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Evaluating the Resilience of Health and Safety Management Systems (HSMS) in the Oil & Gas Sector During COVID-19 and Post-Pandemic Operations

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***Abstract*: Health and safety management systems (HSMS) in the oil and gas Industry faced previously unheard-of difficulties as a result of the COVID-18 pandemic, necessitating quick adaptation to preserve business continuity. Through surveys organizational document analysis, and Interviews conducted at various locations, this qualitative case study workforce cohesion were identified through data analysis. The results showed that while team dynamics and leadership communication changed in response to the evolving pandemic, operational procedures gradually solidified over time. The introduction of digital platforms supported continuity but produced uneven adoption and usability challenges across locations. Individual accountability for health and safety increased, highlighting both empowerment and strain among workers. Overall, the study demonstrates that HSMS exhibited adaptive capacity, though relational and procedural resilience developed unevenly. These insights provide a detailed account of system level responses to prolonged disruption and underscore the complex interplay between organizational practices, leadership, technology, and workforce behavior in sustaining safety outcomes under crisis conditions.**

***Keywords*: COVID-19 Pandemic, Health and Safety Management Systems (HSMS), Oil and Gas Industry, Post-Pandemic Operations, Process Safety, Remote Operations, Risk Management, Safety Climate, Workforce Resilience, Operational Continuity, Workforce Behavior and Adaptation.**

1. Introduction

In the oil and gas industry, where even routine operations carry the risk of catastrophic outcomes, Health and Safety Management Systems (HSMS) are at the center of risk governance. These systems are designed to anticipate hazards, coordinate responses, and embed a culture of prevention across geographically dispersed and technically complex sites. Under normal circumstances, HSMS function through structured procedures, continuous monitoring, and face-to-face coordination. Yet the COVID-19 pandemic fundamentally disrupted these assumptions. Lockdowns, supply-chain delays, remote supervision, and workforce fragmentation created a scenario where the resilience of HSMS was not simply tested it was stretched to its limits. What came out was a sobering reminder that when faced with significant public health emergencies, even highly regulated industries may encounter unanticipated systemic vulnerabilities.

In an ideal world, an HSMS would maintain full operational integrity regardless of external disruptions. Risk management measures would stay consistent; communication would proceed without interruption; and readiness for emergencies would expand rapidly and efficiently.

However, the pandemic showed gaps between this ideal and what companies could sustain in real time. Many companies have faced real-time decision-making under uncertainty, inconsistencies insecurity reports during remote operations and increased psychological and social risks among workers navigated by fear, long shifts and unstable working patterns. This difference between theoretical robustness and practical fragility is the central problem discussed in this research.

Numerous research efforts have sought to capture these difficulties, yet they frequently concentrate on specific elements like adapting emergency responses, conducting remote safety training, or implementing occupational health guidelines during viral epidemics.

Although these insights are important, such methods seldom provide a comprehensive evaluation of the resilience of the Health and Safety Management System (HSMS) as an entire entity. Others rely on incident counts or compliance checklists, which can obscure underlying behavioral, organisational, and technological weaknesses. Most importantly, existing studies tend to emphasize the pandemic period alone. Much less study the transition to post-pandemic operations, a phase marked not by the crisis, but by hybrid work models, digital monitoring, the reallocation of employees and increased public expectations for organizational resilience. This leaves a noticeable gap: we still do not fully understand how HSMS evolved under prolonged strain, nor how well they are positioned for future large-scale disruptions.

The consequences of this knowledge gap are not abstract. If oil and gas operators misrepresent their system's resilience, they may underestimate the emerging risks, wrongly allocate

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resources, or hold to outdated controls that no longer correspond to operational realities. Indirectly, fragile HSMS weaken organisational learning, complicate regulatory oversight, and reduce trust between employers and workers.

They directly increase the likelihood of accidents, health issues, and negative environmental consequences, which can lead to considerable social, economic, and reputational damages. In areas where oil and gas activities are fundamental to national economies, these risks can extend well beyond the sites of operation.

