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Using Card Sorting to Improve Public Health Information: Enhancing Worker Health Charts

Rebecca J. Tsai, PhD[1]; Igor Kalennyy, MS[1]; Stacey Marovich, MHI, MS, PMP[1]; and Amy Mobley, MEn[1]

Abstract

Objective: It is crucial for public health professionals to have easy and timely access to occupational safety and health (OSH) data to monitor adverse outcomes and identify risk factors that may harm our nation's workforce. The National Institute for Occupational Safety and Health created Worker Health Charts (WHC), a data query and visualization tool, to provide quick and easy access to multiple occupational data sources. However, user feedback indicated that the 2016 WHC navigational menu was difficult to use and did not fully meet user needs. Because access to occupational data is critical in many contexts, we sought to design a menu that would be suitable for various types of users.

Methods: The 2016 WHC navigational menu lists 7 high-level OSH topics and 18 OSH subtopics. To gain insight into how users organize and categorize OSH information, we conducted a series of user experience tests using a method known as card sorting. During the process, participants were given a web link that contained occupational health topics, and they were tasked with grouping or combining similar topics.

Results: The card-sorting techniques identified opportunities to reorganize (eg, create, delete, merge, split) or rename topics for clarity. The final proposed WHC menu was restructured into 4 high-level OSH topics and 14 OSH subtopics.

Conclusions: This study details how card sorting can be used to guide and improve the navigation and content structure of OSH information and the acceptability of the user interface to facilitate access to public health data. Future steps for WHC include validating the proposed menu through task-based testing.

Keywords

UI/UX, card sorting, occupational health

The National Institute for Occupational Safety and Health (NIOSH) develops new occupational safety and health (OSH) knowledge and transfers that knowledge into practice for America's workforce. It is important that public health professionals can readily access OSH data to make informed decisions about health and safety in the workplace.[1] The nature and source of work-related exposures, injuries, and illnesses are wide-ranging. To assist public health professionals, NIOSH created Worker Health Charts (WHC), a queryable data visualization tool, to quickly and easily analyze OSH data.[2]

In 2016, NIOSH launched WHC for public use. This web-based application provides a platform for users to examine diverse OSH data in numerous ways.[2] WHC centralizes OSH data from multiple health data sources, including Bureau of Labor Statistics surveys,[3] the National Health Interview Survey,[4] and the Behavioral Risk Factor Surveillance System.[5] NIOSH subject matter experts helped design the 2016 WHC navigational menu, which included 7 high-level OSH topics. These topics divided into 18 OSH subtopics and 75 detailed OSH topics (Figure 1).

Since the 2016 launch, NIOSH has continuously collected user feedback on WHC. Some users reported difficulties finding the data that they sought, suggesting that the navigational menu did not meet some users' needs. To improve navigation and optimize future content expansion, we applied

[1] Division of Field Studies and Engineering, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, OH, USA

Corresponding Author:
Rebecca J. Tsai, PhD, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Field Studies and Engineering, 1090 Tusculum Ave, R-17, Cincinnati, OH 45213, USA.
Email: rtsai@cdc.gov

