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Decision Strategies during a Science Crisis: How Science Organizations Made Adaptations during the Pandemic

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Abstract: During the COVID-19 pandemic, organizations struggled with finding reliable information and effective adaptations, including science organizations. This study explores the information sources and decision-making strategies utilized by science organizations, more specifically, major facilities (MF, e.g., Academic Research Fleets, National Radio Astronomy Observatory, Large Hadron Collider; see https://new.nsf.gov/focus-areas/infrastructure) funded by the US National Science Foundation during the COVID-19 pandemic. We conducted 56 interviews with MF professionals about pandemic adaptation. Through 3 phases of data collection and analyses between December 1, 2020, and August 28, 2023, we developed initial themes. Ten key information sources were identified: (1) leaders/supervisors/managers (4.28/5), (2) health authorities (4.20/5), (3) institutions (universities) (4/5), (4) personal networks (3.88/5), (5) regional and local government (3.83/5), (6) associations/councils (e.g., UNOLS) (3.58/5), (7) funders (e.g., NSF, Research Infrastructure Guide) (3.38/5), (8) peer-reviewed articles (3.25/5), (9) mainstream media (2.92/5), and (10) social media (2.04/5).The study also revealed four primary decision-making strategies science organizations adopt: (1) conducting thorough risk assessments (4.67/5), (2) seeking input from their teams and colleagues (4.27/5), (3) triangulating information from multiple sources (4.08/5), and (4) utilizing top-down decision-making by leadership teams when necessary (3.38/5). Interestingly, the primary strategy was the scientific method of risk assessment, and the leadership-based strategy dropped to the lowest-rated strategy in our second analysis. This suggests that science organizations may approach a crisis using a scientific method but rely on leadership-based sources for information.

Keywords — Adaptation, Decision Making Strategies, Information Seeking, Resilience, Science Organizations,

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INTRODUCTION

Existing research on crises tells us people seek "information for adaptation" [1]. People usually seek information about the crisis, its reason, how to overcome it, etc. So, information matters. In recent concerns, individuals sought information from various sources, including mass media [2]. Regarding academia, current researchers primarily depend on electronic communication resources rather than physical libraries and other resources [3]. However, in research organizations, specifically within science organizations, understanding how this information-processing behavior is sought and how the acquired information influences the decision-making process remains essential.

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Science organizations are large concepts that include institutions, entities, and groups heavily involved with research, education, and advancement of scientific knowledge. Cyberinfrastructure (CI) is a vital part of science organizations. CI refers to advanced computing technologies and remote instruments with vast amounts of data (big data) that are intended to offer involvement through research in the STEM (science, technology, engineering, and mathematics) fields [4, 5]. The National Science Foundation (NSF), which supports many science projects, helps fund CI through programs like the Coordinated Experimental Research Program. Because of these initiatives, CI makes managing, analyzing, and visualizing much larger datasets feasible than earlier capabilities [6]. The most significant science and engineering research investments funded by NSF are called Major Facilities. There are 25+ of them and they utilize advanced CI for their operations. The MFs are diverse, covering many science areas, including astronomy, climate research, ecology, natural hazard engineering, ocean science, physics, and seismology [7]. Previously, those organizations used to be called "Large Facilities" [8]. As science organizations are no exception in facing crises, this paper aims to explore effective adaptation strategies and how they progress to decision-making strategies employed by MFs during a crisis by science organizations.

THEORETICAL LENSES

This study utilizes the frameworks of information diffusion [9] and diffusion of innovation [10]. The information diffusion model emphasizes information clustering, and the diffusion of innovation explains disseminating information, ideas, and technology through a social system. Information Diffusion Model: Altay and Pal [9] used an agent-based modeling approach to stimulate the flow of information in decision-making processes. The authors found that if clusters are properly utilized, it results in better information flow and, consequently, more effective response in terms of adaptation. "Cluster leads must be actively involved in every disaster, demonstrate ownership of operations, and establish long-term relationships with humanitarian agencies" [9, p. 1025], which leads us to the importance of building community and sharing information in science organizations. Another point is sharing information across organizations, which significantly impacts information diffusion. This suggests having a common platform across organizations and communities.