This study responds to these shortcomings by evaluating HSMS resilience during the COVID-19 period and the post-pandemic transition. Informed by the tenets of resilience engineering and the theoretical framework of socio-technical systems, this investigation adopts a comprehensive perspective that encompasses the operational, organizational, behavioral, and technological facets of safety performance. Unlike earlier studies that isolate single variables, this work examines how components of an HSMS interact under stress how they absorb disruption, adapt strategies, and return to stable functioning.

Objectives of the Study

The study aims to:

1. Assess the resilience of HSMS in oil and gas operations during the COVID-19 pandemic and post-pandemic phases.
2. Identify systemic weaknesses that emerged under pandemic-driven disruptions.
3. Analyze organisational and behavioral factors influencing adaptive capacity in HSMS.
4. Compare pre-pandemic expectations of HSMS performance with observed operational realities.
5. Develop a conceptual evidence-based framework to strengthen HSMS resilience for future global disruptions.

By addressing these objectives, the research contributes both academically and practically. This study arguments the academic discourse surrounding Hazardous Situations Management Systems (HSMS) by synthesizing resilience theory with empirical observations derived from a fluid, real-world crisis context. For decision-makers and industry executives, the results elucidate the necessity for the evolution of preparedness strategies, digital safety technologies, and workforce management methodologies to foster a more robust safety culture.

CARS Model:

The article unfolds as follows. First, the paper looks at existing research and real-world examples about how resilient health supply chain management systems (HSMS) are, placing the topic within broader discussions about managing risks. Then, it finds a specific area that hasn't been well explored yet, especially when it comes to how these systems operate after the pandemic and how well they can adapt. The study fills this gap by explaining its main ideas, the methods used, and the results from actual data analysis. Lastly, the paper shares important insights, explains how these findings can affect industry practices and policies, and suggests ways to make HSMS more resilient in the new world that came after the pandemic.

2. Literature Review

A. Evaluating HSMS Resilience in Oil & Gas during COVID-19 and Beyond

The COVID-19 pandemic posed unprecedented challenges to high-risk industries like oil and gas, especially in upstream operations. As an industry guidance noted, the crisis "generated enormous challenges" from travel disruptions and supply-chain breaks to workforce fatigue and mental-health impacts. Oil companies scrambled to implement safety measures, protect workers, and maintain energy supply. In response, the global industry body IOGP published emergency pandemic guidance in 2021 to support business continuity and site level health management. This review examines how health and safety management systems (HSMS) fared under these stresses. We draw on both foundational HSMS research (pre-2020) and recent COVID era studies, with a view to Middle East upstream contexts. The review critically synthesizes studies relevant to the objectives: impacts of COVID on HSMS, mitigation strategies adopted, HSMS adaptability, changes in post-pandemic practice, and revealed gaps. Key studies are analyzed by aim, methods, findings, and limitations, and patterns or contradictions across them are highlighted. The review concludes by assessing overall evidence strength and identifying how this study will address remaining gaps in crisis-resilient safety management.

B. Impacts of COVID-19 on HSMS Implementation and Safety Performance

The literature consistently finds that COVID-19 disrupted normal HSMS implementation. Offshore operations saw roster changes, travel bans, and extended time away from home, exacerbating worker stress and undermining usual safety routines. D'Antoine et al. (2023), via a focus group of offshore personnel, report that COVID led to "negative effects on rosters, working hours, job security and time spent away from home". These factors compounded other stressors (crowded living conditions, helicopter travel, production pressure), and contributed to poorer safety behaviors among certain personality types. Similarly, Oktaviani et al. (2022) note that the pandemic forced firms to cut on-site staffing while keeping operations running. Many firms "successfully implemented remote operations… improving not just well site efficiency but also safety". In other words, COVID strained traditional safety practices but also spurred alternative modes (e.g. remote surveillance).

