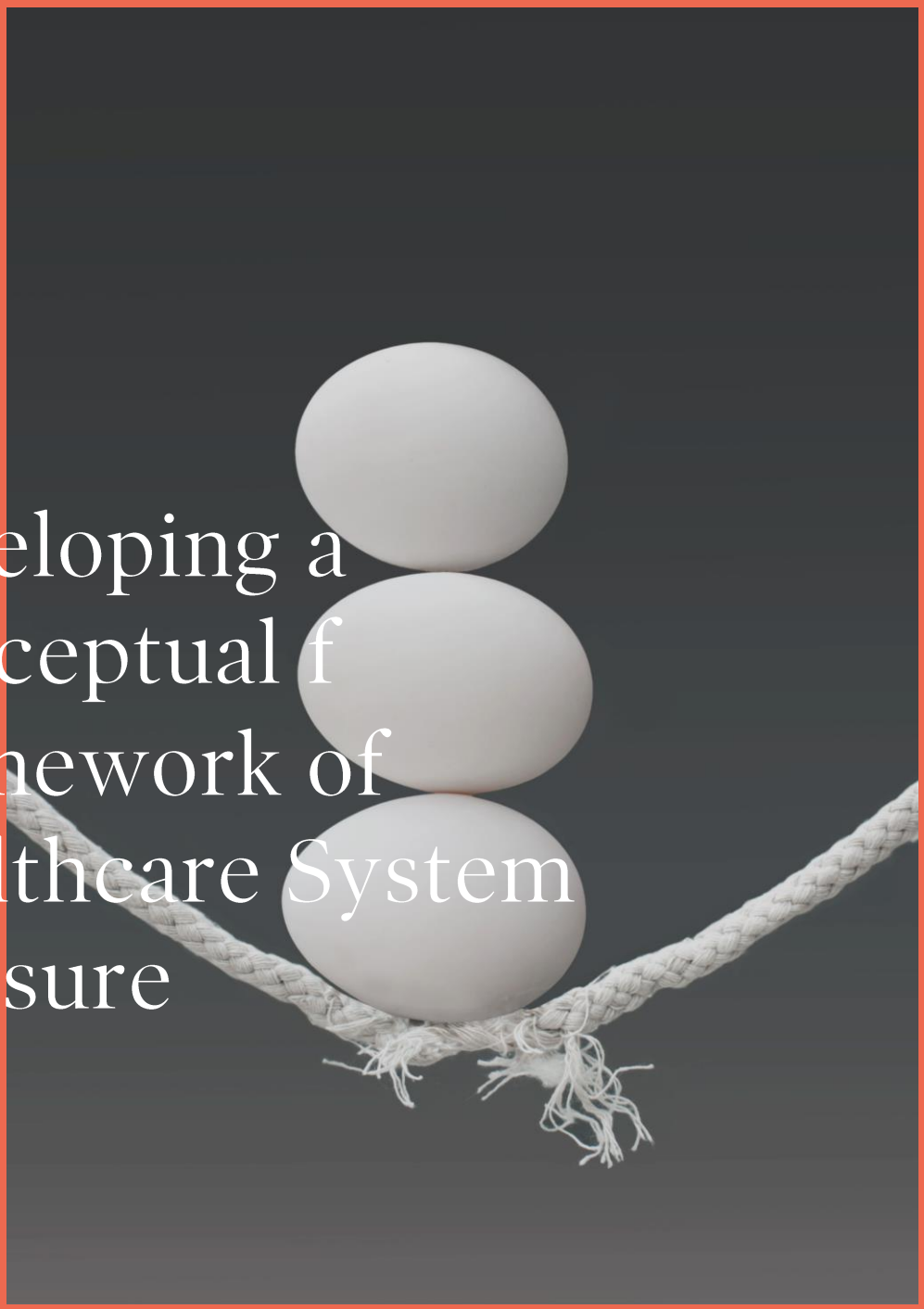
OHE

Developing a Conceptual f Framework of Healthcare System Pressure



CONTRACT RESEARCH REPORT
FEBRUARY 2024

Simon Brassel
Margherita Neri
Hannah Schirrmacher
Fernando Albuquerque de Almeida
Apostolos Charos
Katharina Schley
Kimberly Shea