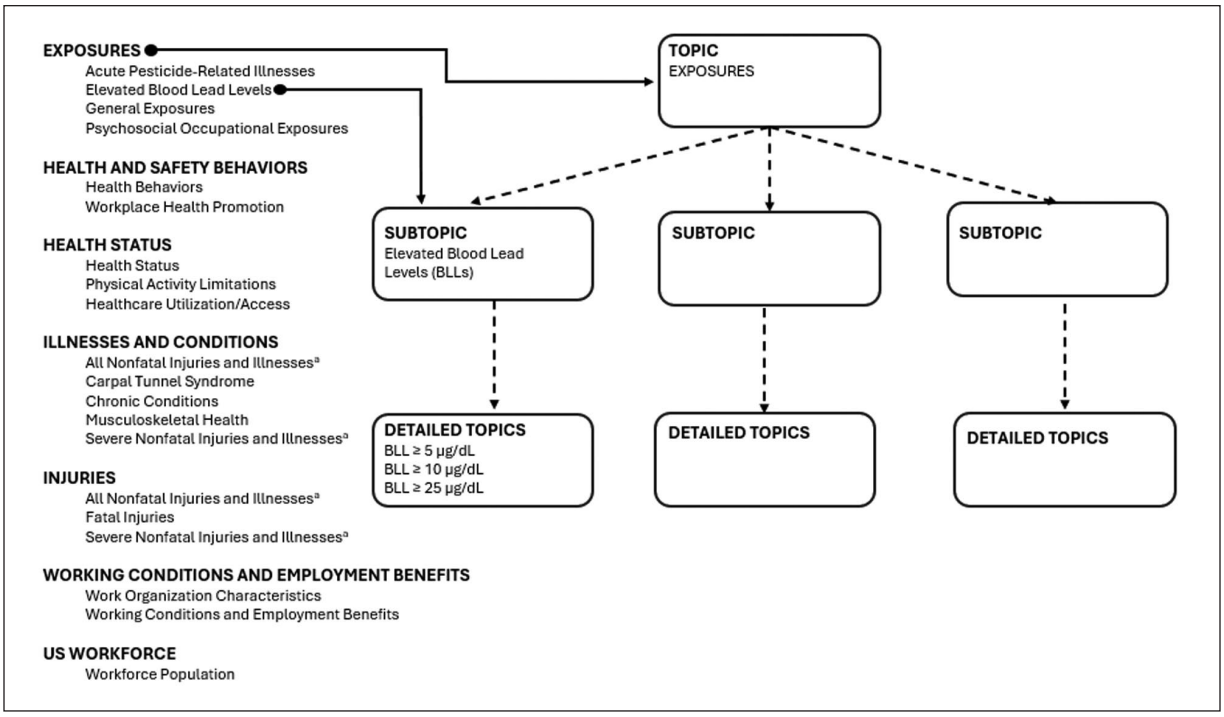


Figure 1. Organization of the navigational menu for NIOSH Worker Health Charts (WHC), 2016. WHC is a web-based application on the Centers for Disease Control and Prevention/NIOSH website for researchers and the general public to examine diverse occupational safety and health data. The left side of the figure lists the 7 topics and 18 subtopics; not listed are the 75 detailed topics into which the subtopics break down. The right side of the figure shows the organization and flow of the WHC menu. Abbreviation: NIOSH, National Institute for Occupational Safety and Health.
[a] Subtopics that appear in >1 topic.

a user experience research method called card sorting to learn how users think about and organize topics in WHC.

In card-sorting exercises, participants are asked to review topics written on individual cards and group them by their similarity. The exercise identifies grouping patterns based on how various users organize information. Card sorting is widely used in psychology by researchers and clinicians to assess mental processes.[6] In the 1990s, card sorting was used in the technology industry to organize information in operation systems.[6,7] More recently, card sorting has been used in hospitals and clinics to improve patient interaction and communication in the health care system.[8-10] Similarly, card sorting can support public health efforts. As compared with surveys and interviews, card sorting is a relatively inexpensive way to gather information systematically. It allows users to provide quantitative and qualitative information, yielding insights that cannot be easily gathered through surveys. Application of card sorting in public health has been limited. Applying card sorting to public health infrastructures (eg, websites, applications, questionnaire design) may greatly improve the success of public health products and interventions.[2] In the current study, we used card sorting to improve the navigation and content structure of WHC.

Methods

The project involved 2 card-sorting techniques conducted in phases: phase 1 was an open card sort and phase 2 was a hybrid card sort. Both card sorts included a convenience sample of NIOSH volunteers with varying degrees of expertise in OSH. Each card-sorting session lasted 30 to 60 minutes. In 2022, we used an online user experience research tool, Optimal Workshop,[11] to conduct and analyze the card-sorting sessions. During online sessions, participants were instructed to verbally describe their reasons for sorting the cards into mutually exclusive categories. Verbal feedback was recorded with consent.

This card-sorting project and its activities were reviewed and approved by the Centers for Disease Control and Prevention (CDC). According to CDC, it was deemed not research; therefore, neither ethics approval nor participant consent was required. This project was conducted by NIOSH consistent with applicable federal law and CDC policy.[12]

Phase 1: Open Card Sort

In phase 1, participants reviewed the 18 subtopics (Figure 1), grouped related cards, and assigned a topic label to that

grouping. We put no restriction on the number of groups that participants could create.

