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REVIEW

Adaptive leadership in health crises: lessons from the COVID-19 pandemic for public health systems

Liderazgo adaptativo en crisis sanitarias: lecciones desde la pandemia de COVID-19 para sistemas de salud pública

Elisabeth Viviana Lucero Baldevenites[1], Pedro Luis Bracho-Fuenmayor[2], Carlos Manosalvas-Vaca[3], María Isabel Santos Quintero[4], Adriana María Castellanos Muñoz[5]

[1]Universidad de Las Palmas de Gran Canaria. Las Palmas de Gran Canaria, España.
[2]Universidad Tecnológica Metropolitana. Santiago de Chile, Chile.
[3]Universidad Estatal Amazónica. Pastaza, Ecuador.
[4]Universidad Autónoma de Sinaloa. Culiacán, México.
[5]Corporación Universitaria Minuto de Dios – UNIMINUTO. Bogotá, Colombia.

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Corresponding author: Elisabeth Viviana Lucero Baldevenites

ABSTRACT

Introduction: the COVID-19 pandemic highlighted the rigidity of traditional leadership models in healthcare systems, underscoring the need for adaptive approaches to manage health crises. These models, based on fixed protocols, proved insufficient in dynamic environments with increasing demands, sparking interest in exploring adaptive leadership as an alternative.
Objective: to analyze the role of adaptive leadership in the resilience of healthcare systems during health crises.
Method: a scoping review was conducted of literature published between 2020 and 2025 in Scopus, Web of Science, and PAHO-IRIS. Thirty studies addressing the practical application of adaptive leadership in health crises were selected, with an emphasis on low- and middle-income countries. Qualitative analysis focused on geographic context, type of crisis, leadership strategies, and key findings.
Results: adaptive leadership proved crucial for systemic resilience, with competencies such as cognitive flexibility, strategic empathy, and innovation. Hybrid patterns combining hierarchy and collaboration were identified as effective in uncertain environments. Resource-limited settings stood out for disruptive solutions and a stronger emphasis on emotional intelligence. However, gaps in training and a lack of standardized indicators to assess adaptive competencies persist.
Conclusions: adaptive leadership is essential for managing health crises, but its implementation requires flexible frameworks and training focused on emotional and collaborative skills. Integrating these approaches into public health curricula and developing metrics to evaluate their impact on institutional resilience is recommended.

Keywords: Adaptive Leadership; Systemic Resilience; Health Crises; COVID-19; Public Health.

RESUMEN

Introducción: la pandemia de COVID-19 evidenció la rigidez de los modelos tradicionales de liderazgo en sistemas de salud, destacando la necesidad de enfoques adaptativos para gestionar crisis sanitarias. Estos modelos, basados en protocolos fijos, mostraron ser insuficientes ante entornos dinámicos y demandas crecientes, lo que generó interés en explorar el liderazgo adaptativo como alternativa.

Objetivo: analizar el papel del liderazgo adaptativo en la resiliencia de los sistemas de salud durante crisis sanitarias.
Método: se realizó una scoping review de la literatura publicada entre 2020 y 2025 en Scopus, Web of Science y PAHO-IRIS. Se seleccionaron 30 estudios que abordaban la aplicación práctica del liderazgo adaptativo en crisis sanitarias, con énfasis en países de ingresos medios-bajos. El análisis cualitativo se centró en contexto geográfico, tipología de crisis, estrategias de liderazgo y hallazgos clave.
Resultados: el liderazgo adaptativo demostró ser crucial para la resiliencia sistémica, con competencias como flexibilidad cognitiva, empatía estratégica e innovación. Se identificaron patrones híbridos que combinan jerarquía y colaboración, eficaces en entornos de incertidumbre. Los contextos con recursos limitados destacaron por soluciones disruptivas y mayor énfasis en inteligencia emocional. Sin embargo, persisten brechas formativas y la falta de indicadores estandarizados para evaluar competencias adaptativas.
Conclusiones: el liderazgo adaptativo es esencial para gestionar crisis sanitarias, pero su implementación requiere marcos flexibles y formación centrada en habilidades emocionales y colaborativas. Se recomienda integrar estos enfoques en los currículos de salud pública y desarrollar métricas para evaluar su impacto en la resiliencia institucional.

Palabras clave: Liderazgo Adaptativo; Resiliencia Sistémica; Crisis Sanitarias; COVID-19; Salud Pública.

INTRODUCTION

According to Wiesman et al[1], managing crises in the healthcare context is a critical element that has been documented as a driving force behind the emergence of skilled leaders. However, Praag et al.[2] rightly point out that something cannot be overlooked in this regard, namely the inability of traditional crisis management models, which are commonly protocolized, to adapt to frequently changing environments. In particular, the experience of the pandemic laid bare this rigidity of procedures, as already pointed out by Bhat et al.[3] who warned of the need for protocols adapted to specific needs and, of course, to specific contexts.

It is precisely in this context that healthcare systems, already under strain in the past, faced pressure from several fronts during COVID. The literature, for example, documents economic collapses, shortages of qualified personnel, and healthcare demands that only grew.[4] This combination of contingencies, each harmful in its own right, was analyzed by Bray[5] who warned of the presence of structural problems underlying the very fabric of organizations and reinforced by collective behavior.

Not everything is bad, however. Contemporary scientific literature is capable of synthesizing solutions (both technical and adaptive) that can be transformed at technical and collaborative levels.[6,7] In this regard, Garrett et al.[8] rightly argue that the challenges outlined above warrant exposing the dysfunctional (and entrenched) institutional assumptions that perpetuate these practices. In this scenario, adaptive leadership, as proposed by Ratcharak & Laur[9] is rightly established as a particularly appropriate coping mechanism ly in crisis contexts where patient care requires innovation in protocols.

In light of the above, command and control models with vertical guidelines continue to be the most common practices in crisis management models, as reported by Baker et al.[11] However, the effectiveness of these crisis management models, which are now obsolete but still prevalent, also depends on what Yeo[12] classifies as less tangible skills, which include active listening, intelligent delegation, and collaborative learning spaces.

In this study, in addition to addressing this notable gap in the literature, the authors aim to analyze how these competencies can contribute to resilience and adaptive leadership in past crises. Beyond documenting experiences, it seeks to develop a conceptual framework applicable to the training of future public health leaders.

METHOD

The study adopts the format of *a scoping* review, an approach particularly suited to systematically mapping the emerging literature on leadership in health crises and its link to systemic resilience. Following the framework proposed by Tricco et al.[13] this methodology, unlike conventional systematic reviews, is not limited to assessing the quality of the evidence, but seeks to identify conceptual trends, areas of omission, and emerging developments in a dynamic field of knowledge.

Bibliographic identification and selection strategy

The period analyzed (2020-2025) intentionally reflects the critical phase of the COVID-19 pandemic and its aftermath, during which health leadership models were put to the test. The search was conducted on three complementary platforms: Scopus (for its multidisciplinary coverage), Web of Science (as a reference index for established publications), and PAHO-IRIS (specialized in Latin American health systems). This combination

sought to balance global perspectives with evidence from resource-constrained contexts, which are often marginalized in conventional analyses.

The search strategy was built around three interrelated conceptual cores:

- Dimensions of leadership (adaptive leadership, decision-making under uncertainty)
- Health crisis management (systemic resilience, risk communication)
- Institutional dynamics (intersectoral coordination, emergency team management)

The use of Boolean operators and truncations optimized the balance between precision and breadth, although the pandemic-related overproduction of literature posed a particular challenge: distinguishing original contributions from mere discursive repetitions with little empirical value.

Selection criteria

Two main filters were established:

- *Thematic focus:* preference for studies that examined the concrete application of leadership models during health crises, rather than abstract theoretical developments
- *Geographic representativeness:* deliberate emphasis on research from low- and middle-income countries, correcting the usual bias toward highly developed realities

The screening process employed blind peer review by independent reviewers with arbitration in case of disagreement. The initial phase (titles/abstracts) eliminated anecdotal documents or those lacking methodological grounding. Subsequent evaluation of full texts discarded works without a defined analytical framework or based exclusively on uncontested opinions.

This meticulous approach, although resource-intensive, avoided two recurring pitfalls in reviews on emerging topics: saturation by redundant literature and conceptual myopia due to overly restrictive filters.

