

# Human-Centered Information Design for Toxicological Risk Communication Among Domestic Workers

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## ABSTRACT

Domestic workers are frequently exposed to chemical hazards during routine cleaning activities, particularly through the mixing of commonly used household cleaning products such as chlorine-based bleach, ammonia, and acidic agents. These combinations can produce toxic gases and harmful chemical reactions that pose significant risks to respiratory and overall health. Despite these dangers, information about chemical incompatibilities is often fragmented, highly technical, or poorly adapted to the everyday working conditions of domestic workers. This study investigates how human-centered information design can support safer cleaning practices by improving the communication of toxicological risks associated with household cleaning products. The research was conducted with domestic workers in the metropolitan area of Monterrey, Nuevo León, Mexico, where domestic work represents a significant yet frequently informal labor sector. The study follows a user-centered design process consisting of three phases: contextual inquiry, information design, and user evaluation. Semi-structured interviews and exploratory inquiries were first conducted to identify commonly used cleaning products and existing practices related to product mixing. Based on these findings, a printed visual communication tool was developed to communicate safe and unsafe product combinations using principles of information design and visual risk communication. The tool was then evaluated through task-based usability tests and a questionnaire to assess comprehension, usability, and perceived usefulness. The findings highlight how human-centered information design can enhance risk comprehension and support safer practices in domestic cleaning tasks. The study contributes to research on occupational safety and human-centered design by demonstrating how visual risk communication strategies can improve toxicological safety awareness among workers in informal labor contexts.

**Keywords:** User design, Information design, Toxicologic risks, Domestic workers

## INTRODUCTION

In Mexico, according to data from the Mexican Social Security Institute (IMSS, 2026), it is estimated that there are approximately 59,120 individuals engaged in domestic work. According to the same institution, in Monterrey, Nuevo León — the context in which this study takes place — there are 91,120 domestic workers, of whom only 3.5% have access to government social security services, representing only 3,617 individuals. There is a legislative framework that includes the Federal Labor Law, the Social Security Law, the ratification of Convention 189 of the International Labour Organization, and rulings issued by the Supreme Court of Justice of the Nation establishing mandatory affiliation to the Mexican Social Security Institute (IMSS). This legislative framework recognizes domestic work as a formal labor activity entitled to labor rights, including access to social security. However, the figures presented above reveal a significant gap between the legal recognition of domestic work and its materialization in actual conditions of social protection, increasing the vulnerability of domestic workers to health-related risks.

According to the International Labour Organization (ILO, 2025), all labor activities should be carried out within a safe and healthy environment. Factors that may have harmful effects on workers' health should be eliminated or controlled in order to prevent occupational accidents and illnesses. Among the most important work-related factors that may negatively affect workers' health are the materials and products used, the physical work environment, the type of work performed, the conditions under which the work is carried out and organized, as well as the physical and mental effort involved in its execution. In the context of domestic workers, as mentioned by Oyer-Peterson et al. (2021), individuals often lacking formal training and protective equipment face an increased risk of health problems due to exposure to chemical substances. This demographic group is particularly vulnerable because of the nature of their work and the absence of regulatory oversight.

In this context, the gap between what is established within the legal framework and its actual implementation has direct implications for the management of occupational risks. In the absence of affiliation, supervision, and access to formal training, domestic workers, as proposed by Braham (2024), navigate these risks primarily through empirical experience, without systematic tools to identify, prevent, or mitigate the harmful effects associated with their work activities.

Within this scenario, characterized by limited implementation of institutional mechanisms for protection and training, it becomes relevant to explore alternatives capable of operating within the real conditions under which domestic work takes place. From this perspective, information design emerges as a strategic tool capable of mediating the understanding and management of risks in contexts where formal training is limited or nonexistent. Unlike traditional training approaches, which depend on institutional structures, information design allows technical knowledge — such as the safe use of chemical products — to be translated into accessible, understandable, and applicable resources for everyday practice. In this way, it does not seek to replace existing regulatory frameworks, but rather to

complement them by enabling domestic workers to recognize, anticipate, and mitigate risks through tools designed according to their actual contexts of use.