Phase 2: Hybrid Card Sort

In phase 2, the hybrid card sort combined aspects of an open card sort (no predefined groups) and closed card sort (predefined groups). Participants were asked to sort 75 detailed topics into 16 predefined subtopics; the predefined subtopics were identified in the open sort (phase 1). The 75 detailed topics were based on the detailed occupational topics contained in WHC at the time of the study (eg, "blood lead level ≥10 µg/dL," "high job demands," "smoking") (Figure 1).

If participants could not place a detailed topic into 1 of the predefined subtopics, they were instructed to create additional subtopics or leave the detailed topic unsorted.

Data Analysis

Optimal Workshop includes tools that analyze quantitative data collected through card sorting by identifying data patterns. These tools assess the number of topics, determine the subtopics within each topic, and provide evidence for adjustments.

Dendrogram

We used the dendrogram tool (tree diagram) to guide the number of topics needed for the WHC menu and the subtopics within each topic. We used the actual agreement method to construct the dendrogram,[13] which is built from the bottom up, with groupings at the bottom having the highest percentage of agreement. We standardized topics based on the dendrogram findings by combining the content that participants labeled similarly (Figure 2).

Standardization Grid

After standardization, we used Optimal Workshop's grid to determine whether we needed to adjust the subtopics. A standardization grid is a tool that displays how items are organized or distributed across predefined categories. For phase 1, we used the grid to examine how participants grouped the subtopics under the standardized topics. In phase 2, we used it to evaluate how participants sorted the detailed topics across the subtopics.

For phase 1, we looked for subtopics that were sorted into >1 topic and subtopics that were not sorted into any topic. We considered a subtopic to be a good fit if a high percentage of participants placed it under the same standardized topic. A column labeled "not standardized" captured instances in which participants felt that a subtopic did not fit under any of the standardized topics. The same criteria were used in phase 2 to assess how well the detailed topics fit within each subtopic.

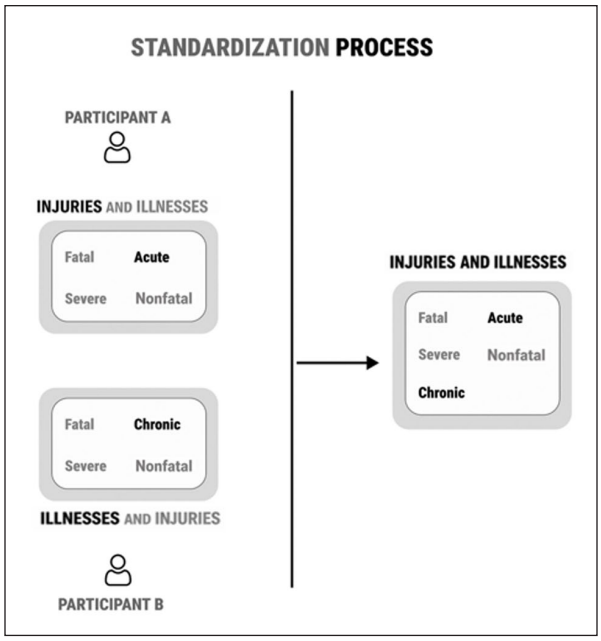


Figure 2. Standardization of participant-generated labels from card sorting. In a hypothetical example of a card sort, participant A grouped 4 subtopics to create a topic and labeled it "injuries and illnesses." Participant B also grouped 4 subtopics but labeled the topic "illnesses and injuries." These responses were standardized by merging the subtopics from similarly labeled groups, thereby providing a standardized "injuries and illnesses" topic with 5 subtopics: fatal (100% agreement), severe (100%), acute (50%), nonfatal (100%), and chronic (50%). The averaging of the percentage agreements for all 5 cards produced 80% agreement between the participants. This percentage agreement was calculated by Optimal Workshop, an online platform used for conducting user experience research.[11]

Qualitative Data

We used verbal feedback to determine whether any topic, subtopic, or detailed topic labels needed to be changed and to refine our quantitative findings from the dendrogram and standardization grid. We encouraged participants to indicate areas of confusion, which leads to opportunities to reorganize or rename labels.