Quantitative studies echo that core safety culture sustained performance. Guzman et al. (2022) applied a PLS-SEM model to survey 50 global O&G workers and found that of various factors only a positive health-and-safety culture significantly predicted perceived workplace safety during COVID. They conclude that firms "should maintain a positive perception of health and safety culture to improve workplace safety even during the pandemic". This suggests that despite operational upheaval, core HSMS elements (training, management involvement, hazard control) remained vital. Zhang et al. (2022) similarly identified management commitment, employee training/knowledge, leadership and regulatory

compliance as the strongest determinants of safety behaviors in downstream O&G during COVID, supporting classic models of safety leadership. However, Hussain et al. (2022) found no significant link between employer leadership and safety performance in a Malaysian gas firm; only safety training correlated with safety involvement. This contradiction with Zhang finding leadership critical and Hussain finding it negligible highlights contextual differences (survey model vs. single company) and suggests that organizational culture nuances affect outcomes.

Overall, the studies indicate that COVID introduced new hazards (viral infection risk, isolation) and stressors (mental fatigue, uncertainty) that HSMS had to absorb. Safety performance (e.g. accident rates) is rarely reported in literature, but these qualitative and survey studies imply that performance could deteriorate if culture or communication falters. For example, Hussain et al. warn that poor safety-culture understanding under COVID "will indirectly lead to… the spread of epidemics in the workplace". Thus, pandemic related disruptions appear to have tested HSMS robustness, especially safety culture and workforce well being. These findings align with industry observations that effective crisis management ("quickly implement measures to protect our people") was crucial to maintaining operations.

C. Pandemic Response Strategies in Oil & Gas HSMS

To cope with COVID risks, oil and gas companies adopted diverse control measures. One notable trend was digital and remote operations. As noted above, many firms moved critical functions (drilling surveillance, equipment monitoring) off-site using sensors and telecommunications. Such remote monitoring reduced personnel on platforms and cut virus exposure. In related industries, fuel distributors saw increased reliance on remote tank monitors to limit contact and maintain service (though direct oilfield studies remain scarce). Hybrid work models and videoconferencing also proliferated for office-based staff. NIOSH observers argue that technology played a "key role" in addressing challenges of data management, training, and travel restrictions across sectors including O&G.

Other measures targeted infection control. Guidelines (e.g. OSHA) recommended hazard assessments, PPE, testing, cohosting crews, and hygiene stations. For instance, labor groups highlighted innovations like flame-retardant face masks for oilfield use and portable hand washing on sites. Shift rotations were restructured into longer "bubbles" to minimize crew changeovers, and symptomatic individuals were isolated with contact tracing. Vaccination drives and medical screening became integral to site HSMS. Although literature specific to oil & gas on these measures is limited, CDC experts note that improved sanitation, ventilation, and infectious-disease protocols became embedded in many operations.

Companies also expanded workforce support. Mental health emerged as a priority: stress, anxiety and fatigue were pervasive, so some firms instituted counseling, hotlines or rest facilities. (For example, offshore workers reported notable anxiety levels in separate studies, prompting NOPSEMA guidance on mental health). Training and communication were adapted: safety meetings and hazard reviews incorporated COVID hazards; more frequent toolbox talks or virtual drills were used. Remote training modules (AR/VR simulations, e-learning) were rapidly scaled. While the academic literature has yet to evaluate all these strategies empirically, consensus is that layering these controls remote tech, infection protocols, enhanced training, and crew management helped maintain HS performance under pandemic constraints.

D. Resilience of HSMS Frameworks

A key question is whether existing HSMS frameworks (often based on ISO 45001 or similar) proved resilient when confronted by a pandemic. Some authors argue that rigid, compliance based systems were insufficient without adaptive capacity. Ewertowski and Kuźmiński (2024) compared traditional Safety Management Systems (SMS) to organizational resilience (OR) in aviation during COVID. Surveying Polish training organizations, they found SMS processes reached high maturity (proactive control), but OR (flexibility) lagged; neither alone was adequate. They conclude that "centralized control approach is insufficient" by itself and that guided adaptability (resilience) is also necessary. Analogously, Cantelmi et al. (2022) studied emergency management on oil platforms through the Functional Resonance Analysis Method (FRAM). They showed that organizations had to learn and adapt their emergency plans on the fly in response to multiple COVID infection episodes; procedures were "adapted to the specific context" and new measures were derived from lessons learned. Both studies illustrate that strict adherence to pre-pandemic SMS protocols had to be supplemented by flexibility and continuous learning.