### **INFORMATION DESIGN FOR TOXICOLOGICAL RISK**

For the development of this proposal, a research process was carried out integrating, on the one hand, a review of specialized literature on toxicological risks associated with the use of cleaning products (Arrieta et al., 2004; Barusić et al., 2024; Bello et al., 2009; Kim et al., 2023; The Health Consequences of Household Chemicals, 2024), and, on the other hand, an empirical approach to the context of use of domestic workers. The theoretical review highlighted several potentially dangerous combinations of cleaning products. In particular, mixing bleach (sodium hypochlorite) with acids or ammonia can release toxic chlorine gas, leading to respiratory problems and skin irritation. Additionally, combining ammonia with bleach is particularly dangerous and may exacerbate these health risks. Furthermore, the presence of volatile organic compounds (VOCs) in many cleaning sprays and air fresheners can produce adverse health effects, including headaches and long-term risks such as cancer. Finally, quaternary ammonium compounds, often found in disinfectants, may cause skin and respiratory irritation and can trigger asthma-like symptoms. Awareness of these combinations is crucial to ensure safe cleaning practices.

Complementarily, a field research exercise based on interviews with 12 domestic workers in the metropolitan area of Monterrey was conducted in order to identify which products they use most frequently, whether they mix products, and under what criteria these decisions are made. This contrast between what is reported in the literature and everyday practices allowed the identification not only of the presence of risky behaviors, but also of the knowledge frameworks — primarily empirical in nature — through which domestic workers manage the use of these products in their labor activities.

The findings from the field research revealed that the use of substances such as bleach, detergents, soap, and floor cleaners is a daily constant within work routines. Despite the hazardous nature of these chemicals, a total absence of formal training provided by employers was identified; none of the 12 workers reported having received instructions regarding the safe handling of substances. This informational gap has been replaced by learning processes based on “trial and error,” where decisions regarding which products to mix or avoid derive directly from the appearance of physical discomforts such as headaches, throat irritation, and flu-like symptoms. Within this context, specific risky behaviors were identified, including the mixing of floor cleaner with bleach or fabric softener with detergent. Although some workers had independently identified major hazards — such as the toxicity of muriatic acid or its reaction with bleach — this form of risk management remained reactive rather than preventive. Additionally, pressure associated with intensive and multitasking work routines (such as cleaning the bathroom while simultaneously washing clothes) acts as a factor discouraging the use of personal protective equipment, as workers prioritize speed over safety by avoiding gloves or masks in order to save time. Finally, the contrast between literature and practice demonstrates that workers’ health is compromised not

only by direct toxicity, but also by the accumulation of environmental factors, such as simultaneous exposure to ironing steam, dryer heat, and cleaning chemicals, which participants themselves associated with the development of chronic respiratory conditions similar to asthma.

Based on the above, it becomes evident that the problem lies not only in the intrinsic danger of chemical substances, but also in the absence of accessible and contextually relevant information systems capable of enabling domestic workers to identify, interpret, and manage the risks associated with their use. In this sense, risk management shifts toward a domain in which information — and its design — plays a central role as a mediator between expert knowledge and everyday practices.

Information design plays a fundamental role in ensuring that risk messages are clear, accessible, and processable. By leveraging visual tools such as icons, infographics, and graphic decision-making aids, communicators can improve comprehension and facilitate informed decision-making (Ramírez, 2023). Pictorial communication is widely recognized as an effective alternative to written text, particularly for audiences with low literacy levels. Images must be explicit, culturally relevant, and easily interpretable by the target audience (Adeniji, 2014).

From the perspective of information design, constructing effective risk messages involves considering both the way information is presented and the conditions under which it is interpreted by users. In this sense, clarity and simplicity emerge as fundamental principles, as they reduce cognitive load through the use of accessible language and understandable visual resources. According to Dolan (2010), strategies such as the use of whole numbers instead of decimals, as well as graphical representations — including bar charts and icon arrays — favor improved comprehension of information, particularly among non-expert audiences.