Results

Phase 1: Open Card Sort

Twenty people participated in the open card sort. Thirteen participants (65%) sorted 18 subtopics into ≤5 topics. The 2016 WHC navigational menu had 7 topics; the open card sort results indicated that fewer topics were needed.

Dendrogram. Six distinct groups were identified at 50% agreement (Figure 3). This means that at least 50% of participants agreed that these subtopics belonged together:

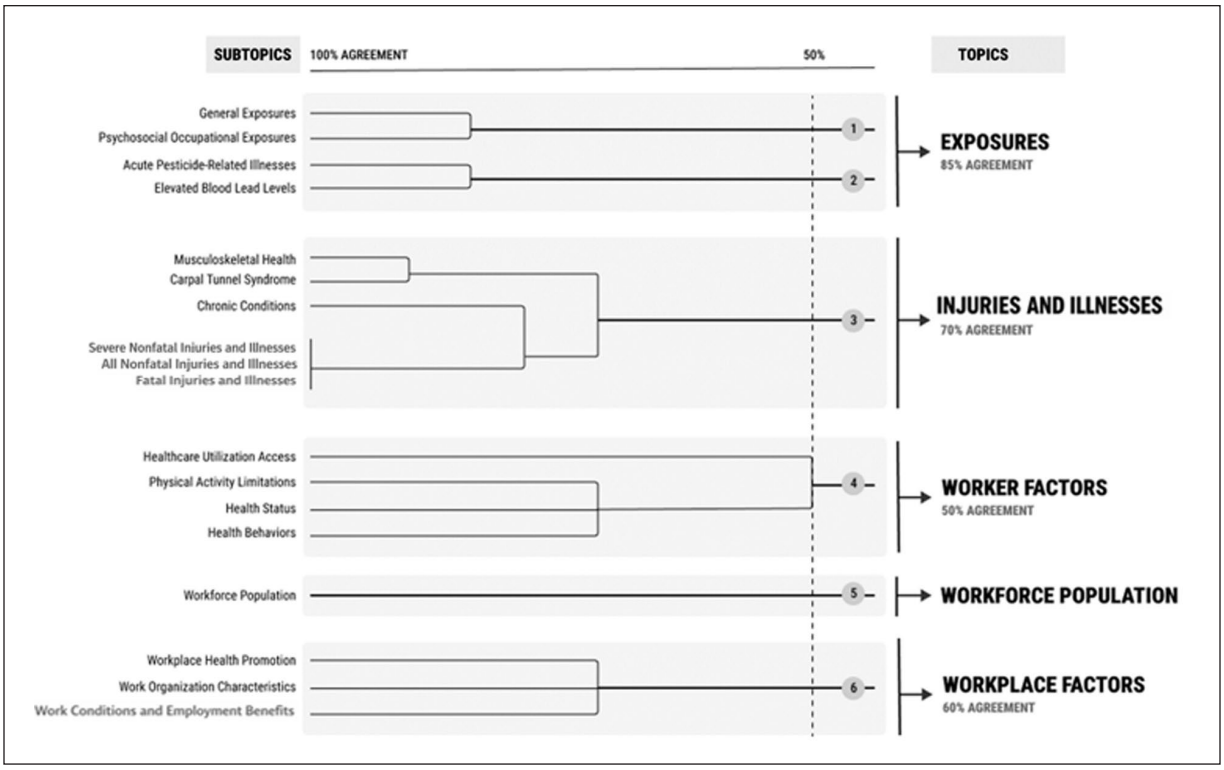


Figure 3. Thematic structure based on Worker Health Charts (WHC) subtopics derived from an open card sort dendrogram (tree diagram). The dendrogram helped guide the number of topics on the WHC menu and the subtopics within each topic. This dendrogram shows relationships between subtopics and how they cluster by participants' sorting patterns. WHC is a web-based application on the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health website for researchers and the general public to examine diverse occupational safety and health data.

- Groups 1 and 2 included subtopics that pointed to exposure categories (both at 85% agreement).
- Group 3 included subtopics related to injuries and illnesses (70% agreement).
- Group 4 included subtopics related to worker factors (50% agreement).
- Group 5 had only 1 subtopic, workforce population.
- Group 6 included subtopics related to workplace factors (60% agreement).