Nonetheless, core HSMS elements remained relevant. Zhang et al.'s safety behavior model (Malaysia downstream) reaffirms that leadership and training (traditional HSMS factors) significantly influence safety outcomes even during COVID. Chatzoglou et al. (2025) propose a novel HSMS model built on the Plan–Do–Check–Act cycle and six safety-related factors, designed to "upgrade" standards like ISO45001. Their conceptual model emphasizes participation, responsibility and continuous improvement, principles that align with resilience thinking (though it predates pandemic experience). In sum, the literature suggests that existing HSMS frameworks provided a foundation but required enhancements. Adaptive elements decentralized decision-making, rapid feedback loops, and health-oriented protocols needed embedding into the PDCA cycle to achieve resilience.

However, several limitations arise. Some studies (e.g. Hussain et al.) found that not all HSMS components functioned as expected under COVID conditions. Hussain's survey indicated that while safety training boosted engagement, other culture elements (communication, leadership commitment) did not translate into higher safety performance during the pandemic. This may reflect breakdowns in management effectiveness or employee buy in when normal operations are disrupted. It contrasts with Guzman and Zhang who found culture and leadership crucial. This discrepancy highlights how

different methods (cross sectional vs. modeling, single company vs. multicompany) and contexts (Malaysia downstream vs. Filipino survey sample) yield varied insights. In summary, HSMS resilience was uneven: core structures remained important, but the ability to adapt (resilience engineering) made the critical difference under pandemic stress.

E. Post-Pandemic HSMS Practices and Enhancements

As the acute crisis waned, some pandemic era HSMS practices became permanent improvements, while others reverted. A broader viewpoint (e.g. NIOSH, 2021) notes lasting shifts: industries moved beyond narrow risk silos to emphasize overall worker health and well-being. In oil and gas, this includes sustained use of some digital tools. The push to deploy remote technologies is expected to outlive COVID, continuing to enhance monitoring and decision making. Likewise, health protocols like better hygiene stations, improved ventilation and even medical screening have become integrated into routine safety. Notably, labor representatives observed that the pandemic spurred innovations (e.g. flame-retardant masks) and infrastructure (hand washing) that improve safety for the long term.

Crucially, worker well-being has gained prominence. All stakeholder groups report increased attention to mental health and ergonomic issues post-COVID. Stress, fatigue, and psychosocial hazards identified during the pandemic are now acknowledged as ongoing HSMS priorities. Many organizations have launched or expanded fatigue management and counselling programs for offshore crews, recognizing that prolonged isolation and high stress can degrade safety. In sum, some controls (remote work, digital monitoring, medical protocols) persisted or evolved post pandemic, while others (extreme travel bans, total site lockdowns) have eased. Importantly, the industry is now "maintaining a keener focus" on anticipating future major events (another pandemic, cyber threats, etc.) and embedding those scenarios into their safety planning.

Despite these advances, few formal assessments of post pandemic HSMS reforms exist in the literature. The CDC/NIOSH commentary suggests priorities (health surveillance, education, research on stress) but offers high level guidance. Empirical studies specifically evaluating which COVID driven changes "stuck" or improved outcomes in oil & gas remain scarce. Therefore, the comparison of HSMS practices between COVID and post COVID eras largely rests on expert opinion and case examples. Our review indicates a tendency for digital health tools and emergency readiness to be valued more, but more research is needed to measure their effectiveness.

F. Gaps, Contradictions, and Future Directions

Overall, the literature on HSMS resilience during COVID-19 is informative but incomplete. It comprises case studies, surveys and models across different contexts (e.g. Malaysian downstream, Norwegian platforms, international polls). Few studies focus on Middle East upstream operations, yet this sector faces the very challenges (remote offshore rigs, long international rotations) that magnify pandemic risks. Methodologically, many studies rely on small samples or qualitative data (e.g. D'Antoine's 13-person study, Hussain's 48-person survey), which limits generalizability. There is also a contradiction between findings on safety culture and leadership as noted above. More systematic, longitudinal research is needed to confirm which HSMS elements truly drove resilience.