Qualitative data analysis

The study adopted a dynamic interpretative approach, based on an extraction matrix designed to capture four critical dimensions in the reviewed literature:

- Geographic and health context.
- Type of crisis analyzed.
- Documented leadership strategies.
- Main findings obtained.

This tool, enriched with metadata such as authorship and time periods, systematized the comparison between heterogeneous health systems in order to reveal recurring methodological gaps in the assessment of managerial competencies.

RESULTS

Characterization of the studies included in the research

The final analysis included 30 studies that rigorously met the selection criteria (table 1).

Table 1. Studies included

Code	Authors	Year	Country
A1[14]	Sott, M. K., & Bender, M. S.	2025	Brazil
A2[15]	Kuluski, K., Reid, R. J., & Baker, G. R.	2021	Canada
A3[16]	Santra, S., & Alat, P.	2021	India
A4[17]	Aouad, M., Jalbout Hastie, M., & Yazbeck Karam, V.	2025	Lebanon
A5[18]	McKimm, J., Ramani, S., Forrest, K., Bishop, J., Findyartini, A., Mills, C., et al.	2023	Saudi Arabia
A6[19]	González-Mendoza, J.A., Riaño-Solano, M., Sánchez-Molina J.	2022	Colombia
A7[20]	Matos, R. I., Cervero, R. M., Melton, J. L., Clemons, M. A., Sims, B. W., & Ma, T.	2024	United States
A8[21]	Bajaba, A., Bajaba, S., Algarni, M., Basahal, A., & Basahel, S.	2021	Saudi Arabia
A9[22]	Garavaglia, C., Sancino, A., & Trivellato, B.	2021	Italy
A10[23]	Sriharan A, Hertelendy AJ, Banaszak-Holl J, et al.	2021	Canada
A11[24]	Petropanagos, A., Oliver, J., & Chidwick, P.	2025	Canada
A12[25]	Fernandes, V., Wong, W., & Noonan, M.	2023	Australia
A13[26]	Pring, E. T., Malietzis, G., Kendall, S. W. H., Jenkins, J. T., & Athanasiou, T.	2021	United Kingdom

A14[27]	Smithson R.	2021	Australia
A15[28]	Nöthel, S., Nübold, A., Uitdewilligen, S., Schepers, J., & Hülsheger, U.	2023	Netherlands
A16[29]	Sahu, N., Sriram, S., Samrat, B., Choudhary, A. S., Amita Garg, A. G., & Naregal, P. M.	2024	India
A17[30]	Singh, PK; Singh, S; Kumari, V; Tiwari, M.	2024	India
A18[31]	Carter J and Burke H	2023	United States
A19[32]	Alhayli, M. R. S., Alhayli, A. R. S., Alalawi, M. Y. A., et al.	2024	Saudi Arabia
A20[33]	Wu, A., & Preker, A.	2023	United States
A21[34]	Njuguna, C., Tola, H., Maina, B. N., Magambo, K. N., Namukose, S., Kamau, S., & Woldemariam, Y. T.	2024	Uganda
A22[35]	Ferrinho, P., Lehman, U., Kovács, E., & Dal Poz, M.	2022	Portugal
A23[36]	Wald, H. S.	2020	United States
A24[37]	Bookey-Bassett S, Rose D, Purdy N, et al.	2024	Canada
A25[38]	Evans, J., Grudniewicz, A., Yang, M., Gutberg, J., & Singer, S.	2023	Canada
A26[39]	Karreinen, S., Paananen, H., Kihlström, L., Janhonen, K., Huhtakangas, M., Viita-aho, M., & Tynkkynen, L.-K.	2023	Finland
A27[40]	Smallwood, N., Bismark, M., & Willis, K.	2023	Australia
A28[41]	Crain, M. A., Bush, A. L., Hayanga, H., Boyle, A., Unger, M., Ellison, M., & Ellison, P.	2021	United States
A29[42]	Schlinkert, C., Muns, L., van Tuyl, L., & Wagner, C.	2024	Netherlands
A30[43]	Nzinga, J., Boga, M., Kagwanja, N., Waithaka, D., Barasa, E., Tsofa, B., Gilson, L., & Molyneux, S.	2021	Kenya

The epistemological gap between prescriptive leadership models, so prevalent in classical theoretical frameworks, and empirically observed hybrid practices (table 2) not only challenges traditional assumptions but also reveals a critical conceptual void. This divergence is most pronounced in materially constrained environments, where operational constraints, far from inhibiting innovation, have catalyzed disruptive solutions. This paradox radically rethinks the prevailing axioms in the crisis management literature.

The analysis of pandemic leadership shows how this tension between the normative and the feasible generated unprecedented adaptive capacities (table 2). It is surprising that these emerging mechanisms, particularly iterative decision-making patterns, remained marginal in conventional models until 2020. As qualitative data suggest, this theoretical omission reflects a cognitive bias toward ideal conditions that rarely exist in critical contexts.

An alternative reading would suggest that it is not the gap itself, but its late recognition, that is truly problematic. Empirical evidence shows, beyond any reasonable doubt, that rigid models had been inconsistent with real organizational dynamics for decades. In this sense, the pandemic acted less as a catalyst than as a revealer of a pre-existing epistemological fracture.

Table 2. Main results of the research

Code	Type of crisis	Leadership model examined	Main findings
A	Health crises (COVID-19 pandemic)	Adaptive leadership	Identifies flexibility, empathy, innovation, and long-term vision as key characteristics.
A2	Care for complex patients	Adaptive leadership	Separates technical solutions from adaptive ones. Requires changes in relationships and behaviors, with a supportive organizational context.
A3	COVID-19 pandemic (health sector)	Adaptive leadership	Key competencies: stress management, direction, collaboration, and communication. Evidence of gaps in leadership training.
A4	Economic crisis, pandemic, disaster	Adaptive leadership + Maslow's hierarchy	Innovative strategies such as improvised clinics and psychological support. Transparent communication and staff recognition are crucial.
A5	Education in health professions	Various leadership models	Provides a framework for developing leadership skills in health educators, emphasizing the importance of adaptability.
A6	Crisis in the hotel sector (COVID-19)	Adaptive leadership skills	Defensive strategies and service differentiation are key . Emphasize customer loyalty and safety.

A7	Pandemic among military healthcare personnel	Adaptive leadership	Negative association between adaptive leadership and burnout. Suggests training in adaptive leadership to reduce exhaustion.
A8	Business crisis (COVID-19)	Adaptive personality	Self-efficacy and motivation to lead are key mediators between adaptive personality and performance.
A9	Local management during COVID-19	Adaptive leadership	Importance of institutional cooperation, technology for sharing information, and trusted platforms for knowledge exchange.
A10	Pandemic crises (from SARS to COVID-19)	Review of leadership competencies	Task-oriented, people-oriented, and adaptive competencies are essential in pandemics.
A11	Ethical challenges in healthcare	Adaptive leadership	Technical tools are insufficient; adaptive approaches are needed for sustainable behavioral and organizational change.
A12	Educational crisis (COVID-19)	Adaptive and agile leadership	Emotionally intelligent leadership approaches (commander, driver, gardener, engineer) are effective in prolonged crises.
A13	Institutional crisis in surgery	Crisis management models	Parallels between military and healthcare management. Proposes frameworks to improve resilience and preparedness for future crises.
A14	Healthcare response to COVID-19	Combined leadership (command and relational)	Dual styles (discipline and agility) are necessary to manage complex crises.
A15	Dynamic business environments	Adaptive Leadership Behavior Scale (ALBS)	Validates an instrument for measuring adaptive leadership, useful in changing environments.
A16	Health crisis management	Leadership competencies	Identifies key skills: change management, emotional intelligence, and alignment. Collaboration and difficult decision-making are essential.
A17	Challenges in healthcare leadership	Review of leadership theories	Leaders need vision, emotional intelligence, and adaptability. Styles such as transformational and participatory are relevant.
A18	Medical crises	Adaptive Healthcare Organization (AHO)	Proposes a framework with seven key capabilities for adapting in real time to medical crises.
A19	Resilience in health administration	Transformational and adaptive leadership	Transformational leadership traits drive resilience. Recommends integrating resilience metrics into performance evaluations.
A20	International medical education	International leadership competencies	International leadership skills require specialized knowledge and integrated competencies.
A21	Emergencies in drought-affected districts	Adaptive leadership	Effective coordination, frequent communication, and training of local actors are key to the continuity of health services.
A22	Public health emergencies	Authentic and distributed leadership	In complex contexts, leadership must be agile, transformative, and participatory. Agile tools are necessary to assess impacts on human resources.
A23	Public health crises	Integrative resilience approach	Strategies to support the well-being of professionals and students during crises, including curricular flexibility and culturally sensitive interventions.
A24	COVID-19 pandemic (frontline leaders)	Transformational leadership	Representative behaviors include self-care, teamwork, and collaborative support. Recommends leadership training programs for future crises.
A25	Transition to virtual care	Team leadership	Team-focused behaviors (communication, empowerment) improve perceived performance during the transition to virtual care.
A26	Uncertainty in primary care	Adaptive leadership	Embracing uncertainty and adapting are essential. Key enablers: workforce, collaboration, and meaning-making.
A27	Burnout in healthcare workers	Organizational and leadership approaches	Identifies 12 strategies to support well-being, such as valuing staff and reducing workloads.
A28	Transformation during COVID-19	Kotter model (8 stages)	Rapid changes in policies and protocols, with positive results in response capacity and vaccination rates.