The dendrogram identified 5 topics. We standardized 4 of them as "exposures," "injuries and illnesses," "worker factors," and "workplace factors." Subtopics that are largely unstandardized may indicate gaps in the proposed topics. "Workforce population" was the most frequently unstandardized subtopic, meaning that it did not fit well into any topic. Therefore, we created 1 unstandardized topic, "workforce population" (the fifth topic).

Standardization grid. Figure 4 shows how participants distributed the subtopics across the 4 standardized topics. Most participants sorted the subtopics "acute pesticide-related illnesses" and "elevated blood lead levels" into the "exposures" topic or the "injuries and illnesses" topic, indicating that they could belong under both topics.

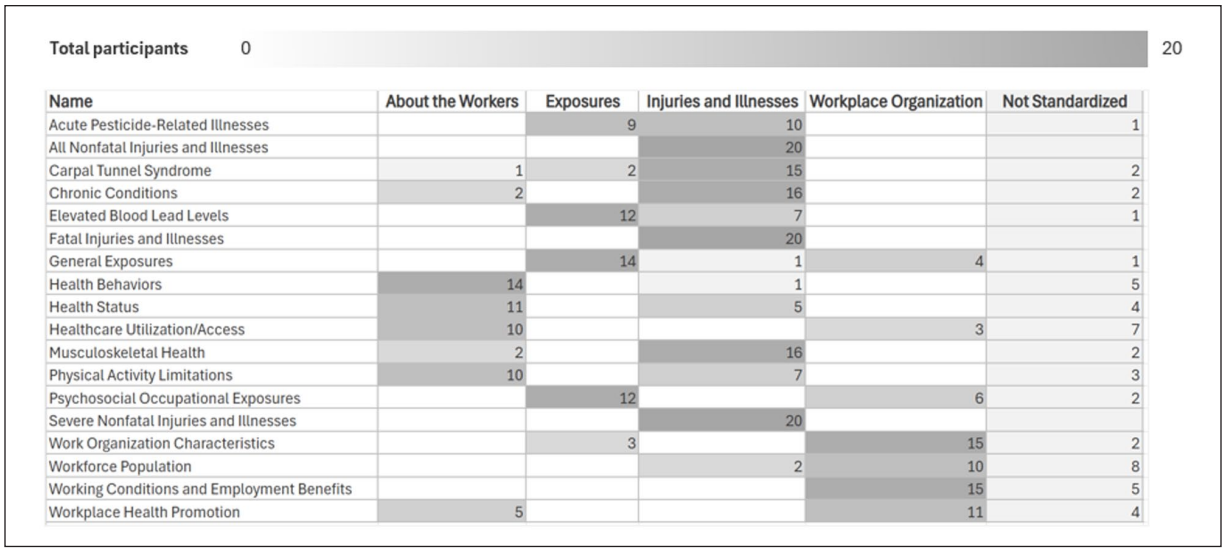
Qualitative data. Participant feedback resulted in reorganizing and renaming subtopics. For example, 7 participants expressed that they were confused by the subtopic "health care utilization access." We reviewed the detailed topics under the "health care utilization access" subtopic and saw that it could be split into 2 distinct subtopics: "health care coverage" and "health care usage."

In another example, we renamed "chronic conditions" to "health conditions" because "chronic conditions" was too specific for a subtopic. At the conclusion of the open card sort, 5 topics and 16 subtopics emerged (Figure 5b).

Phase 2: Hybrid Card Sort

Twenty-four people participated in the hybrid card sort; 71% (n = 17) of phase 2 participants had participated in the phase 1 open card sort. Participants sorted the 75 detailed topics into the 16 predefined subtopics that were identified during the phase 1 open card sort.

