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Developing a Data-Focused Resilience Framework to Support Pandemic Preparedness

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Abstract: The COVID-19 pandemic exposed significant weaknesses in health system preparedness, particularly in data readiness, governance and cross-organisational intelligence (UK Covid-19 Inquiry, 2023; Haldane et al., 2021). Although resilience frameworks are widely used, they give limited attention to the role of data and analytics as core enablers of innovation and system resilience (Reiss et al., 2024; D'Souza et al., 2024). This study examines the role of data and intelligence in supporting pandemic preparedness in the Welsh health system, drawing on experiences from the COVID-19 response.

Using qualitative semi-structured interviews with data leaders, analysts, clinicians, policy leads and senior managers, the study explores how data were accessed, shared and used during the pandemic. Emerging findings highlight an over-reliance on reactive data mobilisation, governance delays, fragmented documentation and a heavy dependence on tacit knowledge, reflecting challenges observed internationally (Haldane et al., 2021; Embrett et al., 2025).

The research proposes a Data-Driven Resilience Framework that positions data infrastructure, governance and analytical capability as central to crisis response

and innovation. The findings offer practical insights for strengthening data-enabled preparedness and decision-making for future pandemics.

Keywords: COVID-19 pandemic; health system preparedness; data readiness; data governance; cross-organisational intelligence; data sharing; analytical capability; data infrastructure; health system resilience; data-driven resilience framework.

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1. System Issue

Health systems worldwide faced profound challenges during the COVID-19 global pandemic, 30 January 2020 – 5 May 2023 (World Health Organisation, 2023), revealing significant gaps in data readiness and availability, data sharing and clear governance responsibilities (UK Covid-19 Inquiry, 2023). Despite the existence of multiple resilience frameworks, many health systems reported lack of preparedness to support their responses (D’Souza et al., 2024; Reiss et al., 2024). More specifically, they reported operational and cross-organisational blind spots due to fragmented, non-interoperable data environments (Haldane et al., 2021).

This research explores how health systems in Wales can maximise learning from the COVID-19 pandemic utilising existing resilience frameworks and models that have since been evaluated following pandemic responses (Reiss et al., 2024; Embrett et al., 2025). The aim of which is to enhance the role of data and intelligence in supporting pandemic preparedness in the Welsh health system, in alignment with the Wales Resilience Framework (Welsh Government, 2025).

As highlighted in the UK's pandemic preparedness assessments, future pandemics are not a matter of if but when, with the risk of pandemic caused by a novel pathogen one of the top risks identified in the UK’s National Security Risk Assessment and the Wales Risk Register (UK Covid-19 Inquiry, 2023; Welsh Government, 2025). Innovation is therefore crucial during pandemics, enabling health systems to adapt rapidly under conditions of uncertainty (Haldane et al., 2021). Central to this adaptive capacity is timely, reliable data to enable situational awareness and evidence-informed decision-making (Lyu et al., 2025). Without integrated, real-time intelligence, even well-intentioned innovations risk being misdirected or delayed.

2. Current Understanding

Brown et al. (2023) have developed the following definition of resilience:

> "Resilience encompasses the capacity to resist, adapt to, recover, or grow from a challenge."

For health systems, this involves not only maintaining essential functions but creating the conditions that support learning and innovation during crises (Topp, 2024).

Existing resilience frameworks developed by organisations such as the World Health Organisation, academic institutions, and national governments emphasise robustness, adaptability and governance (Reiss et al., 2024; D'Souza et al., 2024). However, these frameworks give limited attention to data infrastructure and analytical capability as core enablers of resilience and innovation (Lyu et al., 2025). During COVID-19, organisations including NHS Wales, Public Health Wales and Welsh Government rapidly created new data pipelines and analytical products, mirroring international experience (Haldane et al., 2021), yet these efforts were largely reactive and constrained by governance friction and system interoperability limitations (UK Covid-19 Inquiry, 2023).

3. Research Question

The central question guiding this study is: What is the role of data and intelligence in supporting pandemic preparedness in the Welsh health system? Sub-questions explore the failures and successes of: COVID-19 data systems and associated process (such as data acquisition, curation and sharing across organisations), organisational and governance enablers, conditions for innovation and the potential for AI-enabled analytics.