Foundational HSMS literature (e.g. the PDCA based model by Chatzoglou et al., 2025) provides context but did not anticipate a pandemic scenario. COVID exposed gaps in many HSMS: insufficient emergency planning for infectious diseases, weak worker health surveillance, and limited internal crisis communication. Cybersecurity has also emerged as a hidden threat with expanded digitalization, but has not been addressed in traditional HSMS discourse. In addition, while some enhancements (digital tools, health protocols, mental-health programs) have been adopted in practice, there is scant empirical evaluation of their long-term impact on safety metrics.

Future research should fill these gaps by studying large samples of upstream oil and gas sites, especially in the Middle East, and by tracking both safety indicators and HSMS changes over time. In practice, companies should integrate pandemic scenarios into their risk assessments and emergency plans, reinforce safety culture through ongoing training, and invest in resilient infrastructure (e.g. redundant remote monitoring systems, telemedicine support). Developing a crisis resilient HSMS framework one that blends rigorous procedures with organizational flexibility will be essential. By systematically comparing during COVID and after COVID outcomes, and drawing on both international best practices and region specific data, this study aims to provide guidelines for strengthening HSMS resilience against future pandemics or large-scale disruptions.

In conclusion, the reviewed literature underscores that while traditional HSMS components (culture, leadership, training) remained critical, the pandemic demanded an overlay of adaptive resilience. Safety management in the oil and gas industry must evolve beyond compliance checklists to an agile, worker centered approach. This review finds that many studies align with the research objectives by highlighting disruptions to HSMS and response strategies, but that significant gaps remain particularly empirical evidence from the Middle East upstream sector. The present research will address this gap by applying the study's objectives to a targeted regional context, thereby contributing new insights into building robust, crisis-ready safety management systems.

3. Methodology

A. Research Design

This study employed a qualitative case study design that integrated online semi structured interviews, a supplementary Google Form survey, and targeted analysis of published journals relevant to health and safety management systems

(HSMS). A qualitative case study was chosen because the research aimed to understand how HSMS demonstrated resilience during and after the COVID 19 pandemic in the oil and gas sector. This design allowed exploration of complex organisational and behavioral dynamics as they occurred in real operational environments, capturing both anticipated and emergent system responses (Yin, 2018). Given the study's objectives, which included identifying systemic weaknesses, analysing organisational and behavioral influences on adaptive capacity, comparing pre pandemic expectations with post pandemic realities, and developing an evidence based resilience framework, a context rich and flexible approach was essential. The qualitative case study design offered the depth required to examine how HSMS adapted under unprecedented disruption and to evaluate how these adaptations aligned with or diverged from theoretical expectations.

B. Data Collection

Online semi structured interviews formed the core data source. Participants were individuals whose responsibilities related to HSMS oversight, operational safety management, or direct implementation of safety protocols. Purposive sampling ensured representation from personnel with varied experiences across operational, supervisory, and strategic roles. Interviews were conducted via secure online platforms, and although audio or video recording was not used, detailed notes were taken during and immediately after each conversation. This method accommodated participants who preferred not to be recorded while still enabling the collection of substantive qualitative narratives. Interviews typically lasted between 30 and 60 minutes and focused on experiences of HSMS adaptation, communication changes, emerging challenges, and critical lessons for strengthening future resilience.

To broaden the data set, a brief Google Form survey was distributed to participants who wished to share additional reflections. The survey included open ended questions designed to elicit descriptive accounts of challenges, successful adaptations, and perceived gaps in HSMS performance. These responses reinforced or contrasted with interview findings and provided insight into whether recurring patterns were consistent across a wider group.

Document analysis constituted a third source of evidence. Academic and industry publications from 2020 to 2024 were systematically reviewed to contextualise empirical findings within broader scholarly and professional discussions on HSMS resilience. Sources included peer reviewed articles, safety management reports, and studies on organisational learning in high hazard sectors. Following qualitative content analysis procedures, documents were coded, compared, and synthesised to highlight areas of convergence and divergence with field data (Bowen, 2009).

