Building Resilience: Lessons Learned by Big Science Organizations During the Pandemic

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Abstract: The COVID-19 pandemic challenged organizations worldwide, offering important lessons about resilience and adaptation. This study focuses on resilience of professionals working in Big Science Organizations (BSOs), specifically National Science Foundation (NSF)-funded Major Facilities (MFs), Mid-Scale Research Infrastructures (MSRIs), and other related large research infrastructures. These organizations, such as the U.S. Academic Research Fleet and the Green Bank Observatory, play a critical role in advancing science and had to quickly adjust to pandemic disruptions. Between December 2020 and August 2023, we conducted 56 interviews across three phases. Phase 1 explored early responses (n=13), Phase 2 examined long-term adaptations (n=17), and Phase 3 involved member-checking validation (n=26). Using grounded theory for analysis and participant ratings for validation, we identified five key lessons: (1) pivoting to hybrid work is possible; (2) organizations must respect employees' personal and family needs; (3) workplaces should offer and promote mental health and counseling resources; (4) not all employees will comply with policies that threaten personal freedoms; and (5) pandemic preparedness planning is essential. These findings, confirmed across phases, highlight the importance of flexibility, employee well-being, and proactive crisis planning. They offer a practical framework to strengthen resilience for big science organizations facing future global disruptions.

Keywords — Crisis communication, Big Science Organizations, Major Facilities, Mid-Scale Research Infrastructures, organizational resilience, pandemic preparedness

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INTRODUCTION

The COVID-19 pandemic forced organizations across sectors to reconsider their operations and priorities, and Big Science Organizations (BSOs) were no exception. BSOs, such as National Science Foundation (NSF)-funded Major Facilities

(MFs), Mid-Scale Research Infrastructures (MSRIs), and other large-scale initiatives had to rapidly adapt to protect both their missions and their employees (see a complete list of MFs and MSRIs at https://www.nsf.gov/bfa/lfo/docs/major-facilities-list.pdf). Understanding how these organizations responded and the lessons they learned is essential for strengthening crisis preparedness and building organizational resilience for the future.

This paper presents findings from a three-phase qualitative study investigating how MFs and MSRIs adapted during the pandemic and what strategic insights emerged from their experiences. Drawing on grounded theory analysis [1] and validated through member-checking interviews, the paper identifies five ranked lessons learned and offers actionable recommendations for future crisis resilience. To guide this study, the next section introduces the theoretical framework, focusing on Situational Crisis Communication Theory (SCCT) [2], and its relevance to organizational resilience. This is followed by an overview of the study's methods, including participant recruitment, interview phases, and the analysis process used to identify key themes. The results section presents the major lessons learned during the pandemic, highlighting both participant insights and their practical significance. The discussion explores how these findings connect to broader crisis management practices and suggests actionable strategies for strengthening future preparedness. Finally, the conclusion emphasizes the importance of applying these lessons to ensure that BSOs are better equipped to face future disruptions.

THEORETICAL FRAMEWORK

SCCT provides the conceptual foundation for this study. SCCT, developed by Coombs [2], explains how organizations should respond to crises based on the degree of public responsibility attributed to them. Crises are categorized into three clusters: victim, accidental, or preventable, with each requiring different communication strategies. It is important to note, however, that this classification system is based on perceived responsibility and reputational threat, rather than actual preparedness. SCCT does not explicitly account for an organization's level of readiness before a crisis occurs. As such, a well-prepared organization may still be perceived as a victim if the crisis is seen as external and uncontrollable. This distinction highlights a limitation of SCCT—it provides valuable guidance for strategic communication during and after a crisis, but it does not address pre-crisis planning or proactive resilience measures. Our study helps fill this gap by identifying preparedness actions that, while not part of SCCT's original taxonomy, are essential for organizational resilience and thus guide the communication strategies.

In the case of the COVID-19 pandemic, organizations, including MFs and MSRIs, largely belong to the "victim cluster." These organizations were viewed as victims of an external, uncontrollable event, meaning they bore minimal responsibility for the crisis itself. According to SCCT, organizations in the victim cluster are advised to show concern, demonstrate corrective actions where appropriate, and reinforce their existing positive reputations to maintain public trust [2]. While SCCT does not equate lack of preparation alone with preventable crises—which are defined by organizational misdeeds or unethical actions—it does emphasize the importance of learning from past crises. In repeat crisis scenarios, such as a major future pandemic or even a local organizational crisis, stakeholders may still perceive organizations as having a heightened responsibility to demonstrate preparedness and adaptation. Although such a situation would not shift MFs and MSRIs into the "preventable" cluster under SCCT's strict definitions, a failure to show learning and preparedness could nonetheless result in reputational harm. Therefore, proactive communication about lessons learned and improvements implemented becomes crucial for sustaining public trust within the victim cluster.

If BSOs fail to apply the lessons learned during COVID-19, they risk reputational damage in future crises. Thus, SCCT not only shaped how we coded participant insights but also guided our interpretation of the emerging lessons. This theoretical lens emphasizes the need for proactive planning, clear communication, and organizational learning to protect and strengthen the resilience of BSOs moving forward.