ohe.org

FEBRUARY 2024

Developing a Conceptual Framework of Healthcare System Pressure

Simon Brassel
Office of Health Economics, London

Margherita Neri
Office of Health Economics, London

Hannah Schirrmacher*
Triangulate Health Ltd

Fernando Albuquerque de Almeida
Pfizer Inc, New York

Apostolos Charos
Pfizer Ltd, Surrey

Katharina Schley
Pfizer Pharma, Berlin

Lotte Steuten
Office of Health Economics, London

Kimberly Shea
Pfizer Inc, New York

Please cite this report as:
Brassel, S., Neri, M., Schirrmacher, H., Albuquerque de Almeida, F., Charos, A., Schley, K., Steuten, L. & Shea K., 2024. Developing a conceptual framework of healthcare system pressure. OHE Contract Research Report, London: Office of Health Economics. Available at: https://www.ohe.org/publications/developing-a-conceptual-framework-of-healthcare-system-pressure/

Corresponding Author:
Margherita Neri
mneri@ohe.org

* Hannah Schirrmacher was an employee of the Office of Health Economics at the time of conducting the research.

For further information please contact:

Professor Graham Cookson
Chief Executive, OHE
Honorary Visiting Professor in Economics at City, University of London

Tel +44 (0)207 747 1408
Email gcookson@ohe.org

About OHE Contract Research Reports

Many of the studies OHE performs are proprietary and the results are not released publicly. Studies of interest to a wide audience, however, may be made available, in whole or in part, with the client's permission. They may be published by OHE alone, jointly with the client, or externally in scholarly publications. Publication is at the client's discretion.

Studies published by OHE as OHE Contract Research Reports are subject to internal quality assurance and undergo external review, usually by a member of OHE's Editorial Panel. Any views expressed are those of the authors and do not necessarily reflect the views of OHE as an organisation.

Funding acknowledgements

This manuscript was funded by Pfizer Inc.

Table of Contents

Executive Summary

The term 'pressure' has been used in a variety of contexts to describe the status of the healthcare systems since long before the COVID-19 pandemic. However, a formal definition of healthcare system pressure (HCSP) is currently lacking. To fill this gap, we developed and tested a conceptual framework of HCSP comprising: (1) a general definition of HCSP and the underlying concepts; (2) approaches to alleviate HCSP and (3) a classification of HCSP metrics.

We conducted a targeted literature review to find definitions of HCSP, types of interventions used to respond to HCSP, and metrics of their impact. To test the 'framework's usefulness, we conducted interviews with healthcare professionals using respiratory syncytial virus and Clostridioides *difficile* hospital infections.

We found no existing conceptualisation of pressure in healthcare settings. Therefore, we defined HCSP using related concepts of resources, capacity and utilisation as occurring when the demand determining the utilised capacity of a resource exceeds its usable capacity. Responses to HCSP include expansion of capacity in anticipation of pressure or as a pressure-mitigating action. HCSP can be measured using direct metrics of utilisation of each resource, or indirect metrics of the impact of pressure. The interviews confirmed the overall comprehensiveness of our framework as a tool to describe pressure and responses to it.

The framework contributes to improving the understanding of HCSP and its implications. By defining and describing measures of HCSP it may aid future decision-making in measuring the value of health technologies that prevent and mitigate pressure.