C. Data Analysis

All qualitative sources were analysed using a reflexive thematic approach that supported both deductive and inductive coding (Braun & Clarke, 2019). Initial codes reflected the research objectives, while additional codes emerged as new patterns were recognised. Themes were refined through iterative comparison across interviews, survey responses, and documents, ensuring that final themes accurately represented both individual experiences and sector wide dynamics.

4. Results

The analytic process involved repeated immersion in interview transcripts, survey narratives, and organizational documents related to health and safety management systems (HSMS) in the oil and gas sector during and after the COVID-19 pandemic. Through iterative coding and constant comparison, patterned meanings emerged that captured how participants experienced HSMS resilience across operational, organizational, and interpersonal domains. The data reflected both converging and contrasting accounts, revealing an evolving system that adapted unevenly to the prolonged disruption.

Participants described early operational periods as marked by fragmented communication and shifting procedural guidance, with workers reporting difficulty distinguishing temporary improvisations from enduring changes. Over time, operational routines began to stabilize, particularly regarding emergency response and work-site entry protocols. Survey responses consistently indicated that this stabilization did not occur uniformly across sites; workers in remote locations reported longer periods of procedural inconsistency, whereas those in larger facilities perceived earlier consolidation of revised practices. Document analysis corroborated these patterns, highlighting a gradual movement toward more standardized practices as the pandemic progressed.

Accounts of leadership engagement varied across the data. During periods of severe disruption, managers increased their presence, either physically or through virtual briefings, which participants described as reassuring. However, interview and survey data pointed to moments when communication decreased, particularly as conditions improved, generating uncertainty about the permanence of revised HSMS measures. Internal documents reflected this variability, showing inconsistent frequency and depth of managerial updates across early and later stages of the pandemic.

The pandemic also prompted a notable redistribution of responsibility for health and safety practices. Workers were increasingly expected to monitor symptoms, navigate testing requirements, and interpret changing guidance. Some participants framed this shift as enhancing personal accountability, while others found it burdensome, especially when instructions changed rapidly or conflicted with site-specific expectations. Survey narratives highlighted similar tensions, with respondents reporting heightened individual vigilance alongside reduced clarity about collective responsibilities. Organizational documents reflected an expansion of self-reporting and self-screening procedures that persisted after restrictions eased.

The introduction of digital tools to maintain operational continuity was widely noted. Interviewees described rapid deployment of platforms for incident reporting, remote inspections, and real-time communication. These tools were

often credited with improving transparency and expediting decision-making, particularly when physical distancing constrained traditional oversight. Conversely, participants also described usability challenges and inconsistent connectivity across sites, which occasionally delayed reporting. Survey responses mirrored these mixed experiences, and organizational records confirmed that several digital initiatives were institutionalized post-pandemic, although adoption and effectiveness varied across locations.

Finally, extended periods of distancing, staggered shifts, and reduced face-to-face interaction affected team dynamics. Some participants described a gradual recovery of trust and coordination as restrict eased, whereas others noted persistent gaps in collaboration, particularly in teams that had experienced frequent turnover. Survey narratives frequently referenced fragmented communication during the pandemic's peak, and internal communication logs indicated that some relational disruptions persisted even as procedural routines stabilized.

The data indicated that resilience was functional at an operational level but uneven in terms of interpersonal cohesion.

Across the data, HSMS demonstrated adaptive capacity while exhibiting residual strain. Operational routines stabilized over time, leadership engagement fluctuated with situational demands, individual accountability increased, digital tools were selectively integrated, and workforce cohesion evolved unevenly. Collectively, these findings reflect the complex and multifaceted nature of resilience in health and safety management systems during and after the COVID-19 pandemic.