The proposed model [9] showed the process of information gathering from different sources and combined all of them in an information hub. Later, dissemination and diffusion of information by prospecting all possible solutions which lead to effective responses. Diffusion of Innovations (DOI) is a communication process [10] that explains how innovation (technology, ideas, information, and so on) spreads through a social system. The diffusion process has several steps: knowledge, persuasion, decision, implementation, and confirmation. DOI advocated strategies for effective adaptation, such as identifying key influencers, demonstrating relative advantage, adapting to adopter needs, facilitating trialability (offering low-risk chances to experiment with an innovation), and enhancing observability.

In summary, if there's a flow of information and coordination, it helps organizations make effective decisions during a crisis. Altay and Pal [9]studied the empirical evidence of humanitarian aid organizations during the earthquake crisis in Haiti. They found the effectiveness of coordination and diffusion of information in making decisions. On the other hand, Rogers [10] provided the framework of how innovations are being adopted through a social system and how organizations can implement it. By incorporating Rogers's diffusion of innovations theory and [9] dissemination of information into this research, it is possible to understand how science organizations adopt innovation and information during a crisis.

The following research questions guide this study.

RQ1: What were the sources of information sought by science organizations that contributed to their decision-making?
RQ2: What factors were considered in making adaptive decisions?

METHODS

This study is based on a broader research project funded by the NSF, aimed at understanding collaborations and community building among professionals at major facilities (MFs) during the COVID-19 pandemic. Over the course of three phases spanning from December 1, 2020, to August 28, 2023, we conducted a total of 56 interviews. These interviews were designed to capture insights into how professionals at MFs adapted their teamwork practices during the pandemic.

Our data collection process involved a systematic approach, with interviews conducted via the Zoom online platform and recorded for accuracy. Our targeted participants were top level management, researchers, and scientists from MFs, Mid-Scale Facilities and CI professionals. Participants were reached via email and provided with information about the project's goals before being invited to participate in open-ended discussions. Following each interview, participants were asked to recommend other MF professionals who were demographically and/or professionally different from themselves, facilitating snowball sampling for further data collection. Prior to the data collection phases, we maintained ethical standards by obtaining approval from the Texas Tech University Institutional Review Board. Interview recordings were anonymized, and transcripts were generated using Otter.ai, with manual verification by research assistants to ensure accuracy.

Using grounded theory principles, the analysis began with open coding and systematically categorized and labeled excerpts to identify patterns and themes. Through axial coding, relationships between codes were explored to develop

conceptual categories and dimensions. This step was particularly important during the analysis when we formulated the member check interview protocol based on the first round of interview data. Through iterative reviews and discussions, themes were refined and defined, resulting in a typology of information seeking sources and adaptation strategies employed

by professionals at MFs. The final phase of our analysis involved member-check interviews, where participants were presented with the identified themes and invited to provide feedback, numerical ratings of their (dis)agreement out of 5.00, where 5 is strongly agree and 1 is strongly disagree and additional insights. Based on their ratings we sorted the rankings of themes. This iterative process ensured the validity and/or reliability of our findings.

RESULTS

In this study, we aimed to investigate how science organizations utilized various information sources to make decisions during the COVID-19 pandemic. We focused on two main research questions: RQ1 examined the sources of information consulted by these organizations, while RQ2 explored the factors influencing their decision-making processes.

RQ1 Findings: After conducting 56 interviews and analyzing the data, we identified ten main sources of information. Participants rated their agreement with these sources on a scale of 1 to 5, with 5 indicating strong agreement.