1 Introduction

Extremely high levels of demand for urgent care during the peak of the COVID-19 pandemic, followed by an increase in the pent-up demand for elective care, have highlighted the severe consequences of resource scarcity within healthcare systems. To describe such extraordinary circumstances, the term 'pressure' has often been used in various contexts. For example, it has been applied to describe the impact of the pandemic on healthcare systems as a whole (Legido-Quigley et al., 2020; Siettos et al., 2021), on specific healthcare systems' units (e.g. critical care) (Carter and Notter, 2020), or on different resources, such as staff (Alharbi, Jackson and Usher, 2020) and finances (Barnett, Mehrotra and Landon, 2020). However, the term 'pressure' has been used to describe the healthcare systems' status long before the COVID-19 pandemic. In the UK, a persistent indicator of 'pressure' is the increasing waiting lists and waiting times for treatment (Thorlby, Gardner and Turton, 2019). Pressure is also regularly discussed in the context of the winter season, when surges in accident and emergency (A&E) admissions and higher bed occupancy rates lead to cancellations in elective care (Kershaw, 2018). Despite its relevance, the term ‘pressure’ is widely used in a colloquial sense, and there seems to be no formal, universally accepted definition in the context of health care.

To systematically understand the implications of pressure in the context of healthcare systems, standard definitions of the term, its underlying concepts, and the metrics to assess the related impact are required. In fact, healthcare systems under pressure are likely to perform differently than in normal circumstances, resulting in an inability to deliver care to people who need it in a situation of emergency or postponed planned care (Alderwick, 2022). Further, the quality of care may also decrease due to prolonged pressure on staff, leading to staff burnout and worse health outcomes for patients (Dall’Ora et al., 2020). Establishing a clearer understanding of pressure in the context of health care is also important to assess the value of policies and interventions that mitigate or prevent pressure and improve overall healthcare systems' performance and resilience.

This paper aims to fill this gap by providing a conceptual framework of healthcare system pressure (HCSP). To do so, we are proposing a conceptual framework comprising (1) a general definition of HCSP and the underlying concepts; (2) approaches to alleviate HCSP and (3) a classification of HSCP metrics. Further, we conducted a "proof-of-concept" exercise utilising expert interviews to test the comprehensiveness and usefulness of this framework, using respiratory syncytial virus (RSV) and *Clostridioides difficile* (C. *difficile*) infections as case studies, both of which have a significant risk of transmission in hospitals settings and manifest distinct diseases across different age groups and seasons of the year.

2 Methods

2.1 Development of conceptual framework

We conducted a targeted literature review to find definitions of HCSP, identify the types of interventions used to respond to such pressure, and metrics to quantify their effect. The choice to focus on HCSP in the hospital settings was motivated by their primary exposure to increased patients' demand in case of seasonal infections or pandemics (The Health Foundation, 2020; Iacobucci, 2021). The review's results informed the development of each component of the conceptual framework.

We searched the peer-reviewed literature on PubMed and performed additional targeted searches on Google to capture the grey literature. We conducted the searches in January 2020, hence these were restricted to studies published in English between January 1st 1960 and December 31st 2019. The main reasons for exclusion were records that applied the term 'pressure' in other contexts (e.g. medical: pressure ulcers) or work that focussed solely on low-income countries or the outpatient sector. Due to the heterogeneity of the included records, we looked specifically for existing definitions and conceptualisations of pressure in the healthcare sector, frameworks that help to explain the relationship between investment decisions and the occurrence of any form of pressure and relevant metrics and indicators. We provide details on the literature search strategy in the Supplementary material.

2.2 Proof-of-concept exercise

We conducted nine interviews with healthcare professionals in three countries (Germany, Italy, UK). We chose experts with experience in planning hospital resources for managing RSV in paediatric populations (n= 4) and C. *difficile* infections (n=5) as we hypothesised that both disease areas could contribute significantly to HCSP. Due to the challenge in recruiting experts with this profile during the peak of the COVID-19 pandemic, the interviews were conducted during the third and fourth quarters of 2021.

To test the comprehensiveness and usefulness of the conceptual framework in describing HCSP and its resource impact in hospital settings, the interviews explored experts' experience of pressure due to RSV/ C. *difficile*, the response actions and their resource implications, and the availability of metrics to quantify the HCSP related to RSV and C. *difficile*. We provide the interview guide for each disease area in the Supplementary material.