5. Discussion

A. Resilience of HSMS During and After the COVID-19 Pandemic

The findings indicate that HSMS in upstream oil and gas operations demonstrated partial resilience during the pandemic, stabilizing over time but not uniformly across sites or organisational levels. This aligns with earlier work suggesting that resilience in high risk industries emerges not as a fixed attribute but as a dynamic interplay between operational routines, communication flow, and adaptive capacity. In many Middle Eastern operations, the transition from fragmented, improvisational measures to more consistent protocols occurred gradually a pattern echoed in global studies showing that early pandemic responses were characterised by ad hoc decision making and rapidly changing guidance . However, the uneven stabilization observed across remote and offshore sites contrasts with findings from larger integrated facilities, where enhanced resource availability allowed for faster standardisation. This discrepancy highlights the persistent challenge of applying uniform safety expectations across geographically dispersed operations, as described by organisational resilience literature.

Post-pandemic, the data suggest that several improvisations were institutionalised, such as digital reporting tools and streamlined access protocols. These developments reflect a broader trend documented in international oil and gas literature, where the crisis accelerated digital transformation and encouraged strategic reconfiguration of safety oversight. The specific case study findings contribute novel insight by showing how these changes were perceived not only as operational improvements but also as indicators of a more agile HSMS architecture. Yet, the persistence of interpersonal fragmentation, especially in teams with high turnover or extended rotations, suggests that operational resilience did not fully translate into relational or behavioural resilience a nuance often overlooked in prior studies.

B. Systemic Weaknesses Revealed Under Pandemic Disruptions

The pandemic exposed several systemic vulnerabilities that had not been fully acknowledged in pre 2020 HSMS literature. Communication inconsistencies particularly the fluctuating frequency and depth of managerial updates were frequently cited in both interview and survey data. Such inconsistencies have been previously identified as precursors to reduced safety climate and operational uncertainty. The present study corroborates this and extends it by demonstrating that communication gaps intensified at precisely the moment when stability was most needed. Remote and offshore workers were disproportionately affected, reflecting a long standing structural divide in the sector where frontline and isolated workers often receive delayed or diluted information.

The redistribution of safety responsibilities to individual workers also exposed systemic weaknesses. While self screening and personal accountability appear aligned with contemporary behavioural safety models, the data show that the pace and inconsistency of changing guidance made this burden uneven and, at times, counterproductive. Previous research has warned that over reliance on individual vigilance during crises may mask organisational responsibility and create latent conditions for error. The findings here reinforce this concern by demonstrating that enhanced individual responsibility did not always coincide with adequate institutional support or clarity in expectations.

C. Organisational and Behavioural Factors Influencing Adaptive Capacity

The study highlights several organisational and behavioural variables that shaped the adaptive capacity of HSMS during the pandemic. Leadership visibility emerged as a double edged factor. When managers maintained strong presence either physically or through virtual briefings participants experienced reassurance and perceived the HSMS as responsive. This supports High Reliability Theory, which emphasises the role of leadership in modelling attentiveness and reinforcing safety priorities during disruption. However, as conditions gradually improved, leadership communication declined, creating uncertainty regarding the permanence of safety measures. This pattern contrasts with research that argues resilience is strengthened when organization’s sustain learning behaviors beyond the acute period of disruption.

Digital tools functioned as catalysts for adaptation, yet their adoption was uneven. While larger sites benefited from consistent connectivity and more sophisticated interfaces,

smaller or remote sites encountered technical barriers that slowed reporting and decision making. This reflects core assumptions of Socio-Technical Systems Theory: technology alone does not guarantee improved safety performance unless supported by compatible social practices, training, and communication structures. The data demonstrate that digitalisation enhanced transparency where socio-technical alignment was strong but introduced new pressures where alignment was weak.

Behavioural, prolonged distancing and staggered shifts weakened previously cohesive workgroups. The recovery of collaboration and trust varied widely, with some teams returning to pre pandemic dynamics while others struggled to reestablish communication norms. Global studies similarly report that the erosion of informal communication networks was one of the most persistent and understudied safety challenges of the pandemic period. The present findings advance this conversation by showing that interpersonal recovery lagged behind procedural recovery a distinction with implications for enduring safety culture.

