oils for cleaning should not be used for cooking. Nevertheless, their intended use is frequently unclear on the packaging. This could result in ambiguity for the user and a problematic risk perception, as these different types of essential oils might not be distinguished based on their designated uses by the consumer (Basso, 2011).

5.2. Partial knowledge about the handling of chemical household products and unreasonable fears

The participants’ responses showed an unreasonable fear of synthetic chemicals in general as well as a specific lack of applied knowledge regarding chemical household products. More specifically, in terms of their knowledge, the participants were unaware of the dose–response relationship. A high number of participants did not know that laundry detergent tabs are more hazardous due to their higher concentration when compared with laundry detergent powder or liquid. A similar lack of knowledge is reflected in the previous research (Jansen et al., 2020; Kraus et al., 1992; Ropeik, 2012; Saleh et al., 2019; Slovic et al., 1995).

Most participants seemed to consider chemicals as something that should be avoided. In particular, participants with high levels of chemophobia exhibited a high level of personal risk awareness for chemical household products. This is not surprising, as it has been shown that many laypeople are particularly worried about synthetic chemicals (Jansen et al., 2019; Saleh et al., 2019). However, such an undifferentiated fear of certain chemicals or chemical substances can be problematic. Although laypeople may consider a substance to be natural or free of any synthetic chemicals, this does not necessarily mean that this particular substance is less hazardous than another one. Thus, this could result in laypeople neglecting safety precautions if they believe that they are using a “safe, chemical-free substance” rather than a “harmful, chemical substance”.

5.3. Barriers and negligence concerning the safe handling of chemical household products

The participants were asked to rate their own behavior in comparison to the behavior of other Swiss people. Responses to this question revealed that the great majority of participants (85%) indicated that they behaved in safer ways than the average citizen. People seem to assume that only other people behave unsafely. This phenomenon could be described as an optimistic bias (i.e., the belief that negative events are less likely to affect oneself than others) or as illusory superiority (i.e., the belief that the one’s own behavior is safer than the behavior of others). These phenomena have been identified in previous studies in relation to all sorts of risks, including accidents, natural disasters, and illnesses (Helweg-Larsen and Shepperd, 2001; Hoorens, 1993). Nevertheless, the participants seemed to be aware of the potential barriers to unsafe behavior, especially with regard to a lack of time and distractions. However, attitudinal barriers, e.g. in relation to safety recommendations and not influenceable by lay people themselves, however were rated to be less important. This shows that consumers are willing to take on the responsibility for safe use of chemical household products. Equally, participants with high levels of personal risk awareness found that attitudinal barriers were not that important.

Similarly, for the subsample of participants who provided images of their storage cabinets, a widespread disregard for official recommendations was observed (see https://www.cheminfo.ch for the official recommendations). This is somewhat contradictory, as the participants also indicated knowledge of the safety recommendations, and further, reported that they were neither exaggerated nor too complicated. However, a similar disregard for basic safety precautions...
when storing chemical household products has previously been reported (Beirns et al., 2006; Habib et al., 2006).

5.4. Predictors of the perceived severity of risky situations involving chemical household products

A regression analysis was run to determine the perceived severity of potentially risky situations. The perceived severity of such situations, and therefore, the perceived consequences and threats associated with the use of chemical household products should have a significant influence on laypeople’s behavioral changes toward the more cautious handling of chemical household products (Bearth et al., 2014; Rinker et al., 2014; Rundmo and Nordfjærn, 2017).

The results of our analysis show that personal risk awareness is an important predictor of the perceived severity of potentially risky situations, and therefore, a prerequisite for behavioral change and the uptake of safety precautions. As noted in prior studies, people are rarely aware of the risks before an accident occurs (Weegels and Kanis, 2000). Obviously, in these cases, people do not implement safety measures, even if they theoretically know of the risk and have the necessary resources and motivation to take precautionary action. Further, chemophobia, that is, the unreasonable fear of (synthetic) chemicals, also predicted the perceived severity of potentially risky situations. People who exhibit high levels of chemophobia might be more inclined to recognize what they believe to be dangerous chemicals. Therefore, they might perceive chemical household products to be more dangerous in general, and as a consequence, be more careful when handling such products.

The participants seemed to include their own comparative behavior in their perception of the severity of potentially risky situations. Additionally, those participants who acknowledged more behavioral barriers perceived the higher severity of potentially risky situations. This is due to the fact that a failure to take safety precautions renders risky situations more dangerous. This conditional risk perception phenomenon has been identified in relation to other health risks, for example, radiation or Lyme disease (Boehmert et al., 2016; Brewer et al., 2007).

5.5. Limitations and implications for further research

The main limitation of this study concerns the use of self-reported measures. The participants might not be aware of their own mistakes when handling chemical products. Thus, they might experience difficulty recalling problematic behavior, or as a result of social desirability bias, they might report safer behavior than their actual behavior warrants. To overcome this, as well as to counter possible bias due to the presence of an observer, we suggest the use of new research methodologies such as virtual reality. This would allow researchers to place people in typical risky situations involving chemical household products without actually exposing them to a risk and without the participants seeing or interacting with the researchers.

Further, certain comments made by the participants suggested that not all of them were aware of the meaning of “chemical household products,” as some participants explicitly mentioned that they did not use any chemical household products at all, preferring instead to use only natural products. This occurred despite a definition of what a chemical household product is being given to them during the survey. It cannot be excluded that some participants might have given different answers if it was clear to them that naturally made, organic, or environmentally friendly products are also chemicals. Such a misunderstanding on the part of laypeople seems to be a common problem in research in this field (Hartmann and Klaschka, 2017; Siegrist and Bearth, 2019). We suggest that future studies avoid the use of defined terms and instead work with easily relatable information such as pictures of the products in question.

Finally, our participants are all part of a market research panel and so are used to replying to online surveys. It cannot be ruled out that such people pay less attention to surveys than the average consumer. However, the responses of particularly fast participants were checked for abnormalities, and none were found. In fact, many of these participants provided lengthy and precise answers to the open questions.

6. Conclusion

In conclusion, there are a number of factors that can be used to positively influence the behavior of laypeople when it comes to handling chemical household products. First, it seems to be important to make consumers aware of the risks associated with chemical household products during every step involved in handling them (e.g., during purchase, when choosing a storage place, when using them, and when disposing of them), as they do not seem to intuitively think of the risks. Given that mistakes when handling chemical household products can occur not only when using the product, but also during purchase, storage, and disposal, it seems best to design the products in such a way as to constantly prompt the consumer regarding the risks. For example, this could be achieved using distinctive packaging and front labels featuring large warning pictures or symbols (rather than the small pictograms featured on the back of products).

Second, knowledge concerning basic toxicological principles does not seem to be widespread. In fact, there seems to be a high level of fear regarding synthetic chemicals. Therefore, it seems that additional education could lead to more effective safety measures being initiated by consumers. If laypeople were more aware of what actually reduces the risks associated with a given product, they would be more likely to initiate appropriate safety measures rather than dedicating their limited resources to sometimes superfluous or non-effective measures.

Third, several factors were identified as being related to the perceived severity of potentially risky situations, e.g. personal risk awareness, comparative evaluation if own behavior, chemophobia and behavioral barriers. These factors might ultimately encourage behavioral change toward safer behavior. In terms of future national prevention efforts, it is likely to prove helpful to increase individuals’ personal risk awareness.

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CRediT authorship contribution statement

Kim Buchmüller: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization. Angela Bearth: Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition. Michael Siegrist: Conceptualization, Methodology, Writing - review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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