3 Results

3.1 Conceptual framework of HCSP

The PubMed and Google searches yielded 771 and 44 results, respectively. After screening the records' titles and abstracts, 44 studies were considered eligible for consideration and were read in full text. Of these, 21 studies were included in the review and informed the framework development. The corresponding Prisma flow chart is given in the Supplementary material.

We found no formal conceptualisation of pressure in healthcare settings and therefore analysed the information according to potential definitions, underlying concepts, options to alleviate pressure and useful metrics to measure it.

Definition of HCSP and underlying concepts

There is currently no universally accepted definition of HCSP. Pressure affects different types of resources that can be categorised into 'staff' (i.e., labour resources), 'stuff' (i.e., durable equipment, pharmaceuticals, medical or non-medical supplies that are consumed during the health production process) and 'structures' (physical infrastructure and management infrastructure within the hospital) (Vissers and Beech, 2005, chap.4; Kaji, Koenig and Bey, 2006).

HCSP can affect different resources. The concepts behind a resource's capacity and utilisation are key to conceptualising pressure for each resource. A resource has a usable capacity, which is the amount of capacity available for production in normal circumstances (Vissers and Beech, 2005, p.55). The usable capacity can be split into *utilised* capacity, which is actually used for production, and *idle* capacity, which remains unused (Vissers and Beech, 2005, p.56). From this, a resource capacity's utilisation can be defined as the ratio of utilised to usable capacity.

Using the concepts of resources, capacity and utilisation, we define HCSP as occurring when the demand determining the utilised capacity of a resource exceeds its usable capacity (Figure 1). Crucially, pressure will be perceived when the level of capacity's utilisation exceeds a certain critical threshold, namely, when the level of utilised capacity approaches that of usable capacity. The critical utilisation threshold beyond which pressure is perceived may vary across settings.

Approaches to alleviate HCSP

To keep the utilisation rate under a critical threshold (e.g., in the English National Health System (NHS), the rate of bed occupancy above which hospitals may no longer be able to work safely and effectively is 85% (NHS Providers, 2021)), hospitals' decision-makers and stakeholders can undertake two main actions impacting their resource capacity. First, they can act in anticipation of pressure by increasing the level of their usable capacity and being able to accommodate a higher demand level. However, such pressure-preventative actions may come at an opportunity cost when the risk of pressure is low because a significant part of the usable capacity will remain idle.

The second option is to expand the usable capacity along the intensive or extensive margin as a pressure-mitigating action. The concept of capacity expansion is linked to the concept of surge capacity, which is predominately applied within the field of disaster management (Bonnett et al., 2007; Kaji, Koenig and Bey, 2006; Schultz and Stratton, 2007; Hick et al., 2008; Rubinson et al., 2008). Capacity extension along the intensive margin involves expanding a resource's usable capacity (e.g. staff working overtime). Capacity extension along the extensive margin requires either the temporary utilisation of external resources (e.g., hiring locum staff) or transferring demand outside the service

area (e.g., across hospitals). An undesirable alternative to capacity extension is the reduction of utilised capacity through the rationing of provided healthcare services without being able to transfer patients to another provider (Robertson et al., 2017).

Metrics to measure HCSP

We found no consensus on the metrics of HCSP and its opportunity costs. However, for each resource, HCSP can be measured using usable and utilised capacity metrics. Key performance indicators (KPI) within hospital finance, processes and staff routinely collected (Rahimi et al., 2017) offer various options for measuring pressure. However, while some of the KPIs measure pressure directly through the level of utilisation of different resources (e.g. bed occupancy rate, the average length of stay, over hours per clinical staff member), others are indirect indicators of the underlying pressure on resources (e.g. staff turnover rate, waiting times, rate of patient complaints). This, in turn, can affect quality measures and outcomes (e.g. mortality rate, etc.).

The usefulness of each metric depends on the specific context and data availability within a hospital. Therefore, our framework offers only a selection of direct and indirect metrics that decision-makers can use to investigate the level of HCSP but does not claim to be an exhaustive list.