1. **Leaders/Supervisors/Managers:** Decision-making heavily relied on guidance from leaders, supervisors, and managers, with an average agreement rating of 4.28. Their wealth of experience and knowledge directs the organization's overall strategy and influences day-to-day operational decisions.
2. **Health Authorities:** National and local health authorities provided valuable guidance, with an average agreement rating of 4.205. In crisis, they can provide information about the latest scientific research, best practices for prevention and treatment, and regulations that may affect any organization.
3. **Universities:** Institutional policies and research capabilities of universities served as important information sources, scoring an average of 4.00. The university's institutional policies, guidelines, and extensive research capabilities are crucial in shaping decision-making processes. However, miscommunication or disorganization may arise due to the complex and multifaceted nature of universities with numerous divisions.
4. **Personal Networks:** Close connections with family and friends offered diverse perspectives, scoring an average of 3.88. During the pandemic, obtaining information from personal networks proved to be an effective and more comfortable approach for some of the organization's officials.
5. **Regional Governance:** State, county, and city governments provided crucial information on regulations and policies, with an average agreement rating of 3.83. Decisions made within science organizations are inextricably linked to regional governance structures.
6. **Associations/Councils:** Professional organizations offered guidance, but opinions were mixed, with an average agreement rating of 3.58. Combining experts from diverse fields, associations, and councils provides access to best practices, research, and training opportunities. Moreover, they advocate for the interests of their members at local, regional, and national levels.
7. **Funders:** Funding agencies like NSF played a significant role but were less influential compared to other sources, scoring an average of 3.38. This is likely because funders primarily provide financial support to other organizations, and each organization independently determines how to handle operations during a crisis. They then keep the funders updated on their actions.
8. **Peer-Reviewed Articles:** While valuable, peer-reviewed articles faced limitations due to time delays, with an average agreement rating of 3.25. In such instances, individuals and organizations often require prompt decisions and actionable insights to navigate the crisis effectively. With some time lags, pre-print articles helped a lot in getting information.
9. **Mainstream Media:** Mainstream media is considered less reliable, with average agreement ratings of 2.92. Mainstream media is subject to various opinions, including conflicting guidelines, sensationalized reporting, and potential biases.
10. **Social media:** Social media is considered less reliable, with an average of 2.04. There was a lot of social media disinformation, and almost everyone became frustrated with this issue. Some individuals even experienced the harmful effects of social media disinformation on their teams.

RQ2 aimed to explore the decision-making strategies adopted by science organizations during the COVID-19 pandemic. Initial coding identified four main strategies, which were validated and ranked based on numerical ratings in phase three interviews. The themes, along with their degree of agreement, are as follows:

1. **Risk Assessments:** Organizations prioritized assessing potential risks, scoring highest with an average agreement of 4.67 out of 5. These assessments helped make informed decisions and mitigate disruptions caused by the pandemic.
2. **Seeking Input from Teams and Colleagues:** Collaboration and input from team members and colleagues were valued, with an average agreement of 4.27. This inclusive approach ensured diverse perspectives were considered in decision-making processes.
3. **Triangulating Multiple Sources:** Organizations relied on information from various sources such as universities, local hospitals, and health authorities, scoring an average agreement of 4.08. Evaluating multiple sources enabled organizations to make well-informed decisions.
4. **Leadership Team/Institutional Administrators Making Top-Down Decisions:** While input from teams was sought, ultimate decisions were often made by leadership teams or institutional administrators, scoring an average agreement of 3.38. This hierarchical decision-making approach ensured coherence and consistency in organizational responses.

DISCUSSION & CONCLUSION

During the pandemic, everyone sought information and effective adaptations. Science organizations were no different. This study explored the information sources and decision-making strategies utilized by science organizations during the COVID-

19 pandemic. We utilized information diffusion and diffusion of innovations theory to see how information dissemination helped science organizations adapt effectively. Through thematic analysis of interviews with top leaders of NSF-funded Major Facilities, ten key information sources were identified: leaders/supervisors/managers, health authorities, institutions (universities), personal networks, regional governance, associations/councils (e.g., UNOLS), funders (e.g., NSF, Research Infrastructure Guide), peer-reviewed articles, mainstream media and social media.

The study also revealed four primary decision-making strategies science organizations adopt: conducting thorough risk assessments, seeking input from their teams and colleagues, triangulating information from multiple sources, and utilizing top-down decision-making by leadership teams when necessary. These strategies proved crucial in navigating the uncertainty and complexities of the pandemic. The findings of this study offer valuable insights for science organizations and other entities facing similar challenges. Organizations can effectively navigate crises and uncertainty by diversifying information sources, employing analytical decision-making frameworks, promoting open communication, and remaining adaptable to changing guidelines. Providing additional training in crisis management may help organizations make effective adaptations. On the other hand, having a central information hub may reduce confusion.

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