A29	Hospital resilience	Organizational resilience indicators	Hospitals are prepared for acute crises, but prolonged crises (such as COVID-19) present complex challenges. Staff confidence and autonomy are key.
A30	Leadership development in health systems	Participatory interventions	Improves self-awareness, communication, and emotional skills in leaders. Spaces for reflection and sharing experiences are essential for resilience.

Critical analysis of perspectives on adaptive leadership in health crises

Contemporary literature agrees that adaptive leadership is an irreplaceable pillar of health crisis management, although its operationalization varies dramatically depending on the level of analysis. While theoretical models (A1, A4) favor a virtuous triangle of competencies, cognitive flexibility, strategic empathy, and innovation, its implementation depends on specific organizational structures (figure 1). This finding reframes the very notion of "adaptation" as an individual phenomenon, shifting it toward a systemic dynamic.

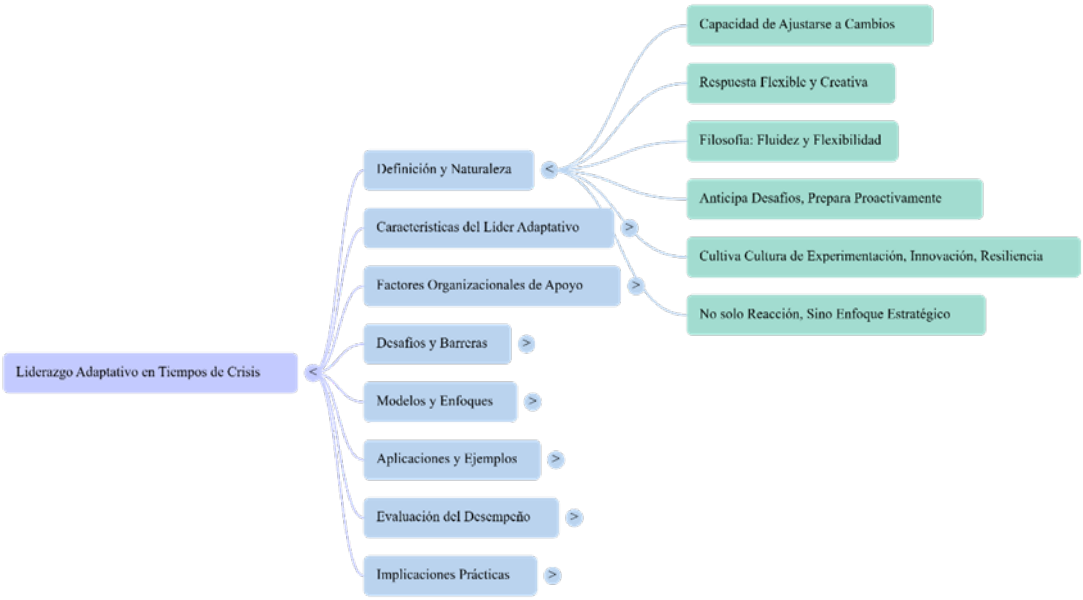

Figure 1. Main conceptualizations

Surprisingly, however, empirical divergence has been observed in high-pressure contexts. Studies of A3 (health sector in India) and A7 (military environments) reveal that collaborative coordination in the face of stress overshadows, in practice, the individual competencies postulated by theoretical frameworks. This effect could possibly be attributed to the asymmetry between experimental designs and real-life scenarios, a limitation that future research should address through stratified sampling. The practical implication suggests that leadership training models, currently focused on personal skills, need to incorporate group mediation mechanisms.

It is counterintuitive that strategic empathy, considered the core of adaptive leadership in A4, shows little transferability in militarized contexts (A7). An alternative reading suggests that its impact is mediated through unmeasured cultural factors, a hypothesis that the available data does not allow us to rule out. As discussed in the opening section, this disparity underscores the need for multilevel frameworks that integrate psychosocial variables alongside organizational ones.

Assessment of tensions emerging at multiple levels

At the meso-organizational level, the coexistence of seemingly antagonistic relational logics and hierarchical structures forms a paradoxical core in highly clinically effective healthcare systems (A9, A14). Far from being an anomaly, this hybridization, as revealed in figure 2, operates as a mechanism of adaptability in uncertain environments, an issue that traditional governance models had overlooked. It is counterintuitive that the friction between the two schemes does not lead to dysfunction, but rather to institutional resilience mediated by structural flexibility, a predictor that has been underestimated until now.

The classical literature initially interpreted this duality as an organizational flaw, but data from A2 and A11 dismantle this premise: there, leadership simultaneously articulates personalized attention to complex cases and the reconfiguration of institutional ethical frameworks (figure 3). It is particularly surprising how the tension between technical and adaptive solutions is not resolved through synthesis, but through asymmetrical coexistence, a finding that rethinks the limits of linear strategic planning. This dynamic, however, exhibits

methodological limitations: the studies cited prioritized samples for convenience, a bias that future research could correct with longitudinal designs.

An alternative reading suggests that the paradox does not lie in hybridization itself, but in its ability to convert structural contradictions into operational resources. As previously discussed, agility does not emerge despite hierarchy, but through its interaction with relational networks—a process where the dysfunctional becomes functional under specific conditions. The practical implication is clear: rather than suppressing tensions, management models should regulate their critical density, a principle that organizational complexity theory is only beginning to explore.

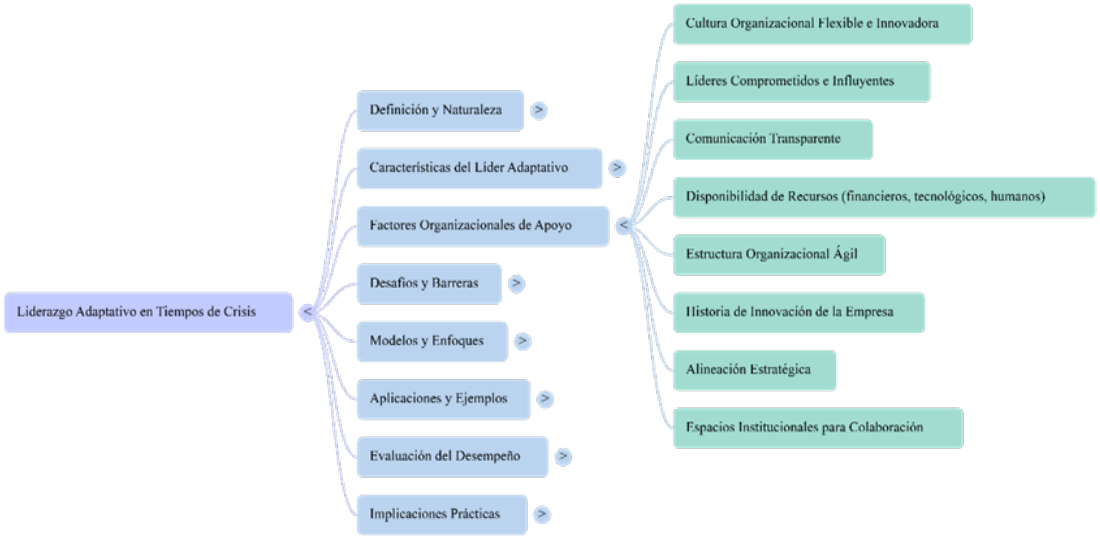

Figure 2. Mind map of the supporting factors that are established at the organizational level