Based on those findings, we synthesised the available information into a framework summarised in Figure 1.

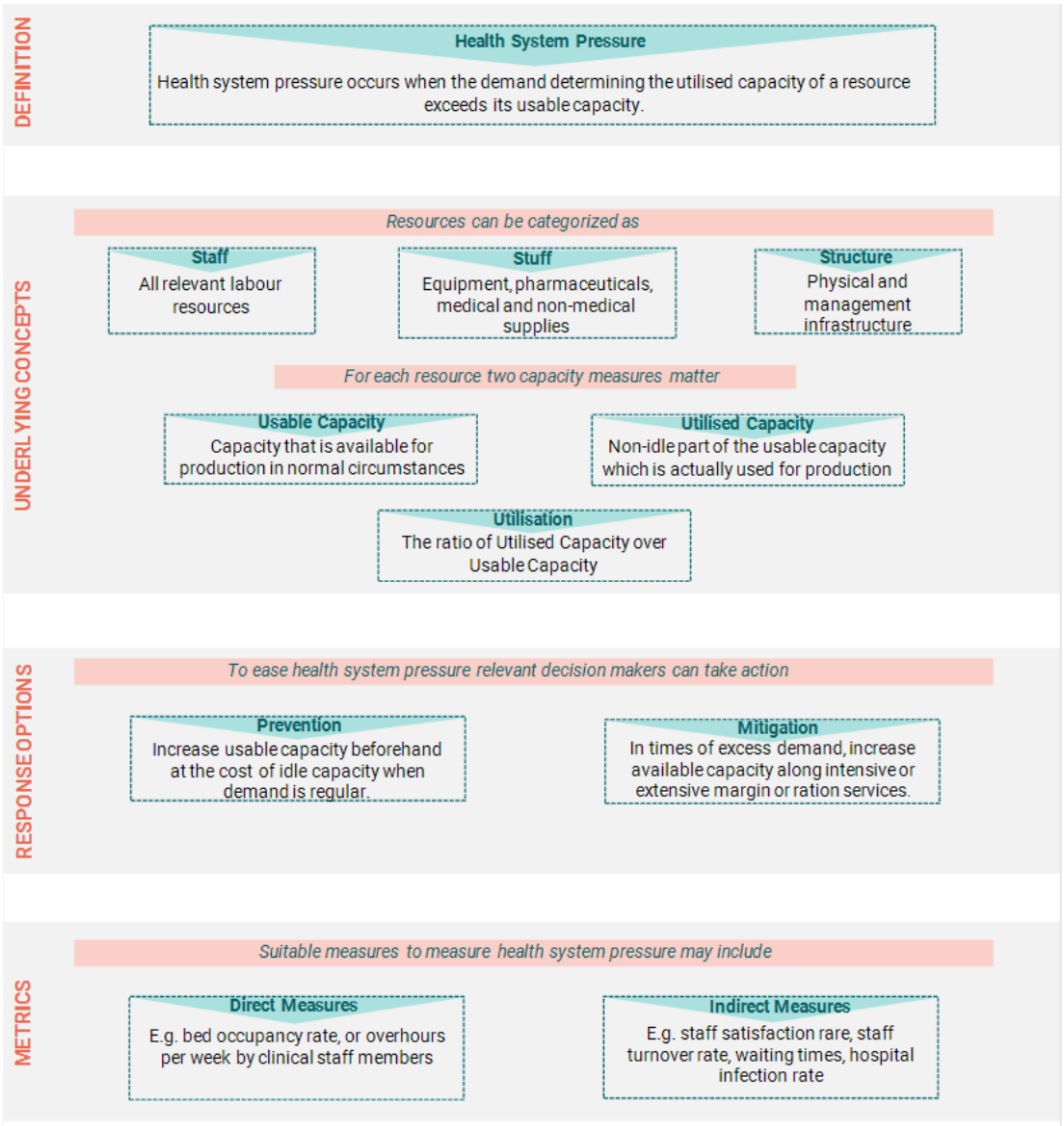


FIGURE 1 CONCEPTUAL FRAMEWORK OF HCSP

3.2 Proof-of-concept exercise

RSV interviews

RSV outbreaks are concentrated in the winter period. Two interviewees commented that the reduced circulation of RSV during the COVID-19 lockdowns may have altered the disease epidemiology, as several cases were observed in the summer months of 2021 after the COVID-19 restrictions were eased. Collectively, RSV outbreaks were perceived as creating HCSP in the form of great demand on paediatric wards, increased staff sickness, surge capacity in intensive care units.

All interviewees discussed preventive actions undertaken before the RSV outbreaks season as operational and organisational measures. For example, staff update internal hospital admission pathways and protocols, plan and align treatment standards across hospitals, and distribute educational material to parents of children at risk.

Pressure mitigating actions against RSV required staff to work extra hours and carry out additional tasks such as participating in extraordinary paediatric ward meetings (n=1), conducting additional cleaning of rooms and wards (n=1) and using disposable equipment to minimise the risk of transmission (n=2), isolating patients in single rooms or shared bays (n=1). Interviewees in Germany and Italy (n=3) mentioned that hiring extra staff in the winter is rarely successful due to staff shortages. A UK-based interviewee stated that hiring of temporary staff is possible, although at a high cost. Three interviewees mentioned elective surgeries are at risk of cancellation and delay, although this is more likely in extreme situations.

All interviewees agreed that there are no metrics of pressure collected specifically for RSV. Indicators of infection prevalence (e.g. volume of admissions, pathogens investigations), hospital occupancy and activity (e.g. bed-days, length of stay) were suggested as proxy indicators. No metrics of the impact of pressure-preventing actions on resources exist. Metrics and data of pressure mitigating actions on staff (e.g. missed shifts, regular/extra working hours reports, staff/patient ratio), stuff (e.g. inventory of single-use equipment in stock), and structures (e.g. elective admissions cancelled) may be possible. However, they are not measured in practice.