Standardization grid. The phase 2 standardization grid summarized how participants distributed the 75 detailed topics across the 16 subtopics. For example, almost all participants sorted detailed topics related to health diagnoses, such as "asthma" or "hypertension," into the "health conditions" or



Name	About the Workers	Exposures	Injuries and Illnesses	Workplace Organization	Not Standardized
Acute Pesticide-Related Illnesses		9	10		1
All Nonfatal Injuries and Illnesses			20		
Carpal Tunnel Syndrome	1	2	15		2
Chronic Conditions	2		16		2
Elevated Blood Lead Levels		12	7		1
Fatal Injuries and Illnesses			20		
General Exposures		14	1	4	1
Health Behaviors	14		1		5
Health Status	11		5		4
Healthcare Utilization/Access	10			3	7
Musculoskeletal Health	2		16		2
Physical Activity Limitations	10		7		3
Psychosocial Occupational Exposures		12		6	2
Severe Nonfatal Injuries and Illnesses			20		
Work Organization Characteristics		3		15	2
Workforce Population			2	10	8
Working Conditions and Employment Benefits				15	5
Workplace Health Promotion	5			11	4

Figure 4. Distribution of Worker Health Charts (WHC) subtopics into standardized topics from an open card sort. The open card sort standardization grid illustrates how participants distribute WHC subtopics into standardized topics. This standardization grid shows how the 20 participants distributed the subtopics across the 4 standardized topics. Participants sorted some subtopics into >1 topic, indicating that they could belong under multiple topics (eg, "acute pesticide-related illnesses" subtopic into "exposures" or "injuries and illnesses" topic). The "not standardized" column reflects instances when participants felt that a subtopic did not fit under any standardized topic.

"health status" subtopic. Twelve participants commented that it was difficult to differentiate between the "health conditions" and "health status" subtopics, so we merged them and relabeled the topic "health status and conditions."

We sometimes found that a detailed topic could belong to >1 subtopic. For example, the detailed topic "influenza vaccination in the past year" was placed under the "health behavior" and "health care use and coverage" subtopics.

Labeling changes. Participant feedback indicated that several subtopic and detailed topic labels were unclear. For example, to improve clarity, we renamed the subtopics "blood lead" and "acute pesticide-related illnesses" to "lead exposure" and "pesticide exposure" because both conditions are caused by hazardous exposures. Relabeling these subtopics resulted in needing to relabel the topic "work environment" to "work environment/exposure."

We further modified topic labels that were initially created during the open card sort. The topic "workplace organization" was changed to "about the workplace," thereby eliminating the "workforce population" topic. The subtopic "workforce population" confused participants, so it was relabeled "workforce statistics" (Figure 5b and c).

After analysis was complete, WHC content had been sorted into 4 topics and 14 subtopics (Figure 5c).

Discussion

Card sorting is a research technique used for designing websites, applications, and other information systems.[6,14] The hierarchical structure of health topics in the 2016 WHC menu required us to conduct card sorting in 2 phases.[7] The high-level open card sort in phase 1 allowed us to elicit shared attributes that may not have been evident if we had conducted only a detailed card sort.[15] For example, if we had conducted only the detailed hybrid card sort, we would have had difficulty identifying subtopics that shared attributes in the "about the worker" topic. Overall, the card-sorting process allowed us to design a menu based on users' mental models.

Applying Card Sorting to Public Health

We built a menu for WHC that was informed by user input. Our project is just 1 example of how card sorting can benefit public health. In a research setting, card sorting can be used for exploratory or confirmatory purposes.[16] The exploratory approach is useful when designing public health interventions to understand how mental constructs differ among groups.[8] Generally speaking, what is important to one group may differ from what is important to another group. The ability to tailor a public health intervention to the population of interest is key to a successful intervention. The confirmatory approach can be used to validate findings, methods, or data collection instruments.

Card sorting can be used to maximize the benefits of new technology. In a hospital-based study, card sorting was used to develop an electronic health record tool for handing off patients from the operating room to the intensive care unit.[17] The card sort ranked various factors to identify patient