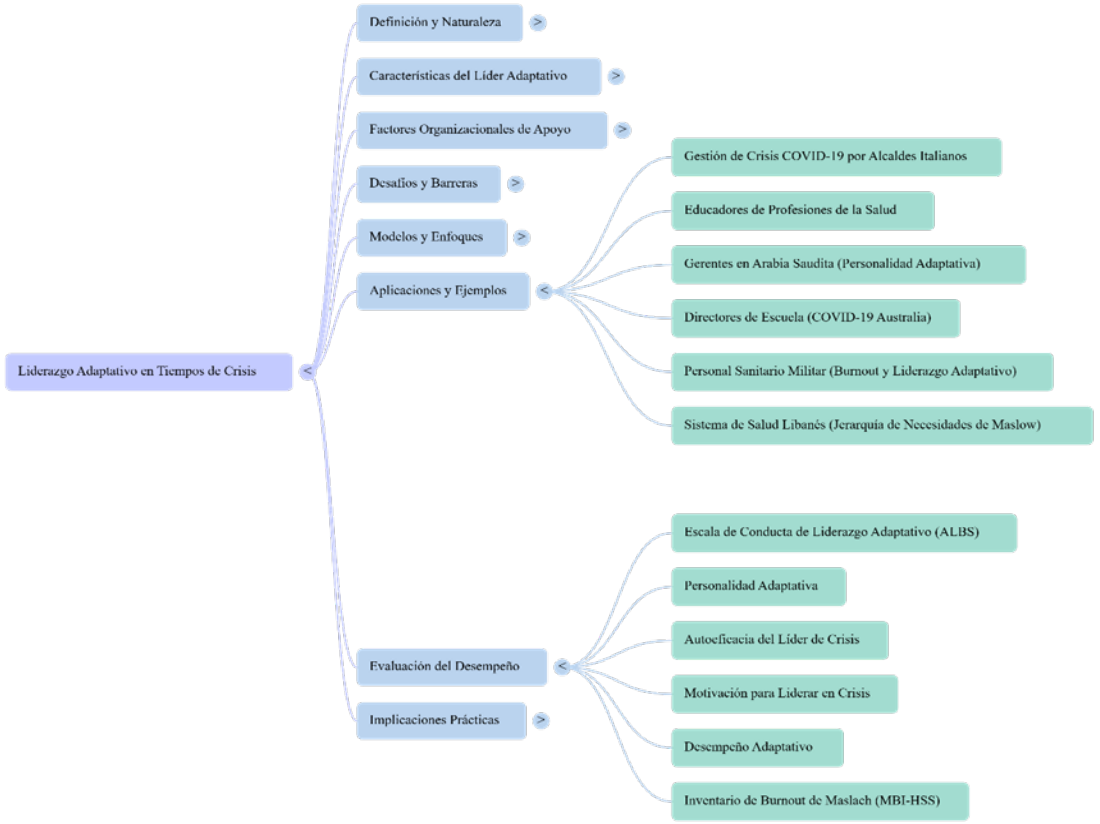

Figure 3. Mind map of mechanisms for organizational performance evaluation

Training and operational challenges

Leadership training emerges as a critical area with two complementary approaches:

- A5 and A12 emphasize the need to incorporate emotional skills into traditional curricula

- A15 and A30 develop specific tools to assess and train adaptive skills

Cases such as A19 and A28 demonstrate how theoretical models (Kotter) can be translated into concrete actions, from the reorganization of services to the management of multidisciplinary teams. However, A26 and A29 reveal persistent limitations: preparation for acute crises does not guarantee adaptive capacity in prolonged emergencies, especially when uncertainty becomes chronic.

Contextual variations

Studies in resource-constrained environments (A3, A22) show distinctive patterns:

- Resource scarcity catalyzes innovations not anticipated in theoretical models
- Emotional intelligence becomes more important than in high-tech contexts
- Prolonged crises require constant modulation of leadership style

This evidence suggests that training models should explicitly incorporate contextual variability, avoiding unrealistic universal prescriptions.

Geographical variations in research

The analysis of the 17 countries represented in the review reveals clear patterns in academic production, marked by both methodological differences and thematic approaches specific to each context. English-speaking countries, particularly the United States (A7, A18, A20, A23, A28) and Canada (A2, A10, A11, A24, A25), dominate quantitatively with studies that favor theoretical models applicable to complex health systems, often using multicenter designs.

Italy (A9) and Portugal (A22) emphasize micro-contextual analysis of local leadership, with a special focus on human resource management in environments of budgetary scarcity. This approach could possibly be related to the particularities of their public systems, where the optimization of limited resources emerges as a critical variable. Although rigorous, the Iberian studies share a notable limitation: their scant consideration of macro-systemic factors which, as will be seen later, are central to other academic traditions.

In stark contrast, Dutch (A15, A29) and Finnish (A26) studies adopt multi-method designs that combine psychometric scales with ethnographic observation. Surprisingly, this methodological hybridization, especially in the Finnish case, does not lead to theoretical eclecticism, but rather manages to capture situated dimensions of organizational resilience. The practical implication here is clear: methodological complementarity allows access to layers of analysis that purely qualitative or quantitative approaches obscure.

The British case (A13) deserves separate consideration for its demonstration of interdomain transferability. By showing how military leadership models can be adapted to surgical settings, the study not only corroborates the flexibility of certain theoretical constructs, but also implicitly questions the contextual essentialism that dominates much of the literature. It is counterintuitive that it is precisely this study—clearly inspired by applied research—that provides the most provocative theoretical reflections on the geocultural limits of knowledge in leadership.

Distinctive regional approaches

Studies from the Middle East, led by Saudi Arabia (A5, A8, A19). These are characterized by quantitative approaches focused on managerial self-efficacy and burnout among military personnel.

Lebanon (A4), on the other hand, documents innovative strategies emerging from multisystemic crises. These prioritize strategies that combine economic, health, and political challenges.

Developing countries make some curiously interesting contributions:

- India (A3, A16, A17) is developing frameworks for assessing adaptive skills in doctors
- Uganda (A21) and Kenya (A30) stand out for community-based capacity development models
- Latin America (Colombia-A6, Brazil-A1) provides case studies in the hotel and health sectors that emphasize adaptability as a factor in organizational survival

This geographical distribution reflects not only disparities in research resources, but also substantial differences in health priorities.

Characterization of leadership models in critical contexts: Toward a dynamic integration of competencies

Leadership models in crisis contexts require a reconfiguration of traditional competencies, not as isolated elements, but as an interdependent system (figure 4). The literature converges in identifying three core attributes: cognitive flexibility, empathic capacity, and long-term strategic vision (A1), but their true potential emerges when distinguishing between technical and adaptive solutions (A2).

The scientific evidence documented and collected in this study indicates that the combination of these seemingly opposing leadership styles is necessary. Such is the situation that, in Australian hospitals, for example,

command leadership coexisted successfully with leadership styles that favored decision-making agility in crisis scenarios, according to reports in A14. Contrary to what might be expected from an outside perspective, the tension between these approaches did not result in conflict between models and personnel. This was because it was able to overcome the hierarchy and horizontality of the chains of command.

The recent pandemic was a natural laboratory for observing these relationships between leadership approaches and their associated competencies. What was curious about this analysis is that socio-emotional competencies and flexible collaborative networks, in their balanced combination, were the main critical predictors of crisis management performance (A3). The Italian case is extremely interesting, as it was the sum of the above, with the co-creation of external actors, that enabled political entities to enhance local responses tailored to the needs of their own people (A4).

In line with these success stories, although it would also be worth asking about the lessons learned from failures, A11 identified three organizational facilitators: innovative cultures, decentralized structures, and resilience-focused strategies. In addition to this, its implementation faced significant systemic barriers. Another paradigmatic case in this analysis was the A5 research on health educators. In this case, the researchers systematically subjected the sample to simulations of disruptive scenarios, which enhanced their ability to adapt in crises.