C. difficile interviews

All interviewees agreed that the incidence of C. *difficile* infections has declined over the years and, consequently, the related risk of outbreaks. The COVID-19 pandemic may have contributed further to the overall decline in incidence due to increased awareness of hygiene measures. One interviewee argued that even a small number of C. *difficile* infections could create pressure on hospital wards because of a set of extraordinary measures impacting the normal functioning of wards.

Four interviewees stated that the majority of the pressure-preventing actions relevant to C. *difficile* belong to general guidelines for the prevention and control of hospital-acquired infections, such as hand hygiene, use of personal protective equipment (PPE) and antimicrobial stewardship.

Pressure-mitigating actions against C. *difficile* are triggered by C. *difficile* 'alert systems'. Overall, these require isolating patients in single rooms (n=5), testing asymptomatic patients (n=1), and increasing sterilisation and cleaning protocols with specific cleaning agents (n=3). One interviewee stated that disease experts are also responsible for advising the clinical staff on the isolation and treatment of a patient, on top of their clinical responsibilities.

As in the case of RSV infections, all interviewees highlighted a scarcity of routinely collected data and metrics on pressure caused by C. *difficile* and the impact of preventive and mitigating actions on different resources.

4 Discussion

This paper proposes a conceptual framework to formally define HCSP, describes the options to alleviate it, and classifies the available metrics for its quantification. We tested the usefulness of the framework with medical experts related to RSV and C. *difficile* infections, as the former are one of the most common respiratory infections in infant populations during the winter season (Scheltema et al., 2017) while the latter are a complication of hospitalised elderly patients, usually presenting multiple comorbidities (Jump, 2013). Both pathogens were chosen because they are likely to contribute to HCSP due to high risk of transmission in hospitals while their epidemiology is sufficiently different to help understanding the generalisability and broader applicability of the proposed framework.