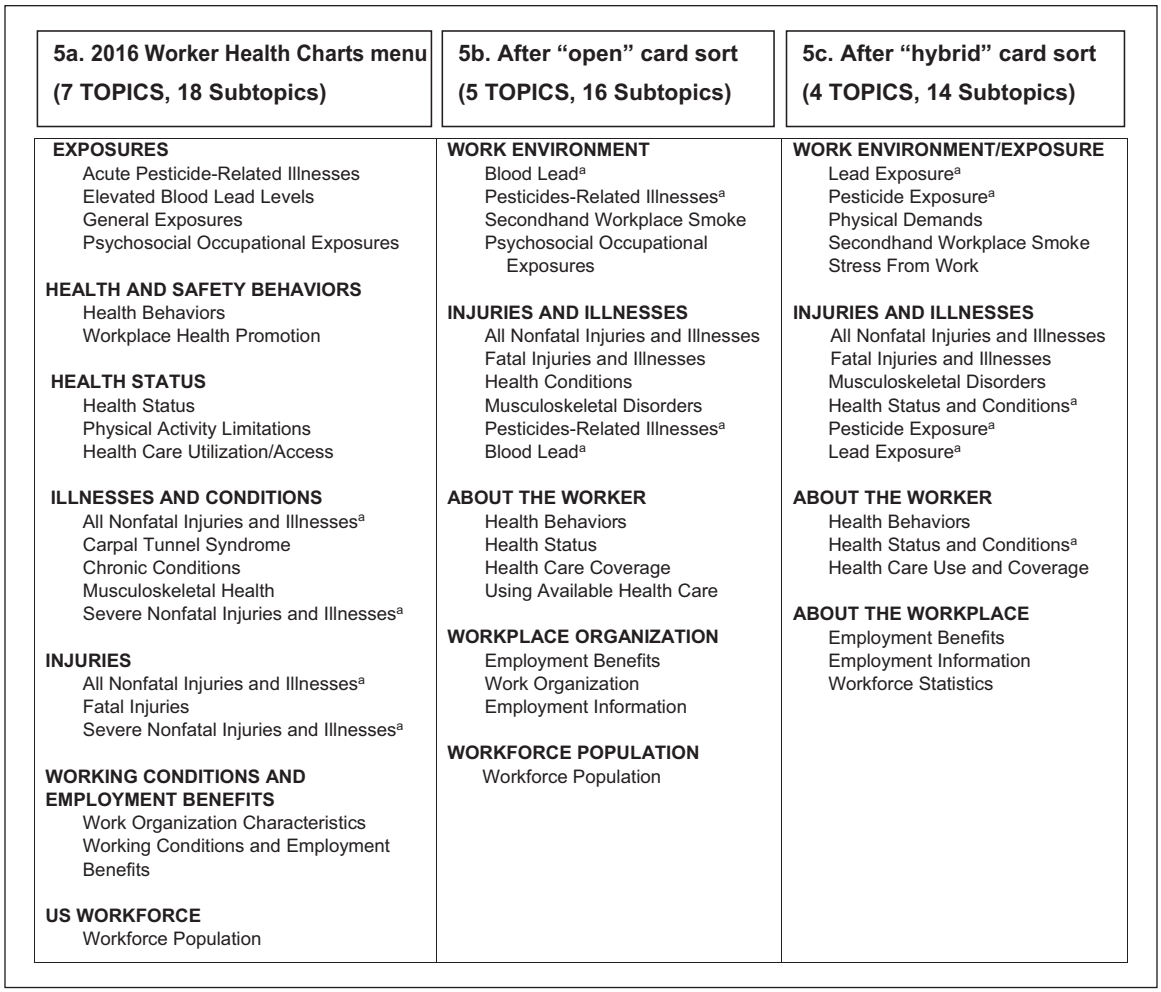


Figure 5. Evolution of the WHC menu before and after open and hybrid card sorts. In an open card sort, participants sort cards into groups and assign labels to each group. In a hybrid card sort, participants sort cards into predefined groups, while having an option to create additional groups if needed. This figure shows how the WHC menu topics and subtopic labels evolved from (a) the initial menu to (b) the intermediate menu and (c) the final proposed menu. WHC, Worker Health Charts.
[a] Subtopics that appear in >1 topic.

information that would be important for a smooth transition to improve patient outcomes.[17] Similarly, during a major public health crisis, public health staff often rotate on and off of an investigation. Card sorting could be used in public health to identify the most important information to pass on while filtering out unnecessary information to ensure continuity of the investigation.