In support of this, and from a psychosocial perspective, the situation is somewhat more complex, as reported by A8, self-efficacy and motivation to lead were mediating elements between the adaptive traits of leaders and their ability to achieve effective results in the exercise of leadership itself. However, an important limitation of this study is highlighted, which is precisely what was pointed out earlier in this research: the application and operationalization in contexts with limited resources.

In addition, there are opposing views between A26 and A27. A26 focuses on active *sense-making* as a predictive element in the ability to manage uncertainty. A27, on the other hand, proposes that the redistribution of workloads and systematic recognition of successful work are key elements in promoting team well-being. A10, for its part, posits the integration of technical skills, collective intelligence, and systemic adaptation, while A19 advocates including resilience metrics in institutional evaluations. However, as previously analyzed, the tension between standardization and flexibility persists, particularly in systems where the urgent overshadows the important. The pending question, and perhaps the mo , is how to design structures that allow leaders to navigate this paradox without falling into the trap of rigid models or, at the opposite extreme, chronic improvisation. The answer, these findings suggest, may lie in conceiving leadership not as a set of attributes, but as an ecology of situated practices.

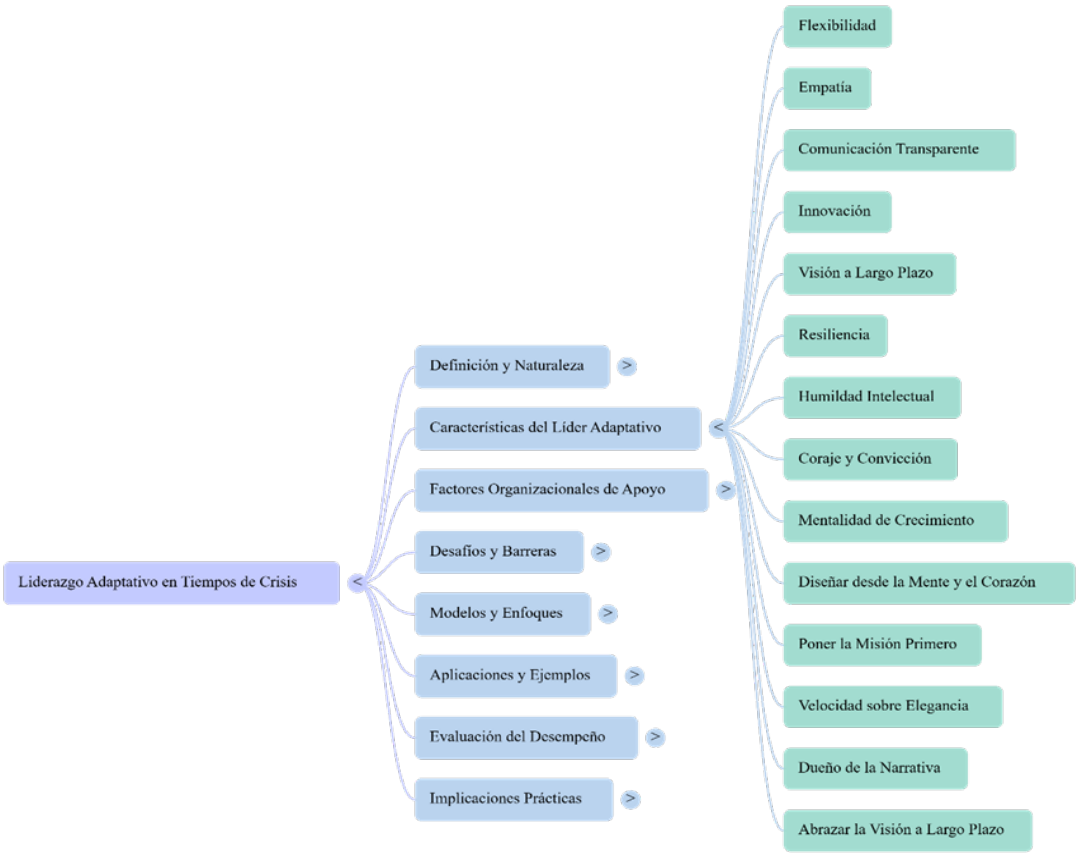

Figure 4. Constituent factors of adaptive leadership during health crises

Role of adaptive leadership in systemic resilience in healthcare contexts

Empirical evidence from multiple contexts, ranging from Lebanon (A4) to Finland (A26), reveals a recurring pattern: leaders' ability to modulate responses according to urgency scales (Maslow applied to healthcare management) correlates with lower burnout rates (A7, A27). This is not limited to logistical solutions such as the improvised clinics documented in Beirut, but includes intangible dimensions, two-way communication that legitimizes team concerns (A14), and flexibility to redefine priorities in real time (A3) (figure 5).

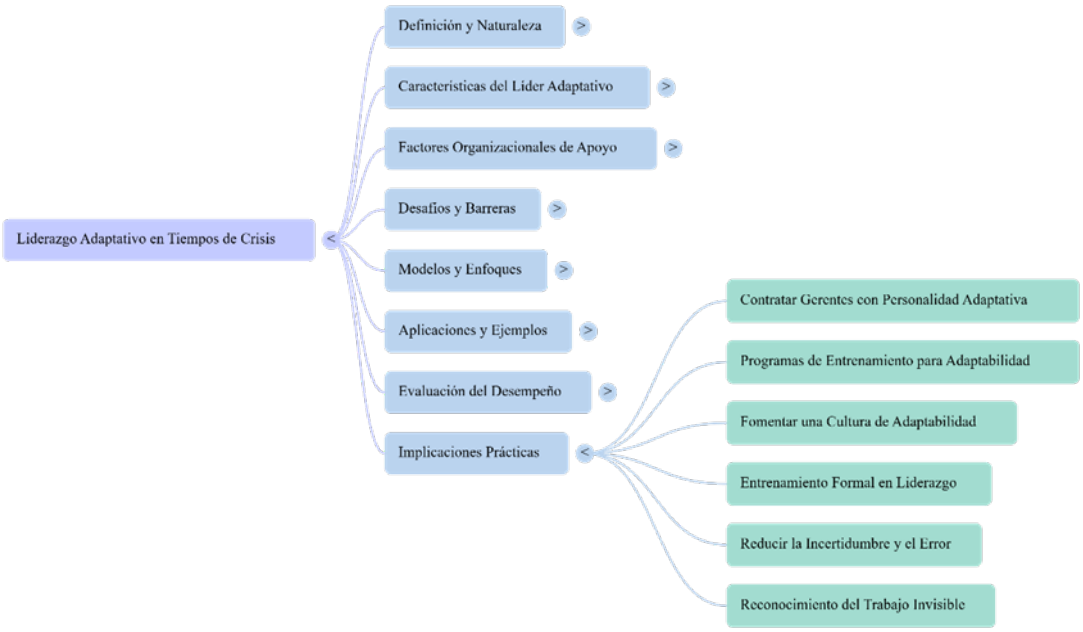

Figure 5. Practical implications

The central paradox here is that resilience is not built on uniformity. Comparative studies in Australia (A14) and Canada (A25) show how the coexistence of relational leadership, to sustain morale, and command-and-control, to ensure protocols, prevented collapse in the transition to telemedicine. This hybridization, far from theoretical, had concrete expressions: dynamic redistribution of personnel in Toronto and collaborative triage systems in Melbourne.

Two systemic factors stand out:

- *Global collaboration:* Uganda's success (A21) in maintaining supply chains during lockdowns depended on partnerships with community leaders, while in Lapland (A26), training local volunteers made it possible to reach nomadic populations.
- *Measurement tools:* Instruments such as the ALBS (A15) have made it possible to operationalize competencies previously considered abstract—stress regulation, situational empowerment—identifying their presence in surgeons (A3) and university rectors (A12).

The revelatory aspect lies in the nuances. When Finnish leaders describe "embracing the unpredictable" (A26), they are not referring to resignation, but rather to active preparation for uncertainty. Frameworks such as the AHO (A18) translate this into organizational architectures that reconfigure hierarchies according to the phase of the crisis. It is no coincidence that training interventions (A30) focused on self-awareness have shown greater impact on team cohesion than traditional technical training.