4. Research Design

This study adopts a qualitative research design, using semi-structured interviews to explore how data and intelligence were accessed, shared and used during the COVID-19 pandemic within the Welsh health system. A qualitative approach was chosen to capture participants' lived experiences, professional judgements and contextual insights, which are central to understanding how data practices shaped system-level responses under conditions of uncertainty and pressure.

A purposive sampling strategy was employed to recruit participants who were directly involved in COVID-19 data, analytical, clinical, policy and operational response activities. Interviewees included data leaders, analysts, clinicians, policy leads and senior managers from organisations such as Welsh Government, Digital Health and Care Wales, Public Health Wales, NHS Health Boards and Trusts, and national innovation and research bodies. These participants were selected to provide system-wide perspectives across policy, delivery and

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intelligence functions. Snowball sampling was also used, enabling participants to recommend additional stakeholders with relevant experience where appropriate.

Semi-structured interviews were conducted to allow for both consistency across participants and flexibility to explore issues arising from individual experiences. Interview questions focused on data readiness, access and sharing; governance and decision-making processes; analytical capability; system coordination; and conditions that enabled or constrained innovation during the pandemic. This approach supported reflection on both challenges and successes, while allowing participants to situate their experiences within their organisational and system contexts.

Interview data were analysed using reflexive thematic analysis**,** following Braun and Clarke's (2021) approach. Analysis involved familiarisation with the data, iterative coding and the development of themes that captured patterned meanings across participants' accounts. The analysis was primarily inductive and experiential**,** focusing on how participants described and made sense of their experiences, while being theoretically informed by resilience and innovation literature. Reflexivity was integral to the analytic process, acknowledging the researcher's position within the system and treating professional expertise as an analytic resource rather than a source of bias.

The resulting themes were used to identify recurring structural and systemic factors influencing data-enabled pandemic response, including data infrastructure, governance alignment and analytical mobilisation. These insights informed the development of a Data-Driven Resilience Framework, grounded in empirical evidence and designed to extend existing resilience models by explicitly incorporating data and intelligence as core enablers of preparedness, innovation and system adaptation.

5. Findings

Emerging findings show that the challenges observed during COVID-19 did not stem from an inability to innovate, but from structural weaknesses in data preparedness and governance alignment reflecting patterns identified internationally (Haldane et al., 2021; Reiss et al., 2024).

Table 1 – Emerging interview findings

Theme	*Description*	*Illustrative Quote*
Pandemic innovation was constrained by reactive data mobilisation rather than lack of capability	Participants described the need to construct core data pipelines during the crisis itself, diverting analytical capacity away from insight generation. This aligns with	"We didn't have bed occupancy data at that level, so we had COVID reporters literally walking around the hospital with a notepad counting beds and

	global evidence that health systems entered the pandemic without pre-positioned, interoperable data assets (UK Covid-19 Inquiry, 2023; Lyu et al., 2025).	emailing spreadsheets to us.”
Governance friction acted as a structural bottleneck on innovation	Across interviews, governance was described as both essential and constraining. Emergency provisions enabled increased data sharing, yet decision-making frequently relied on ad hoc interpretation, expedited approvals, and informal risk acceptance. Governance processes were often negotiated in parallel with operational delivery, rather than enabling it. Participants highlighted a persistent tension between data protection norms and the need for rapid system-wide coordination during emergencies. This misalignment resulted in delays, duplication of effort, and inconsistent data access across organisational boundaries.	“Certain controls were released during the pandemic because we had to be as quick as possible. But those decisions were being negotiated while the response was already happening.”
Fragmented data environments generated multiple “versions of the truth”	Participants reported that the lack of a single, authoritative data environment led to parallel datasets, conflicting metrics, and inconsistent reporting. Different parts of the system produced divergent interpretations of key indicators, including activity, capacity, and outcomes. In some cases, delayed or batch-based reporting produced apparent “spikes” or	“You could very quickly get into a situation where we all had different numbers for how many people had died from COVID, and then spent huge amounts of time defending whose figure was right.” “What looked like death ‘surges’ weren’t real surges at all – it was just batches of paper data coming in at the same time, but