METHODS OR PROCEDURES

This study used a qualitative research design to explore how BSOs, including MFs and MSRIs, adapted during the COVID-19 pandemic. Data collection occurred in three phases between December 2020 and August 2023, using semi-structured interviews conducted via video conferencing platform Zoom. In Phase 1, we conducted 13 interviews focused on participants' initial experiences and immediate organizational responses to the pandemic. In Phase 2, we conducted 17 additional interviews to investigate long-term adaptations and strategies that remained after the initial crisis period. Phase 3 involved 26 member-checking interviews, where participants were presented with the preliminary findings from Phase 1 and Phase 2 and asked to validate, contest, or expand upon them. During this phase, participants also rated their agreement with the identified lessons using a 5-point Likert scale, thus allowing us to rank the lessons based on average scores. We employed purposive sampling to recruit participants directly involved in operational or leadership roles within MFs and MSRIs. Snowball sampling was also used to broaden the pool by asking participants to recommend colleagues with different roles, demographics, or experiences. Data were analyzed using grounded theory procedures [1], beginning with open coding to identify initial categories. Axial coding followed to explore relationships between categories, leading to a focused set of key lessons learned. Member-checking in Phase 3 strengthened the validity of the findings by integrating participants' reactions and ratings. This multi-phase approach allowed us to capture both immediate crisis responses and longer-term reflections, offering a comprehensive view of how BSOs navigated the pandemic.

RESULTS

The analysis of interview data across three phases revealed five primary lessons learned by BSOs during the COVID-19 pandemic. These lessons were identified through grounded theory coding and validated through participant ratings during the member-checking phase.

The highest-ranked lesson was that pivoting to hybrid work is possible (average rating = 4.52 out of 5). Participants described how hybrid environments (in person and/or remote work), virtual conferences, and online collaboration platforms enabled continuity of research and administrative operations. Many emphasized that while not ideal for every task, virtual work proved more feasible than previously assumed, with some organizations even reporting increased inclusivity and efficiency. Respecting employees' personal and family needs during a crisis was the second highest-rated lesson (average rating = 4.44 out of 5). Respondents noted that flexible scheduling, extended leave policies, and understanding management approaches significantly improved morale and productivity during periods of high uncertainty. The third lesson highlighted the critical importance of offering and encouraging the use of mental health and counseling resources (average rating = 4.28). Participants frequently cited burnout, isolation, and stress, emphasizing the need for organizations to proactively address employee well-being. The fourth finding indicated that not every employee will comply with organizational policies, especially when those policies are perceived to threaten personal freedom, such as vaccination mandates or mask wearing requirements (average rating = 4.24). Participants suggested that building organizational trust and maintaining transparency could help reduce resistance. Finally, participants stressed the need for pandemic preparedness plans and updated safety protocols (average rating = 4.04). Several respondents acknowledged that prior to COVID-19, few facilities had robust health emergency plans. Organizations are now working toward developing comprehensive strategies that include designating safety officers and conducting regular preparedness exercises. These findings, ranked by participant input, offer practical insights for enhancing resilience among MFs, MSRIs, and other BSOs.

DISCUSSION

This study provides important insights into how BSOs, including MFs and MSRIs, adapted during the COVID-19 pandemic and what lessons can strengthen future crisis resilience. By systematically gathering experiences from professionals across the field and validating findings through member-checking, this research offers a grounded, practical framework that organizations can apply to enhance preparedness for future disruptions.

Situational Crisis Communication Theory (SCCT) offers a valuable lens through which to interpret these lessons. During the pandemic, BSOs were perceived as belonging to the victim cluster, bearing minimal responsibility for the crisis itself. While SCCT classifies global pandemics as external events that place organizations in the victim cluster, it also emphasizes the importance of organizational learning. Failure to demonstrate lessons learned or reasonable preparedness may not reclassify an organization into the preventable cluster, but it can still increase reputational vulnerability. Stakeholders may expect organizations—particularly those with critical infrastructure roles—to evolve their crisis readiness, and perceived inaction could lead to criticism or diminished trust, even if culpability remains low. Thus, proactively implementing the lessons identified here is critical for maintaining organizational legitimacy and resilience.

The findings of this study translate into five practical recommended actions, which, if implemented, can strengthen organizational capacity to withstand future disruptions. Specifically, 1) promoting hybrid work models addresses the need for operational flexibility; 2) establishing HR task forces supports employees' personal and family needs, reinforcing trust and morale; 3) developing wellness programs directly responds to mental health challenges that undermine productivity; 4) involving employees in decision-making promotes organizational transparency, addressing the compliance challenges revealed in the findings; and 5) appointing Safety Officers institutionalizes preparedness planning, which SCCT emphasizes as essential for long-term reputation management and risk mitigation.