However, three gaps remain:

- Institutional myopia in the face of prolonged crises (A29), where plans designed for acute emergencies fail in multi-year pandemics;
- The absence of standardized resilience indicators (A19), which leads to performance evaluation using obsolete metrics;
- The fetishism of the "lone hero," when evidence (A17, A22) shows that distributed leadership with teams empowered to make decisions is more sustainable.

Herein lies an irony: while the literature emphasizes "soft skills" such as active listening (A10), many systems continue to reward hyper-technicality. Overcoming this dichotomy requires policies that recognize what has been proven: in public health, resilience is not an attribute, but a verb conjugated in the first person plural.

Training gaps and curriculum reorientation in critical healthcare contexts

The literature reviewed reveals a significant gap between the skills demanded during the pandemic and the training content available to healthcare professionals. Research such as A1 and A3 highlights how certain fundamental skills—particularly cognitive flexibility, empathetic team management, and strategic planning in uncertain scenarios—were marginalized in existing curriculum designs. This gap proved particularly problematic in areas where operational pressure was high: military units deployed in emergencies (A7) and surgical services under extreme demand (A13) revealed similar training gaps in emotional self-regulation and interdisciplinary coordination techniques (figure 6).

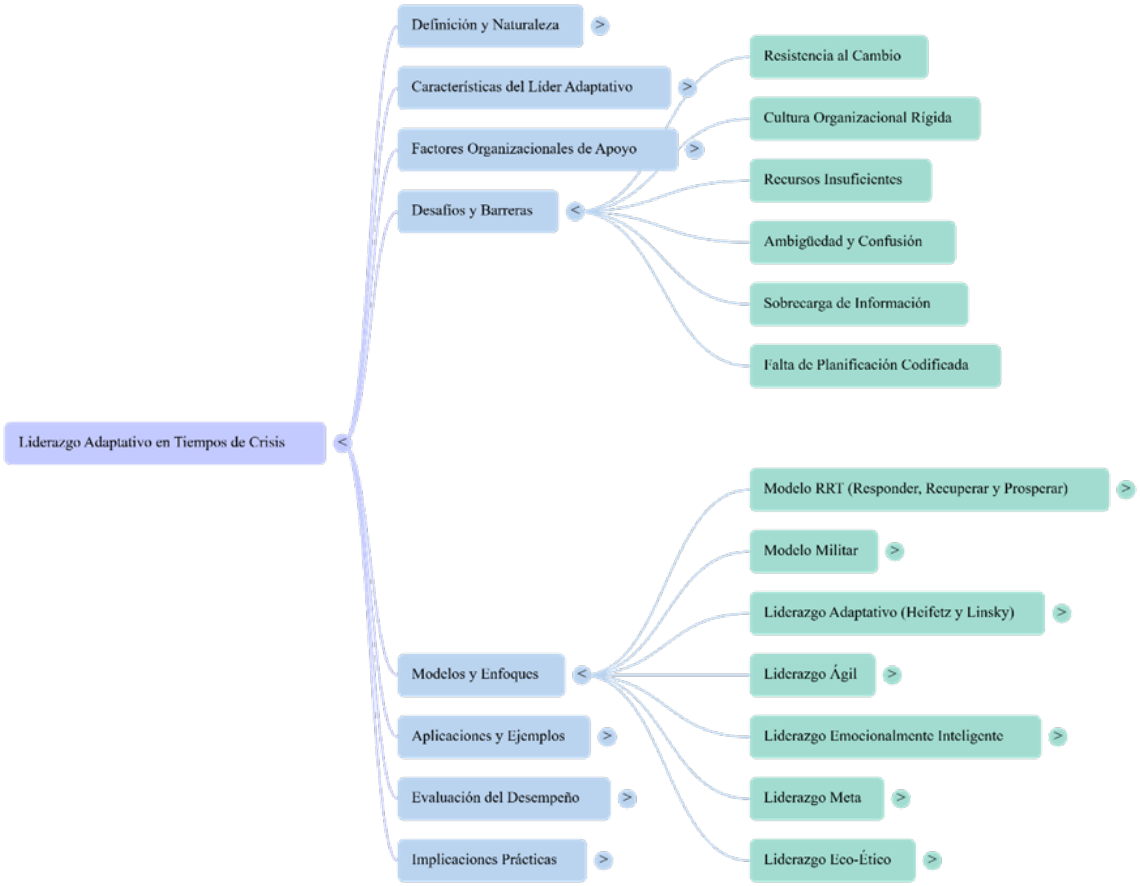

Figure 6. Organizational factors that condition the exercise of adaptive leadership

The structural limitation of current theoretical frameworks lies in their limited transferability to the healthcare setting, where work dynamics, strict protocols, and rigid hierarchies reconfigure conventional leadership models (A5, A17). In this regard, A17 suggests the importance of adapting existing leadership paradigms to healthcare crisis situations. This has some relevant characteristics in common with A5, who insist that these leadership paradigms must be updated and adapted *in situ*. A connecting element between both statements, which could be summarized in the findings of this study, is the inherent tension that emerges from these perspectives and which points, at the very least, to an unresolved tension between the universality of regulatory frameworks for crisis management and their contextualization in health contexts.

Methodologically, this research brings to light another interesting tension in this context of analysis, namely the lack of adapted and empirically validated instruments that can assess adaptive competencies in crisis scenarios, as highlighted by A15 and A16. In the opinion of the authors of this research, this goes beyond the logical limitations of diagnosis and transcends the invisibility of training interventions.

In terms of this educational aspect, which is the subject of this study, it was found that recent curriculum reforms that prioritize applied ethics (A11) and operational resilience (A26) seem to recognize the implications of adaptive leadership as a catalyst for crisis management. In this regard, it is interesting to note that skills historically considered secondary, such as emotional intelligence or nonverbal communication skills, are empirically the best predictors of emergency or crisis management capabilities (A19, A30). This undermines the mechanistic and protocol-based conception of crisis management and indisputably establishes the misnamed soft skills as the cognitive/emotional substrate of technical performance.

Despite this overwhelming evidence, which has been well documented in contemporary scientific literature,

as observed in the present study, the notable prevalence of preparatory deficits reveals an interesting limitation in procedural mechanisms (A28, A29). In such cases, protocols designed for episodic crises, and therefore predictable by human reasoning, showed a notable lack of effectiveness in prolonged scenarios of uncertainty, as documented in A29.

This ineffectiveness, from an external and impartial analysis, has its origins in the presence of educational curricula that favor reaction, without adequate complementation with anticipation. The incorporation of elements such as adaptability, ethics in decision-making, and management of socio-health chaos are therefore connecting elements identified by A29 that could break the documented crack in health leadership in unpredictable contexts.

DISCUSSION

Educational leadership, at its most demanding, experienced a notable boom during the difficult pandemic of 2019, which led to the adaptation of healthcare frameworks for dealing with crises and emergencies. Interestingly, the literature prior to 2020 focused its analysis on the organizational applications of this type of leadership, which, according to research [44] was a determining factor in ensuring business survival. However, it was thanks to COVID that its applications and correlations with protective factors in medicalized environments could be corroborated.

In addition to the evidence obtained during this extreme period, training programs continue to favor technical skills, still ignoring emotional and communication elements with documented evidence of effectiveness.[47,48] In this case, the evidence was overwhelming, as the evidence for standardized protocols was interestingly rooted in their ability to adapt and interpret constantly changing scenarios from various angles.[49] This, at the very least, created a palpable gap between theory and practice, which in turn generated debates about the need to institutionalize mechanisms that allow for the development of leadership in real environments.

In an almost synergistic and correlated manner, the scientific literature available at the time highlighted the need for collaboration between sectors in crisis management. Although it is interesting to note the statements made by Fontes-Filho et al., who directly warn of the limitations of this type of collaboration. For these authors, the collaborative flexibility that has been documented as influencing the capacity of health organizations to manage crises could, if poorly applied, undermine protocol-based decision-making, leading to fragmentation of the chain of command.[51,52] In the opinion of the authors of this study, this data could be biased by a significant methodological limitation, in that most studies focus their analysis on success stories, which overlooks the lessons inherent in failed leadership and crisis management experiences.