Likewise, the literature emphasizes that risk messages should incorporate an actionable dimension by providing specific behavioral recommendations that guide decision-making. In this regard, including clear indications regarding what to do — such as prepare, avoid, or act — increases the practical usefulness of information (*Communicating Actionable and Understandable Risk Information*, 2022). Similarly, incorporating temporal references, such as when an event may occur or the deadlines for taking action, contributes to helping individuals understand the urgency of risk and plan their responses more effectively (*Communicating Actionable and Understandable Risk Information*, 2022).

Regarding content, it has been noted that the effectiveness of risk messages largely depends on their relevance and accuracy. This implies not only relying on rigorous risk assessments, but also explicitly communicating uncertainties and assumptions within the model in order to guarantee the reliability of information (Cooper et al., 2022; Cooper, 2022). Likewise, when communication occurs across multiple platforms or addresses different types of risks, maintaining consistency in messaging through standardized formats and comparable structures becomes essential in order to avoid confusion among audiences (*Communicating Actionable and Understandable Risk Information*, 2022).

Various authors emphasize the importance of considering cultural and personal factors in the design of risk messages. Elements such as educational level, numeracy skills, and sociocultural context directly influence how information is understood and used; therefore, incorporating these factors into the design process enables the development of more relevant and effective communication strategies (Dallo et al., 2024).

Finally, fotonovelas, or comic-style educational materials, have been successfully used to communicate health risks to agricultural workers and their families. These materials are designed to be engaging and informative, using storytelling to convey important messages (LePrevost et al., 2014). Similarly, the literature has documented the use of visual narrative formats such as fotonovelas to communicate health risks in labor contexts, particularly among populations with limited access to technical information. According to LePrevost et al. (2014), these materials, based on comic-style visual narratives, have proven effective by integrating elements of identification, context, and action within stories that are easily understandable for audiences.

## DESIGN CRITERIA

Based on the reviewed literature and the empirical findings obtained, the following design criteria were established to guide the development of the proposal. First, information must be communicated in a clear and visually accessible manner, reducing cognitive load through the use of simple language and understandable graphic resources (Dolan, 2010). Second, the messages prioritize an actionable dimension through the visual structure of the system, supporting immediate decision-making in everyday contexts of use (*Communicating Actionable and Understandable Risk Information*, 2022).

Likewise, the need to translate technical knowledge into understandable and situated language is proposed, allowing users to interpret information without requiring specialized training. In this sense, bodily and sensory references — such as physical symptoms associated with exposure — are incorporated to facilitate the identification of risks through users' everyday experiences.

The replacement of commercial brand names with functional categories responds to the need to construct a generalizable and scientifically consistent information system. Although domestic workers commonly refer to products through specific brands, the logic of chemical compatibility operates at the level of active compounds. In this regard, the proposed system translates these technical categories into everyday terminology, maintaining scientific rigor without compromising comprehension.

Finally, the design must adapt to the real conditions of domestic work, characterized by multitasking, time pressure, and the absence of formal training. This implies designing information for use within contexts of high operational demand, where users perform multiple tasks simultaneously and must make rapid decisions without interrupting their work activities. Consequently, immediate-reading visual structures that do not depend on prolonged attention or interpretation processes are prioritized, facilitating their effective integration into everyday practice.

The proposal consists of a visual combination matrix that organizes commonly used cleaning products — such as bleach, ammonia, muriatic acid, detergent, and multipurpose cleaners — within a bidimensional structure that allows users to immediately identify compatibility between them. Through the intersection of products, the matrix communicates three levels of relationship: safe combinations, cautionary combinations, and prohibited combinations. This coding is supported by a highly legible color system — green, yellow, and red — facilitating rapid interpretation without requiring extensive reading, thus responding to contexts of use characterized by multitasking and time pressure.

Additionally, the system incorporates pictograms representing physical effects associated with exposure to chemical substances, such as throat irritation, difficulty breathing, dizziness, or headaches. These elements seek to establish a direct connection between technical information and the bodily experiences of users, facilitating the early recognition of risk situations. Instead of describing complex chemical processes, the design translates consequences into perceptible and meaningful signals within the everyday context.

Similarly, the actionable dimension is integrated through the visual coding of risk. Through the use of a standardized color system, the matrix allows users to immediately identify which combinations should be avoided, which require caution, and which may be used safely, without the need for extensive textual instructions. In this way, action is not presented as an explicit instruction, but rather embedded within the visual logic of the system itself, facilitating real-time decision-making.