We searched the academic literature on the topic of pressure in healthcare settings and found that a direct and clear conceptualisation was missing. For that reason, we defined the term based on complementary concepts of healthcare demand and resource capacity.

The proposed taxonomy of pressure-alleviating options can be used to evaluate the reaction of healthcare providers to pressure and, where sufficient data are available, could support a quantification of its impact. While these options were derived based on a literature search focusing on hospital settings, they have broader relevance and are applicable to other healthcare settings.

The interviews provided additional insights to improve its comprehensiveness and confirmed the overall usefulness of our framework as a tool to describe pressure and responses to it. The hospital responses to RSV and C. *difficile* outbreaks documented in the interviews confirmed that the types of resources impacted by pressure are within our categorisation of hospital capacity (i.e. staff, stuff, structures). The actions undertaken in response to pressure are indeed of preventative or mitigative nature, although their relative importance seems variable. Preventative actions based on operational and organisational measures are more common than simply investing in accumulating additional capacity of staff, stuff or structures. This is aligned with the notion that hospital capacity planning should focus on the ability to deliver processes (Rechel, Richardson and McKee, 2018).

The majority of the pressure mitigating actions are also within those predicted by the conceptual framework, as they include a mix of capacity expansion of staff along the intensive margin (for staff) and along the extensive margin (for stuff). Some interviewees mentioned (in the case of C. *difficile* infections) patient isolation in single-use rooms as a practice to reduce the spread of infections causing pressure, thus potentially reducing the usable capacity of structures. Our framework does not explicitly capture this action.

On the metrics of pressure, the interviews confirmed our finding from the literature review that pressure measurement is not undertaken systematically through a set of established indicators. While different candidate metrics may be available, further research and policy alignment is required to evaluate the most suitable metrics of pressure and its impact. One key example relevant to the English NHS is the rate of hospital bed occupancy, as a potential indicator of pressure based on the ratio of utilised to usable capacity. The bed occupancy rate is routinely monitored, especially in the winter months, but its optimal level is subject of debate. For example, to avoid the risk of pressure-related adverse events, the National Audit Office in the UK has traditionally recommended that bed occupancy should not exceed 85% (National Audit Office, 2013). More recently, the NHS planned for an expected bed occupancy of up to 95%, attracting concerns that these may not be safe and sustainable. Ensuring that indicators of capacity utilisation such as the optimal bed occupancy rates are based on evidence-based recommendations considering the hospitals ability to cope with demand are key to preventing and identifying pressure.

Our proposed framework might have useful, practical applications. Our formulation of HCSP could support an evaluation of health technologies that ease pressure on the healthcare system in health technology assessment (HTA), where the objective is to inform an efficient allocation of constrained healthcare resources. This is especially relevant when pressure is extremely high and leads to health care rationing in the form of cancelled elective surgeries. Given the large backlogs of elective care and the high opportunity cost associated with delayed treatment, HSCP-easing health technologies such as vaccines might be undervalued using existing HTA methodologies (Brassel et al., 2022).

Furthermore, optimising the available resources and, therefore, efficiency, organisational actions align with our framework as they can be seen as increasing the level of usable capacity (i.e. which is available for production). Further research should therefore explore how this framework could support efforts to optimise efficiency in different care sectors.

One limitation of our work is that the conceptualisation of HCSP is based on the pre-COVID-19 literature. The COVID-19 pandemic elevated the use of the term pressure in health care context to significant prominence (BMA, 2022; Walker, 2022; NHS Confederation, 2022; Murray, 2023). However, to the best of our knowledge, a conceptualisation of HCSP as the one presented in this paper is still missing. Another term that has gained prominence since the COVID-19 pandemic is that of resilience. Resilience is closely linked to the idea of mitigating the impact of HCSP, as it indicates a healthcare system's ability to plan for a hypothetical crisis, absorb shocks and accelerate recovery (OECD, 2023). As part of a set of recommendations to make health systems more resilient, the OECD identifies capacity adaptation and strengthening as a key mitigation strategy for future pandemics (OECD, 2023), consistently with our suggested approaches to alleviate HCSP. While our conceptualisation should be further tested and refined in the future, results from the interviews on the comprehensiveness of the framework, and complementary research on resilience, suggest a continued relevance of the framework in post-pandemic times.