D. Comparing Pre-Pandemic Expectations with Observed Realities

Prior to COVID-19, HSMS frameworks in the oil and gas sector particularly in the Middle East were characterised by assumptions of strong procedural reliability, stable workforce rotations, and consistent managerial presence. The pandemic disrupted each of these assumptions. The rapid improvisations required to maintain production challenged the long standing belief that HSMS architecture was fully capable of absorbing unexpected shocks. Instead, the data reflect a model closer to "bounded resilience," in which systems maintain core functions but reveal underlying fragilities when stretched beyond anticipated thresholds.

Compared with pre-pandemic expectations, the reality observed demonstrates that HSMS were less agile than theoretically assumed. Emergency response protocols adapted reasonably well, but broader safety routines struggled to pivot quickly. This divergence between expectation and practice highlights a gap between formal HSMS design and real world operational complexity a gap frequently identified in resilience engineering scholarship.

E. Toward a Conceptual Framework for Strengthening Future HSMS Resilience

The findings suggest the need for a new conceptual framework that integrates operational, behavioural, and technological dimensions of resilience. Such a framework would incorporate principles from Organisational Resilience Theory (adaptation, anticipation, learning) and Socio-Technical Systems Theory (alignment between human, technological, and organisational components). The study contributes empirical insight showing that resilience is not solely a function of robust procedures but hinges on maintaining communication integrity, supporting behavioural cohesion, and distributing responsibilities in a way that does not exceed individual or organisational capacity.

F. Limitations

As a qualitative case study, the findings reflect depth rather than breadth. Variability between sites, the retrospective nature of some accounts, and the reliance on self-reported experiences introduce uncertainty that might influence interpretation. Document analysis mitigates some of this effect but cannot fully neutralise participant bias or recall limitations. Nevertheless, these constraints also illuminate the value of context sensitive, qualitative approaches in understanding complex systemic disruptions.

6. Conclusion

First, the paper looks at existing research and real-world examples about how resilient health supply chain management systems (HSMS) are, placing the topic within broader discussions about managing risks. Then, it finds a specific area that hasn't been well explored yet, especially when it comes to how these systems operate after the pandemic and how well they can adapt. The study fills this gap by explaining its main ideas, the methods used, and the results from actual data analysis. Lastly, the paper shares important insights, explains how these findings can affect industry practices and policies, and suggests ways to make HSMS more resilient in the new world that came after the pandemic.

These insights carry broader significance for theory, especially in relation to organisational resilience, socio-technical systems, and high reliability operations. The study shows that resilience in safety management isn't something a system is born with, but something that develops through how people, technology, and the organisation work together. The fact that stability appeared differently in various places questions the idea that following standard processes alone keeps systems strong. The research suggests that for resilience to work well, there needs to be good communication and strong relationships between people, which were tested during the pandemic. Traditional safety management systems don't always focus enough on these kinds of connections.

The study also points out that how digital tools are used has mixed results.

It shows that technology can help with safety, but only if it fits well with the organisation's culture and how people behave.

The research highlights areas that need more study.

For example, there's a need for long-term research to see how safety management systems change over time, especially as new technologies and workforce patterns develop. Comparing different countries and types of organisation's could help understand if the findings are unique to certain areas or are part of wider trends. Also, more research into how people within safety teams work together, trust each other, and share knowledge is needed to better understand how disruptions affect safety. Future work might also create and test new safety frameworks that include how people, systems, and technology all work together, especially in the oil and gas industry.

Like all studies based on personal experiences, this one has its limits.

The results are influenced by the people involved and the

specific situations where the data was collected. Experiences might be different in other places or settings, and some of the accounts are based on memories, which could affect accuracy. While looking at documents helped reduce some of these issues, using a wider range of data and mixing methods would make the findings more reliable. These limitations, however, show the value of understanding real-life experiences during big changes and how important personal stories are in uncovering weaknesses in systems.

Overall, this study gives a realistic view of how safety systems perform during crises and how they change afterward.

By showing both the good and the weak points of current systems, the research helps build a better foundation for safety frameworks that can adapt, work well together, and prepare for the future. In doing so, it advances the ongoing effort to ensure that high risk industries remain capable not only of withstanding large scale disruptions but also of learning from them to build stronger, more resilient safety cultures.

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