	"surges" that reflected data artefacts rather than underlying system change. This echoed findings from comparative health system analyses (Lyu et al., 2025; Reiss et al., 2024).	politically it looked like things were out of control."
Crisis response relied heavily on tacit knowledge and individual expertise	A strong and consistent theme was the reliance on undocumented knowledge, personal networks, and individual judgement to sustain the data response. Key decisions, assumptions, and workarounds were often held in informal channels rather than formal documentation. Participants expressed concern that much of this knowledge risks being lost as individuals move on or roles change.	"The system works now because the same people are still here. Once that organisational memory goes, I honestly think we'll end up starting again."
Decentralised autonomy during crises undermined equity and system-level optimisation	Participants described significant variation in how different parts of the system interpreted guidance, deployed data, and made operational decisions. In the absence of strong central coordination, organisations adopted divergent thresholds, practices, and priorities. While local flexibility enabled rapid action in some cases, it also resulted in duplication of effort, inefficient resource use, and inequitable service provision.	"Some organisations stopped elective care, some didn't. Some built field hospitals differently. In a pandemic, that kind of variation shouldn't exist."
Where data, governance and delivery were aligned, innovation scaled rapidly	Participants consistently identified instances where integrated data systems, clear standards, and aligned	"We spun up a single national vaccination system and that's why Wales was world-leading for a period –

	governance enabled rapid, effective innovation. In these cases, shared data infrastructure supported real-time visibility, operational coordination, and consistent execution across the system. These examples reinforced evidence that resilience is achievable when enabling conditions are pre-established (Reiss et al., 2024; Welsh Government, 2025).	we knew where the vaccines were and whose arms they were going into.” “Creating a single COVID data store and a national dashboard meant everyone was looking at the same measures, rather than multiple disconnected views.”

These emerging findings therefore support the central proposition:

Welsh health system resilience depends on the pre-existence of data infrastructure, governance mechanisms, and analytical capability that enable rapid innovation, rather than requiring their construction during a crisis.

By grounding this argument in anonymised lived experience, the study demonstrates why existing resilience frameworks must be extended to explicitly incorporate data architecture, governance readiness, and analytical mobilisation as core enablers of resilience and innovation.

6. Contribution to Knowledge and Practice

By explicitly integrating data architecture, governance readiness and analytical capability into resilience thinking, this research extends innovation management and resilience theory (Brown et al., 2023; Reiss et al., 2024). The proposed Data-Driven Resilience Framework offers an empirically grounded model for understanding how health systems innovate under crisis conditions, contributing to debates on dynamic capabilities, ecosystem coordination and digital transformation (Lyu et al., 2025).

In practice, a data-driven resilience framework requires more than a shared definition. Evidence from COVID-19 demonstrates that such a framework must incorporate pre-positioned, interoperable data infrastructure to avoid reactive data mobilisation during crises (Haldane et al., 2021; UK Covid-19 Inquiry, 2023; Reiss et al., 2024). It must also include governance mechanisms that balance speed and assurance and can be rapidly activated under emergency conditions, rather than negotiated in parallel with operational delivery (UK

Covid-19 Inquiry, 2023; Embrett et al., 2025). Analytical capability embedded within decision-making is essential to support real-time situational awareness and adaptive response (Lyu et al., 2025; Reiss et al., 2024). Finally, agreed standards, clear accountability and documented decision processes are required to reduce reliance on tacit knowledge and support coordinated system-wide action (Brown et al., 2023; Embrett et al., 2025).

7. Practical Implications

Strengthening data-driven pandemic preparedness can significantly improve real-time situational awareness, enable more proportionate responses, and enhance coordination across health systems (Haldane et al., 2007; Welsh Government, 2025). These insights have direct relevance for policymakers, digital leaders and researchers seeking to embed resilience and innovation capabilities ahead of future large-scale disruptions. By exploring the role of data and intelligence in pandemic preparedness, this work highlights practical implications for improving real-time decision-making and system-wide coordination under conditions of uncertainty. It also informs how digital systems, analytical capability and information flows should be designed and used in practice, creating stronger conditions for earlier risk identification, more proportionate responses, and enhanced system resilience in future pandemics.

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9. Areas for Feedback & Development

Although we have undertaken a thorough literature review of existing resilience frameworks and have interviewed a good sample of relevant stakeholders to garner representative user experiences from the COVID-19 pandemic, feedback is invited on the role of data and intelligence to support the conditions for innovation during a pandemic. This may be particularly useful to compare experiences and views outside of the Welsh health system that could be used as a comparison. Feedback is also invited on how this research connects to current thinking in innovation management, and opportunities to extend applicability to wider system resilience areas.