Understanding the Impact of Asset Failure on Patient Harm within an Acute Healthcare Setting

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Introduction: The NHS has long faced challenges with aging infrastructure, exacerbated by the additional pressures of the COVID-19 pandemic. Reports by the Institute for Government indicate that insufficient investment in healthcare facilities has led to a less resilient health system. Notably, clinical incidents related to environmental factors have doubled from 2011 to 2020, highlighting a growing concern over the condition of NHS estates. With a maintenance backlog exceeding £11.6 billion in 2023, asset failures, both active and latent, pose significant risks to patient safety.

Active failures, such as slips and trips caused by poor facility conditions, are well-documented in the National Reporting and Learning System (NRLS). However, latent failures, including those resulting from environmental factors like noise, heat, or inadequate ventilation, are less understood but contribute to adverse outcomes like hospital-acquired infections. This research aims to bridge the gap by examining how infrastructure shortcomings influence patient harm, using systems dynamics modelling to map these complex interactions.

Literature Review: Historically, the healthcare sector has focused more on clinical processes than on the physical environment in which care is delivered. Studies by Leape (1994) [(1)] and others argue that many errors attributed to human factors are influenced by poor environmental conditions, suggesting that system-level changes are necessary to reduce errors. Evidence-based design (EBD) has shown promise in improving the environment [(2)], but its adoption within the NHS is hindered by slow implementation cycles. Similarly, there is little to no uptake of an evidence-based approach to the management of the built environment leading to a detrimental impact on the patient pathway [(3)].

As an established methodology in healthcare research, Systems dynamics is suitable for analysing complex systems where variables are tightly coupled [(4)]. This approach allows researchers to create causal loop diagrams that visually represent how variables interact over time, identifying points where small changes could have significant impacts [(5,6)]. The method's adaptability to both qualitative and quantitative analysis makes it particularly relevant for studying the NHS's infrastructure challenges, where hard data on asset failure impacts are scarce.

Methodology: The research employs systems dynamics modelling following the framework outlined by Sterman (2000) [(7)]. Key steps include problem articulation, formulation of dynamic hypotheses, and the creation of causal loop diagrams. Four main variables—asset condition, financial resources, staffing, and patient outcomes—were identified as critical to understanding the systemic impact of infrastructure failures.

A boundary diagram was created to delineate which elements were endogenous versus exogenous. For example, the availability of capital and revenue funding (endogenous) directly affects the state of the assets and subsequently patient safety. The study also highlights the importance of understanding the broader financial implications of reactive versus planned maintenance.

Undertaken using Vensim™ software, the causal loop diagram was built in four stages, incorporating each of the sub-systems, and colour coded as per the model boundary diagram (figure 1) to clearly identify each of the key emerging themes.

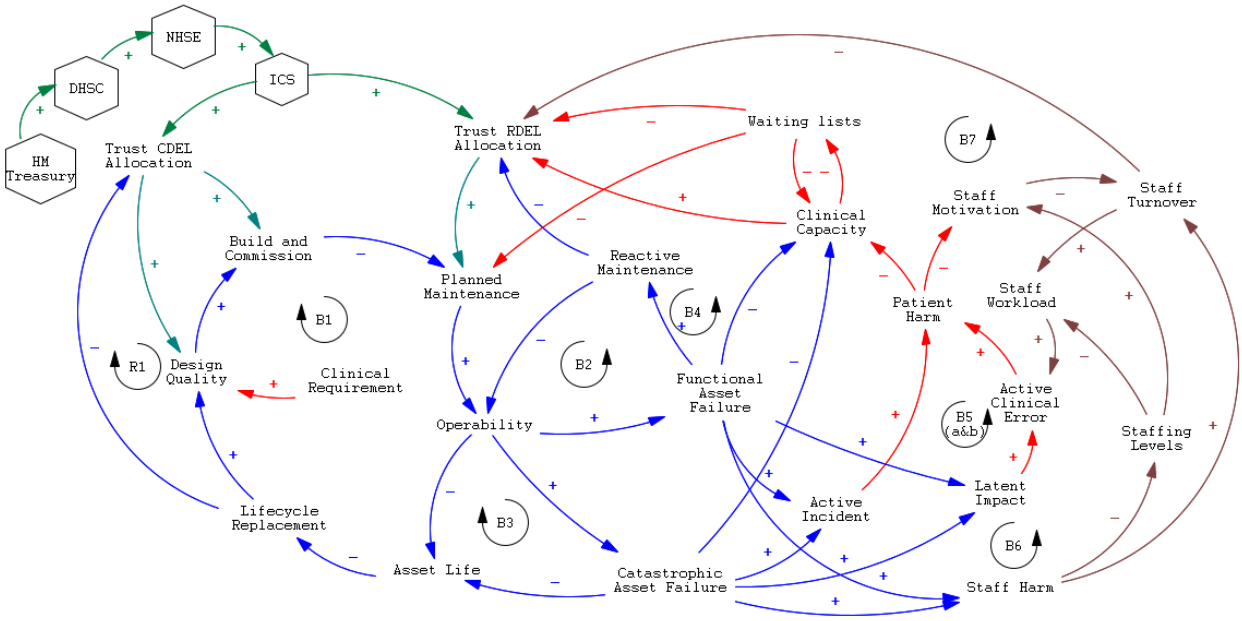

Figure 1 – Causal loop diagram of key variables

Findings: The study identifies several key feedback loops within the NHS infrastructure system:

1. **Financial Allocation Loop:** Limited capital funding constrains the ability to address maintenance backlogs, leading to asset degradation and increased operational costs. This creates a reinforcing cycle where poor asset conditions drive up the need for reactive maintenance, which further strains the financial resources.
2. **Asset Lifecycle Loop:** Aging assets that are not regularly maintained or replaced on schedule lead to higher rates of functional failures. These failures disrupt clinical services, reduce bed availability, and directly increase the risk of patient harm.
3. **Patient Harm Loop:** Infrastructure failures contribute to both direct (active) and indirect (latent) patient harm. Active failures include visible incidents such as equipment malfunctions, while latent failures involve subtler impacts like poor air quality that exacerbate health conditions.
4. **Staffing Impact Loop:** Poor infrastructure conditions also affect staff morale and retention, increasing turnover rates and reducing the quality of patient care. This loop further ties back into financial considerations, as staffing shortages lead to increased operational costs and reduced capacity for planned maintenance.

Discussion: The study underscores that financial investment alone is insufficient without systemic changes in how NHS assets are managed. Effective decision-making requires a clear understanding of the complex feedback loops that drive asset degradation and patient harm. The research suggests that improved data collection and analysis on asset conditions could inform better resource allocation, prioritising interventions that offer the highest return on investment in terms of patient safety and operational efficiency.

The findings also highlight the need for a cultural shift within the NHS, where the built environment is recognized as a critical component of patient care, on par with clinical interventions. This includes advocating for policies that provide dedicated funding streams for infrastructure improvements, as well as integrating asset management more closely with clinical operations.

Conclusion: This research provides a foundational framework for understanding the systemic impact of infrastructure failures on patient outcomes within the NHS. By applying systems dynamics modelling, the study offers a nuanced view of the interconnected factors that contribute to patient harm, emphasizing the importance of a holistic approach to healthcare management. Future work should aim to develop quantitative models that can validate these qualitative insights, providing a stronger evidence base for policy decisions.

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