Recall that our earlier note that according to SCCT, organizations in the victim cluster are advised to show concern, demonstrate corrective actions where appropriate, and reinforce their existing positive reputations to maintain public trust [2]. Interestingly, the lessons learned of "respect employee's personal/family needs" and "provide mental health resources" demonstrate the SCCT recommended strategy of showing concern. Moreover, the lessons learned of "pivot to hybrid work if possible" and "have a pandemic preparedness plan" illustrate the SCCT moves to demonstrate corrective actions where appropriate.

Additionally, while SCCT recommends reinforcing existing positive reputations as a key strategy for organizations in the victim cluster, our data did not reveal examples of this move among the MFs and MSRIs we studied. One plausible explanation is that during the pandemic, these organizations were primarily focused on internal survival—ensuring operational continuity and supporting employees—rather than actively managing external perceptions. Additionally, given their strong preexisting reputations within the scientific community, participants may have assumed that public trust was stable and did not require deliberate reinforcement. If this third SCCT strategy were to emerge in the BSO context, it would likely involve external communication efforts that highlight organizational resilience, continued contributions to public good, and employee-centered values. For example, promoting success stories of how the organizations adapted to pandemic disruptions while maintaining their scientific missions could serve to reassure stakeholders and reinforce positive reputations. Instead of reinforcing existing positive reputations, a notable lesson learned from the data was that "not every

employee follows policies," particularly when personal freedoms were perceived to be at stake. From an SCCT perspective, this insight suggests the importance of bolstering strategies—emphasizing the organization's commitment to transparency, fairness, and employee engagement. Organizations can emphasize their past good deeds and their commitment to fair, transparent enforcement of policies. This helps buffer potential criticism when noncompliance issues arise. Moreover, organizations could proactively acknowledge the challenges of achieving full compliance during crises and highlight their efforts to involve employees in policy development and decision-making. Overall, this approach not only supports trust-building internally but also helps to buffer the organization's reputation externally by demonstrating a commitment to open, ethical management practices.

While SCCT categorizes organizations like MFs and MSRIs as victims during the initial emergence of the COVID-19 pandemic, we argue that this framework must evolve to account for repeat crisis contexts. In a future pandemic, these organizations would likely still be classified in the victim cluster due to the external and uncontrollable nature of the event. However, public and stakeholder expectations would shift—organizations would be expected to have learned from the first experience and implemented robust preparedness measures. Failure to do so could blur the boundary between the "victim" and "preventable" clusters. Thus, we propose an extension of SCCT that captures this nuanced space: a *repeat-victim with heightened responsibility*, where the organization is still a non-culpable recipient of harm but is judged based on its proactive preparedness and learning from past crises. This adaptation of SCCT emphasizes the importance of organizational memory, iterative learning, and transparent communication as critical components of crisis readiness and reputational maintenance in long-duration or recurring crisis environments.

Although the findings were derived from the context of BSOs, they have broader relevance for any large, mission-driven entity aiming to build organizational resilience. Future research should investigate how the implementation of these recommended actions influence organizational performance during subsequent crises, providing empirical validation of this framework. Overall, this study contributes to the crisis communication literature by connecting real-world operational lessons from the COVID-19 pandemic to theoretical predictions about crisis reputation management. The findings offer a practical roadmap for BSOs to move from reaction to preparation, ensuring they are better equipped to meet future challenges.

CONCLUSION

The COVID-19 pandemic tested the flexibility and resilience of BSOs in ways few could have anticipated. This study captures essential lessons that not only highlight the immediate adaptations made during the crisis but also offer a pathway for building more resilient, people-centered institutions. The identified strategies (embracing hybrid work, supporting employee well-being, fostering organizational trust by mental health resources, and strengthening preparedness) are not just temporary responses but necessary investments for long-term success. As crises become more complex and unpredictable, organizations that take proactive steps today will be better positioned to protect their missions and serve their communities tomorrow. By embedding the lessons learned during the pandemic into daily operations, BSOs can move beyond survival toward sustained leadership in a rapidly evolving world.

In addition to these practical insights, our study contributes to the refinement of Situational Crisis Communication Theory (SCCT) in the context of big science organizations. Although SCCT recommends that organizations in the victim cluster should show concern, demonstrate corrective actions, and reinforce positive reputations, our findings suggest that during extreme crises, reinforcing reputations may be deprioritized in favor of internal operational survival. We propose that, in such contexts, a bolstering strategy focused on promoting transparency, ethical management practices, and employee engagement offers an effective adaptation of SCCT principles. Specifically, the lesson that "not every employee follows policies" emphasizes the importance of building organizational trust through participatory decision-making and proactive acknowledgment of internal challenges. By expanding SCCT's application to include bolstering internal trust and transparency during prolonged crises, our study highlights a nuanced strategy for maintaining legitimacy and resilience in victim-cluster crises where external image management may not be an immediate organizational focus. Finally, future refinements of SCCT should account for scenarios where an organization, while still objectively a victim, may be perceived as partially responsible if it fails to demonstrate organizational learning from prior crises. Our findings suggest that the framework must adapt to include expectations of cumulative preparedness and evolving responsibility over time.

FUNDING

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