Even so, the practical implications of this review are clear. Adaptive leadership, as a catalyst in health crisis management, must be understood as a collective phenomenon dependent on the context in which it occurs, beyond a simplistic set of skills inherent to the leader. Based on this, COVID has clearly demonstrated that its effectiveness will depend on the flexibility of organizations and their ability to learn in real time and adapt to unforeseeable circumstances.

CONCLUSIONS

The pandemic crisis exposed the obsolescence of pyramidal models of leadership in health, rethinking the attributes necessary for governing systems under extreme pressure. This study confirms that cognitive flexibility, understood as the ability to reinterpret scenarios in real time, and strategic empathy, not as a mere emotional disposition but as an instrument of organizational cohesion, emerge as predictors of systemic resilience. This finding implies that effectiveness in health crises can no longer be measured solely by logistical parameters, but must incorporate indicators of behavioral adaptability and decision-making under conditions of incomplete information. Paradoxically, environments with severe budget constraints demonstrated a greater capacity to generate disruptive solutions, a phenomenon that challenges the assumed linear link between resources and effectiveness. Collective intelligence, catalyzed by horizontal leadership, compensated for infrastructural deficiencies in these cases, a lesson that should reorient training policies in low-income regions. However, this emerging adaptability contrasts with the rigidity observed in institutions with rigid hierarchies, where centralized decision-making exacerbated operational bottlenecks during peaks of contagion. An alternative reading would suggest that the real lesson of the pandemic lies not in the “what” of leadership, but in the “how” of its contextualization: no competence is universally optimal when health systems operate on the brink of chaos. Perhaps the greatest post-COVID challenge will be to institutionalize the paradox that the most effective strategic planning is that which learns to unlearn.

BIBLIOGRAPHICAL REFERENCES

1. Wiesman J, Baker E. The Public Health Worker Mental Health Crisis—A Major Leadership Challenge. Journal of Public Health Management and Practice. 2022;28:95-98. https://doi.org/10.1097/PHH.0000000000001476

2. Praag L, DiasM, Farias S, Oliveira A, Vasconcelos M, Milicevic M, et al. Leadership in public health crisis: a review to summarize lessons learned from COVID-19 pandemic. The European Journal of Public Health. 2022;32(3):ckak129.544. https://doi.org/10.1093/eurpub/ckac129.544

3. Bhat Z, Bhat J, Saba N. Navigating the Storm: An Exquisite Leadership Insight into Healthcare Management amidst the COVID-19 Pandemic. Disaster Medicine and Public Health Preparedness. 2023;17:e484. https://doi.org/10.1017/dmp.2023.130

4. Rafila A, Blidaru T, Garofil D, Strilciuc Ș, Muresanu D. Addressing the Healthcare Crisis - The Bucharest High-level Regional Meeting on Health and Care Workforce in Europe: TIME TO ACT. Journal of Medicine and Life. 2023;16:963-966. https://doi.org/10.25122/jml-2023-1024

5. Bray J. Navigating the Crisis: Strategies for Addressing Healthcare Staffing Shortages. American Journal of Healthcare Strategy. 2024; 1(2):13-18. https://doi.org/10.61449/ajhcs.2024.3

6. Bracho Fuenmayor PL. Criminalización de la comunidad queer. Un estudio comparado con visión latinoamericana. Encuentros. Revista de Ciencias Humanas, Teoría Social y Pensamiento Crítico. 2023;18:226-241. https://doi.org/10.5281/zenodo.7901702

7. Poon Y, Lin Y, Griffiths P, Yong K, Seah B, Liaw S. A global overview of healthcare workers' turnover intention amid COVID-19 pandemic: a systematic review with future directions. Human Resources for Health. 2022;20:70. https://doi.org/10.1186/s12960-022-00764-7

8. Garrett J, McNolty L, Wolfe I, Lantos J. Our Next Pandemic Ethics Challenge? Allocating "Normal" Health Care Services. The Hastings Center Report. 2020;50(3):79-80. https://doi.org/10.1002/hast.1145

9. Ratcharak P. Leadership dynamics in health care crises: The impact of initiating structure and consideration behaviors on safety climate in public hospitals. Health Care Management Review. 2025;50:221-231. https://doi.org/10.1097/HMR.0000000000000444

10. Laur C, Agarwal P, Mukerji G, Goulbourne E, Baranek H, Pus L, et al. Building Health Services in a Rapidly Changing Landscape: Lessons in Adaptive Leadership and Pivots in a COVID-19 Remote Monitoring Program. Journal of Medical Internet Research. 2020;23(1):e25507. https://doi.org/10.2196/preprints.25507

11. Baker E, Irwin R, Matthews G. Thoughts on Adaptive Leadership in a Challenging Time. Journal of Public Health Management and Practice. 2020;26:378-379. https://doi.org/10.1097/phh.0000000000001179

12. Yeo R. In praise of COVID-19: discovering adaptive leadership in unprecedented times. Strategic HR Review. 2021; 20(3): 102-108. https://doi.org/10.1108/SHR-01-2021-0009

13. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Annals of Internal Medicine. 2018;169(7):467-473. https://doi.org/10.7326/M18-0850

14. Sott MK, Bender MS. The Role of Adaptive Leadership in Times of Crisis: A Systematic Review and Conceptual Framework. Merits. 2025;5(1):2. https://doi.org/10.3390/merits5010002

15. Kuluski K, Reid RJ, Baker GR. Applying the principles of adaptive leadership to person-centred care for people with complex care needs: Considerations for care providers, patients, caregivers and organizations. Health Expectations: An International Journal of Public Participation in Health Care and Health Policy. 2021;24(2):175-181. https://doi.org/10.1111/hex.13174

16. Santra S, Alat P. Adaptive leadership of doctors during COVID-19. Leadership in Health Services (Bradford, England). 2021;ahead-of-print(ahead-of-print). https://doi.org/10.1108/LHS-08-2021-0073

17. Aouad M, Jalbout Hastie MJ, Yazbeck Karam V. Adaptive leadership in crisis: a healthcare system's resilience journey. BMJ Leader. 2025;9(2):89-93. https://doi.org/10.1136/leader-2023-000958

18. McKimm J, Ramani S, Forrest K, Bishop J, Findyartini A, Mills C, et al. Adaptive leadership during

challenging times: Effective strategies for health professions educators: AMEE Guide No. 148. Medical Teacher. 2023;45(2):128-138. https://doi.org/10.1080/0142159X.2022.2057288

19. González-Mendoza JA, Riaño-Solano M, Sánchez-Molina J. Adaptive Leadership And Its Competencies For Times Of Crisis. Journal of Language and Linguistic Studies. 2022;18(2):1049-1061. https://www.jlls.org/index.php/jlls/article/view/4734

20. Matos RI, Cervero RM, Melton JL, Clemons MA, Sims BW, Ma T. Adaptive Leadership and Burnout in Military Healthcare Workers During a Global Health Pandemic. Military Medicine. 2024;189(Suppl 3):106-112. https://doi.org/10.1093/milmed/usae057

21. Bajaba A, Bajaba S, Algarni M, Basahal A, Basahel S. Adaptive Managers as Emerging Leaders During the COVID-19 Crisis. Frontiers in Psychology. 2021;12:661628. https://doi.org/10.3389/fpsyg.2021.661628

22. Garavaglia C, Sancino A, Trivellato B. Italian mayors and the management of COVID-19: adaptive leadership for organizing local governance. Eurasian Geography and Economics. 2020;62(1):76-92. https://doi.org/10.1080/15387216.2020.1845222

23. Sriharan A, Hertelendy AJ, Banaszak-Holl J, et al. Public Health and Health Sector Crisis Leadership During Pandemics: A Review of the Medical and Business Literature. Medical Care Research and Review. 2021;79(4):475-486. https://doi.org/10.1177/10775587211039201

24. Petropanagos A, Oliver J, Chidwick P. How adaptive leadership can enhance healthcare ethics. Healthcare Management Forum. 2025;38(4):290-294. https://doi.org/10.1177/08404704251327667