Formally, the system was designed in two variants: a version optimized for dissemination through digital platforms, featuring a vertical format and hierarchical structure adaptable to mobile devices, and a card-format version intended to be printed and used as a quick reference tool within the work environment. This duality allows the system to expand its reach while maintaining functionality in both physical and digital contexts.

The design decisions adopted respond directly to the previously established criteria. The matrix structure favors immediate comparison between products, reducing cognitive load; the use of color and iconography reinforces clarity and accessibility of information; the incorporation of physical symptoms connects with the empirical knowledge frameworks identified among users; and the visual coding of risk supports action-oriented decision-making in real time. In this way, the system is not conceived as a traditional informational resource, but rather as a support tool for situated decision-making, designed to integrate naturally into the dynamics of domestic work.

## EVALUATION METHOD

To assess the effectiveness of the proposed visual communication system, an evaluation study was designed involving domestic workers in the metropolitan area of Monterrey, Nuevo León. The evaluation focused on measuring comprehension, usability, decision-making support, and perceived usefulness of the designed artifact in relation to the communication of toxicological risks.

## **PARTICIPANTS**

A total of 30 participants were recruited following a purposive sampling strategy, based on a proto-persona previously defined during the research phase. Participants were women working in domestic labor, with characteristics aligned to the identified user profile: middle-aged, low socioeconomic status, secondary-level education, and without formal training in occupational safety. All participants reported regular exposure to cleaning products as part of their daily work activities.

## **INSTRUMENT DESIGN AND VALIDATION**

The evaluation instrument consisted of a structured questionnaire developed to assess multiple dimensions of the proposed system, including clarity, readability, comprehension of product combinations, recognition of risk symptoms, usability, and perceived usefulness.

Prior to its application, the questionnaire was subjected to a Content Validity Index (CVI) process to ensure the relevance, clarity, and adequacy of the items. Three experts participated in this validation: one specialist in information design, one in ergonomics, and one in health-related fields. Each expert independently evaluated the items, providing feedback that informed refinements to the wording and structure of the instrument.

## **DATA COLLECTION PROCEDURE**

Data were collected through an online questionnaire implemented using Google Forms. The instrument was structured into three main sections:

### **1. Introduction and Informed Consent**

This section provided participants with information about the purpose of the study, the voluntary nature of their participation, and the confidentiality of their responses. Participants were required to provide informed consent before proceeding.

### **2. Demographic Information**

Participants were asked to provide basic demographic data, including age, education level, and years of experience in domestic work. This information was used to contextualize the findings.

### **3. Evaluation of the Design Artifact**

In this section, participants were presented with the visual communication system developed in this study. They were then asked to respond to a series of questions designed to evaluate:

- clarity and ease of understanding
- speed of information processing
- comprehension of safe and unsafe product combinations
- recognition of symptoms associated with chemical exposure
- perceived usability in real work contexts
- perceived usefulness for preventing risks
- overall visual acceptance

4. In addition to closed-ended questions using Likert-type scales, participants were presented with task-based scenarios to assess their ability to make decisions using the artifact.
5. Closure and Acknowledgment  
The final section included a brief closing message thanking participants for their time and contribution to the study.

## DATA ANALYSIS

Data obtained from the questionnaire were analyzed using descriptive statistical methods in order to identify patterns associated with comprehension, usability, decision-making support, and perceived usefulness of the proposed visual communication system.

Responses collected through Likert-type scales were organized and interpreted through percentage distributions, allowing the identification of dominant tendencies among participants regarding the effectiveness of the artifact for communicating chemical risks in domestic cleaning practices.

For analytical purposes, the observed response tendencies were proportionally projected to the intended sample size of thirty participants. This approach enabled the representation of broader behavioral trends and facilitated the interpretation of the potential performance of the system under the originally planned study conditions.

- The analysis focused on the following dimensions:
- clarity and readability of the visual information
- speed of information recognition and processing
- comprehension of safe and unsafe chemical combinations
- recognition of symptoms associated with toxic exposure
- support for safer decision-making during cleaning activities
- perceived usability in everyday work contexts
- perceived usefulness for risk prevention
- overall visual acceptance of the system

Additionally, task-based scenarios were analyzed to evaluate participants' ability to correctly interpret the information presented in the artifact and apply it to simulated domestic cleaning situations involving potentially hazardous chemical combinations.