Strengths

This study had several strengths. First, we collected participant feedback, which provided insight into how users may want to find information in WHC. The collection of qualitative data allowed us to understand why participants grouped certain subtopics, providing insight beyond what subtopics they grouped (quantitative data).[18] We learned that some participants tried to determine whether a given health condition (eg, illnesses by pesticides) should be placed under the "fatal injuries and illnesses" subtopic based on whether it could be fatal. This verbal feedback provided additional insight to plan the next phase of menu design, where we will test to see whether participants expect to find certain health conditions under "fatal injuries and illnesses." Second, we identified areas for improvement in the study design. We learned that for card sorting, the information on the cards should be straightforward and simple. In this study, we used the exact wording for the detailed topics as they appear in WHC. For example, we had 2 detailed topics for asthma ("ever diagnosed with asthma" and "currently have asthma"). We realized that we would have gotten clearer results by having just 1 detailed topic that simply stated "asthma." Participants focused on the descriptors of asthma rather than the condition. This realization highlighted that providing too much information on a detailed topic label can detract from the card-sorting objective, and it allowed us to adjust how we interpreted

quantitative findings. Lastly, the online application that we used to collect and analyze the card-sorting results allowed us to recruit participants remotely, eliminate data entry errors, and reduce analysis and interpretation time.[10]

Limitations

This study had several limitations. First, for the open and hybrid card sort, we recruited 20 and 24 participants, respectively. Although traditional quantitative research has found that having more participants yields more stable estimates, a study found that large sample sizes are not needed in card-sorting studies.[19] Correlation estimates may be stabilized with only 20 to 30 participants.[19]

Second, selection bias was a concern because all participants were NIOSH employees, most of whom have many years of experience in OSH. As such, the resulting menu may include technical or niche phrases that are not easily understood by all users. Although WHC is targeted to OSH professionals and researchers, we wanted to design a menu that would be easy for all people to use. Selection bias may have been partially reduced and user input enhanced because several participants working at NIOSH had a minimal OSH background. Their input likely reflected the knowledge of users from the general population. Additionally, bias may have been reduced because NIOSH researchers are not necessarily familiar with all occupational health and exposure terminologies, making their classification of unfamiliar topics more comparable to that of the general public. However, additional participants from more varied backgrounds could have yielded different groupings. For the next phase of testing, we plan to recruit participants from outside NIOSH.

Third, we did not collect data on the demographic characteristics of participants or information on OSH expertise. Therefore, we could not determine whether differences occurred in card-sorting patterns between experienced and inexperienced participants. Future studies may include an assessment of the years of experience in occupational or public health.

Fourth, most participants in phase 1 had not participated in previous card-sorting activities; almost three-quarters of phase 2 participants also participated in phase 1. As such, we could not determine whether familiarity with card sorting in phase 1 influenced the results in phase 2.

Lastly, although we did not experience these issues, conducting an online card sort could have been limited by technology-related problems, such as limited computer skills or bad connections, thereby affecting how cards were categorized.[20]

Our resulting proposed hierarchical menu is the first step of the menu redesign process. Although our proposed hierarchy design and labels are based on quantitative and qualitative data, the way that we conducted card sorting gave us only a starting framework. The mental model used for card sorting may not be the same mental model used for navigating a menu. Therefore, in subsequent phases of the process, we plan to test and validate our proposed menu through task-based testing.

Conclusions

Card sorting helped create a navigational and content structure for WHC based on how users conceptualize OSH information. The insights obtained through card sorting allowed us to propose a new menu design that better aligns with how WHC users think. This study demonstrated a case for card sorting as a useful user experience research and design tool. While card sorting is an important exploratory method for developing a browsable menu, it did not give us a final design. Therefore, the next step would be to validate our proposed hierarchical menu by asking participants to complete a series of tasks to find specific OSH information. For each task, participants would indicate where they expect to find the information by navigating a browsable menu. In the future, card-sorting techniques could be used in WHC to identify design features that are most important to WHC users. Public health professionals may want to consider using card sorting in their research or public health projects because the technique can be used to maximize the effectiveness of design or intervention efforts.

ORCID iDs

Rebecca J. Tsai, PhD https://orcid.org/0000-0001-8656-9836
Stacey Marovich, MHI, MS, PMP https://orcid.org/0000-0002-1143-5363

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