25. Fernandes V, Wong W, Noonan M. Developing adaptability and agility in leadership amidst the COVID-19 crisis: Experiences of early-career school principals. International Journal of Educational Management. 2023;37(2):483-506. https://doi.org/10.1108/IJEM-02-2022-0076

26. Pring ET, Malietzis G, Kendall SWH, Jenkins JT, Athanasiou T. Crisis management for surgical teams and their leaders, lessons from the COVID-19 pandemic; A structured approach to developing resilience or natural organisational responses. International Journal of Surgery (London, England). 2021;91:105987. https://doi.org/10.1016/j.ijsu.2021.105987

27. Smithson R. The compatibility of multiple leadership styles in responding to a complex crisis: leading a health service COVID-19 response. Journal of Health Organization and Management. 2021;ahead-of-print(ahead-of-print). https://doi.org/10.1108/JHOM-07-2021-0263

28. Nöthel S, Nübold A, Uitdewilligen S, Schepers J, Hülsheger U. Development and validation of the adaptive leadership behavior scale (ALBS). Frontiers in Psychology. 2023;14:1149371. https://doi.org/10.3389/fpsyg.2023.1149371

29. Sahu N, Sriram S, Samrat B, Choudhary AS, Amita Garg AG, Naregal PM. Assessing Healthcare Leadership Competencies in Crisis Management. Health Leadership and Quality of Life. 2024;3:371. https://doi.org/10.56294/hl2024.371

30. Singh PK, Singh S, Kumari V, Tiwari M. Navigating healthcare leadership: Theories, challenges, and practical insights for the future. Journal of Postgraduate Medicine. 2024;70(4):232-241. https://doi.org/10.4103/jpgm.jpgm_533_24

31. Carter J, Burke H. An Adaptive Healthcare Organization Can Effectively Respond to Medical Crises. International Journal of Public Health. 2023;68:1605581. https://doi.org/10.3389/ijph.2023.1605581

32. Alhayli MRS, Alhayli ARS, Alalawi MYA, Alalawi MMI, Alghubayshi AIA, Alghubayshi HIA, et al. Advancing resilience: Transformative roles of nursing leadership in shaping health administration. Power System Technology. 2024;48(4). https://powertechjournal.com/index.php/journal/article/view/999

33. Wu A, Preker A. Identifying international leadership competencies in medical education. Medical Science Educator. 2023;33:1405-1408. https://doi.org/10.1007/s40670-023-01897-7

34. Njuguna C, Tola H, Maina BN, Magambo KN, Namukose S, Kamau S, et al. Roles of health system leadership under emergency in drought-affected districts in northeast Uganda: A mixed-method study. BMJ Open. 2024;14:e080374. https://doi.org/10.1136/bmjopen-2023-080374

35. Ferrinho P, Lehman U, Kovács E, Dal Poz M. Relevant HRH leadership during public health emergencies. Human Resources for Health. 2022;20(28). https://doi.org/10.1186/s12960-022-00723-2

36. Wald HS. Optimizing resilience and wellbeing for healthcare professions trainees and healthcare professionals during public health crises – Practical tips for an 'integrative resilience' approach. Medical Teacher. 2020;42(7):744-755. https://doi.org/10.1080/0142159X.2020.1768230

37. Bookey-Bassett S, Rose D, Purdy N, et al. Multidisciplinary First-Line Healthcare Leaders' Roles and Experiences During the COVID-19 Pandemic in Ontario Canada. Canadian Journal of Nursing Research. 2024;56(3):269-280. https://doi.org/10.1177/08445621241236665

38. Evans J, Grudniewicz A, Yang M, Gutberg J, Singer S. The role of leaders in shifting to virtual primary care delivery during the COVID-19 pandemic in Ontario's CHCs. The Annals of Family Medicine. 2023;21(1):3624. https://doi.org/10.1370/afm.21.s1.3624

39. Karreinen S, Paananen H, Kihlström L, Janhonen K, Huhtakangas M, Viita-aho M, et al. Living through uncertainty: A qualitative study on leadership and resilience in primary healthcare during COVID-19. BMC Health Services Research. 2023;23:233. https://doi.org/10.1186/s12913-023-09223-y

40. Smallwood N, Bismark M, Willis K. Burn-out in the health workforce during the COVID-19 pandemic: Opportunities for workplace and leadership approaches to improve well-being. BMJ Leader. 2023;7:178-181. https://doi.org/10.1136/leader-2022-000687

41. Crain MA, Bush AL, Hayanga H, Boyle A, Unger M, Ellison M, et al. Healthcare leadership in the COVID-19 pandemic: From innovative preparation to evolutionary transformation. Journal of Healthcare Leadership. 2021;13:199-207. https://doi.org/10.2147/JHL.S319829

42. Schlinkert C, Muns L, van Tuyl L, Wagner C. How well prepared are hospitals for future crises? Board members perceive their hospitals as resilient for acute crises. BMC Health Services Research. 2024;24(817). https://doi.org/10.1186/s12913-024-11197-4

43. Nzinga J, Boga M, Kagwanja N, Waithaka D, Barasa E, Tsofa B, et al. An innovative leadership development initiative to support building everyday resilience in health systems. Health Policy and Planning. 2021;36(7):1023-1035. https://doi.org/10.1093/heapol/czab056

44. Angeler D, Eyre H, Berk M, Allen C, Hynes W, Linkov I. Adaptation, Transformation and Resilience in Healthcare. International Journal of Health Policy and Management. 2022;11:1949-1952. https://doi.org/10.34172/ijhpm.2022.7043

45. Ali H, Ranse J, Roiko A, Desha C. Developing a Healthcare Transformational Leadership Competency Framework for Disaster Resilience and Risk Management. International Journal of Disaster Risk Reduction. 2024;113(15):104898. https://doi.org/10.1016/j.ijdrr.2024.104898

46. Finstad G, Giorgi G, Lulli L, Pandolfi C, Foti G, León-Pérez J, et al. Resilience, Coping Strategies and Posttraumatic Growth in the Workplace Following COVID-19: A Narrative Review on the Positive Aspects of Trauma. International Journal of Environmental Research and Public Health. 2021;18(18):9453. https://doi.org/10.3390/ijerph18189453

47. Hertelendy A, Chekijian S, McNulty E, Mitchell C, Grimes J, Durneva P, et al. Crisis leadership: a case for inclusion in accredited Master of Public Health program curricula. Public Health. 2022;209:14-18. https://doi.org/10.1016/j.puhe.2022.05.012

48. Cai W, Gao R, Jing Q, Wang C, Hou N, Liu W, et al. Doctor of Public Health-Crisis Management and COVID-19 Prevention and Control: A Case Study in China. Frontiers in Public Health. 2022;10:814632. https://doi.org/10.3389/fpubh.2022.814632

49. Hollis J, Kocanda L, Seward K, Collins C, Tully B, Hunter M, et al. The impact of Healthy Conversation Skills training on health professionals' barriers to having behaviour change conversations: a pre-post survey using the Theoretical Domains Framework. BMC Health Services Research. 2021;21:880. https://doi.org/10.1186/s12913-021-06893-4

50. Bradley E. Diversity, Inclusive Leadership, and Health Outcomes. International Journal of Health Policy and Management. 2020;9:266-268. https://doi.org/10.15171/ijhpm.2020.12

51. Bracho-Fuenmayor PL. Estado fallido. Un análisis desde la perspectiva de Rotberg. Encuentros. Revista de Ciencias Humanas, Teoría Social y Pensamiento Crítico. 2025;23:228-244. https://doi.org/10.5281/zenodo.14268859

52. Fontes-Filho J, Kaufmann C, Fonseca T, Pimenta R, Souza J, Novaes E. Governance of interorganizational health emergency networks: Facing the Zika pandemic. Annals of Public and Cooperative Economics. 2020; 92(2):333-354. https://doi.org/10.1111/apce.12299

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AUTHOR CONTRIBUTION

Conceptualization: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Data curation: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Formal analysis: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Research: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Methodology: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Project management: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Resources: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Software: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Supervision: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Validation: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Visualization: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Original draft: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.

Writing – revision and editing: Elisabeth Viviana Lucero Baldevenites, Pedro Luis Bracho-Fuenmayor, Carlos Manosalvas-Vaca, María Isabel Santos Quintero, Adriana María Castellanos Muñoz.