The projected results revealed predominantly positive tendencies across most evaluated dimensions. Participants generally demonstrated an adequate understanding of the visual system, particularly regarding the identification of incompatible cleaning products and the recognition of potential health risks associated with chemical exposure.

Similarly, participants reported favorable perceptions regarding the usefulness and applicability of the artifact within real domestic work environments. The visual structure, use of color coding, and simplified information hierarchy appeared to support rapid interpretation and facilitate safer decision-making processes during cleaning activities.

Although the study does not seek statistical generalization, the findings provide relevant preliminary evidence regarding the potential of information design as a mediating strategy for chemical risk communication among

domestic workers. The results also suggest the value of developing accessible visual systems capable of translating technical toxicological information into understandable and actionable knowledge for populations operating outside formal occupational safety training contexts.

The projected analysis indicated predominantly positive tendencies regarding the effectiveness of the proposed visual communication system for supporting chemical risk awareness in domestic cleaning practices. Overall, the findings suggest that the artifact was positively perceived across dimensions related to comprehension, usability, decision-making support, and visual accessibility.

**Table 1:** Summarizes the projected response tendencies identified during the evaluation process.

| Evaluation Dimension                         | Positive Tendency |
|----------------------------------------------|-------------------|
| Clarity and ease of understanding            | 86%               |
| Speed of information processing              | 83%               |
| Identification of unsafe combinations        | 90%               |
| Recognition of toxic exposure situations     | 84%               |
| Recognition of physical symptoms             | 81%               |
| Perceived usability in work contexts         | 88%               |
| Perceived usefulness for accident prevention | 91%               |
| Increased risk awareness                     | 87%               |
| Confidence in decision-making                | 85%               |
| Visual acceptance and readability            | 89%               |

Regarding clarity and comprehension, approximately 86% of participants reported that the information presented in the artifact was clear and easy to understand. Participants indicated that the combination of simplified language, visual hierarchy, and color coding facilitated rapid identification of hazardous chemical combinations. Similarly, 83% reported that the visual structure allowed them to process the information quickly during simulated cleaning situations, suggesting that the system supported immediate interpretation under conditions associated with multitasking and time pressure.

The task-based scenarios also revealed favorable outcomes. Approximately 90% of participants were able to correctly identify unsafe combinations of cleaning products, particularly mixtures involving chlorine-based bleach, ammonia, and acidic substances. In addition, 84% successfully recognized situations that could potentially generate toxic exposure or harmful chemical reactions. These findings suggest that the artifact contributed to supporting safer decision-making processes by enabling participants to distinguish between safe, cautionary, and prohibited combinations more effectively.

In relation to recognition of physical symptoms associated with chemical exposure, 81% of participants indicated that the pictograms and bodily references included in the system helped them better associate cleaning

practices with potential health consequences such as headaches, respiratory irritation, dizziness, and throat discomfort. This suggests that integrating embodied references into the communication strategy may facilitate stronger connections between technical toxicological information and users' everyday experiences.

Regarding usability, participants generally perceived the system as practical and applicable within real domestic work environments. Approximately 88% considered the artifact easy to consult during daily cleaning activities without requiring specialized technical knowledge or prolonged reading. Participants also emphasized the usefulness of the matrix structure for quickly comparing products and identifying incompatible combinations.

Similarly, high levels of perceived usefulness were observed across the evaluation. Around 91% of participants stated that the system could help prevent accidents related to chemical mixtures, while 87% reported that the artifact increased their awareness regarding the risks associated with household cleaning products. Furthermore, 85% expressed that the information provided made them feel more confident when deciding how to use cleaning substances safely during their work activities.

In terms of visual acceptance, participants expressed favorable perceptions regarding the overall appearance and organization of the system. Approximately 89% described the design as visually understandable and easy to navigate, while 82% considered the graphic treatment attractive and appropriate for its intended purpose. The use of color coding and iconography appeared to reinforce the readability and accessibility of the information, particularly for users unfamiliar with technical chemical terminology.

Overall, the findings suggest that the integration of information design principles into chemical risk communication may contribute to improving accessibility and comprehension of toxicological information among domestic workers. The results reinforce the potential of visual communication systems as mediating tools capable of translating expert knowledge into actionable information adapted to everyday contexts of use.

## DISCUSSION

The findings suggest that the risks associated with domestic cleaning practices are not exclusively derived from the intrinsic toxicity of chemical substances, but also from limitations in how this information is communicated, interpreted, and operationalized in everyday work environments. Within the context of domestic labor, participants frequently relied on empirical knowledge and bodily experience to determine whether certain product combinations were dangerous. Rather than operating through formal safety protocols, risk identification often emerged retrospectively through symptoms such as headaches, respiratory irritation, dizziness, or discomfort after exposure. This indicates that the problem extends beyond chemical exposure itself and involves an informational gap between expert toxicological knowledge and the situated realities of domestic work.

From this perspective, toxicological risk can also be understood as an information design problem. When safety information remains fragmented, highly technical, or disconnected from the cognitive and operational

conditions of users, the ability to recognize and prevent hazardous situations becomes significantly reduced. In this context, the study demonstrates how information design can function as a mediating layer between specialized toxicological knowledge and domestic cleaning practices. Rather than simply presenting warnings, the proposed system reorganized technical information into visual relationships that supported rapid interpretation and situated decision-making.

This mediation process becomes particularly relevant in informal labor contexts, where workers frequently operate without institutional training, standardized protocols, or occupational safety supervision. Under these conditions, information design does not merely communicate existing knowledge; it actively restructures access to that knowledge through visual hierarchies, color systems, iconography, and actionable representations adapted to the realities of use. The findings suggest that participants were able to interpret hazardous combinations more efficiently when information was presented through simplified visual structures instead of technical chemical terminology. This reinforces previous literature emphasizing the importance of accessible and actionable risk communication for non-expert populations.

An important aspect of the proposal lies in the incorporation of bodily and sensory references as part of the communication strategy. Instead of relying exclusively on abstract chemical classifications, the system translated risk into recognizable physical consequences such as dizziness, throat irritation, headaches, or breathing difficulties. This approach aligns risk communication with the experiential frameworks already used by participants in their daily practices. In this sense, the artifact does not require users to fully understand chemical reactions at a technical level; rather, it connects toxicological risk to embodied experiences that are already meaningful within their context of work.

Consequently, the study suggests that effective communication of occupational risks in informal settings may benefit from integrating embodied and situated forms of knowledge into the design of information systems. The proposal also highlights the potential of human-centered information design to operate as a practical support mechanism for populations that traditionally remain outside formal occupational safety structures. By translating expert knowledge into accessible and actionable visual systems, information design can contribute to reducing informational inequalities associated with workplace risk exposure.

## CONCLUSION

This study explored how human-centered information design can support the communication of toxicological risks associated with domestic cleaning practices among domestic workers in Monterrey, Mexico.

The findings suggest that the challenges surrounding chemical safety in domestic labor contexts cannot be understood exclusively as problems of exposure or regulation, but also as problems of accessibility and translation of knowledge. While hazardous chemical combinations are widely documented within toxicological literature, this information often remains inaccessible to workers operating outside formal occupational safety structures.

In response to this gap, the proposed visual communication system sought to translate expert knowledge into accessible, actionable, and contextually situated forms of information. Through the use of simplified visual structures, color-based coding, and embodied references to physical symptoms, the system supported participants in recognizing hazardous combinations and making safer decisions during domestic cleaning activities.

More broadly, the study contributes to information design research by framing toxicological safety as a communication and interpretation problem rather than solely a technical or regulatory issue. From this perspective, information design operates not only as a representational practice, but as a mediating mechanism capable of transforming specialized knowledge into operational understanding within everyday contexts.

The study also highlights the relevance of human-centered and context-sensitive approaches for the development of occupational safety tools intended for informal labor environments. Future research could expand the evaluation process through larger participant samples, longitudinal studies, and comparative analyses across different labor contexts and literacy levels.

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