Secondly, our framework does not explicitly mention the harms resulting from pressure, although this is closely linked to the response options and metrics. Harm results from service rationing in case patient demand cannot be diverted to another provider. The resulting lack of care or a late diagnosis might lead to deteriorating health or higher infection rates within the population in case of an untreated infectious disease. This is an "insider-outsider" challenge that requires to make a choice of optimising care for those who are already in the system, or shifting resources towards those unattended and outside of the system. Harm might also result from the indirect consequences of pressure that will reduce productivity and efficiency of the service, eventually eroding the quality and, hence, the outcomes of health care delivery in the long run. A final limitation of our work is the small sample size of the interviews, which prevents a full generalisation of their insights or cross-country comparisons. However, while the interviews were undertaken primarily as a proof-of-concept exercise, they provided preliminary insights on pressure associated with RSV and C. *difficile* infections and the healthcare system's response to it. Our qualitative findings may therefore guide future quantification of the impact of RSV and C. *difficile*-related HCSP.

5 Conclusions

Our framework is a first important step to improving the understanding of HCSP related to infectious diseases in hospital settings and its implications. Firstly, it creates a shared language for policy and decision-makers to define, address and measure impact on HCSP more systematically. Secondly, it may aid future decision-making by supporting HTA bodies in measuring the value of health technologies that prevent and mitigate pressure. Additional research on metrics and data that enable pressure measurement are required to achieve this (Brassel et al., 2022).

6 References

1. Alderwick, H., 2022. Is the NHS overwhelmed? *bmj*, 376.

2. Alharbi, J., Jackson, D. and Usher, K., 2020. The potential for COVID-19 to contribute to compassion fatigue in critical care nurses. *Journal of Clinical Nursing*, p.10.1111/jocn.15314. 10.1111/jocn.15314.

3. Barnett, M.L., Mehrotra, A. and Landon, B.E., 2020. Covid-19 and the Upcoming Financial Crisis in Health Care. p.6.

4. BMA, 2022. *An NHS under pressure*. [online] The British Medical Association is the trade union and professional body for doctors in the UK. Available at: https://www.bma.org.uk/advice-and-support/nhs-delivery-and-workforce/pressures/an-nhs-under-pressure [Accessed 3 Feb. 2023].

5. Bonnett, C.J., Peery, B.N., Cantrill, S.V., Pons, P.T., Haukoos, J.S., McVaney, K.E. and Colwell, C.B., 2007. Surge capacity: a proposed conceptual framework. *The American Journal of Emergency Medicine*, 25(3), pp.297–306. 10.1016/j.ajem.2006.08.011.

6. Brassel, S., Neri, M., Schirrmacher, H. and Steuten, L., 2022. The Value of Vaccines in Maintaining Health System Capacity in England. *Value in Health*. [online] 10.1016/j.jval.2022.06.018.

7. Carter, C. and Notter, J., 2020. COVID-19 disease: a critical care perspective. *Clinics in Integrated Care*, 1, p.100003. 10.1016/j.intcar.2020.100003.

8. Dall'Ora, C., Ball, J., Reinius, M. and Griffiths, P., 2020. Burnout in nursing: a theoretical review. *Human Resources for Health*, 18(1), p.41. 10.1186/s12960-020-00469-9.

9. Hick, J.L., Koenig, K.L., Barbisch, D. and Bey, T.A., 2008. Surge capacity concepts for health care facilities: the CO-S-TR model for initial incident assessment. *Disaster Medicine and Public Health Preparedness*, 2 Suppl 1, pp.S51-57. 10.1097/DMP.0b013e31817fffe8.

10. Iacobucci, G., 2021. Covid-19: How is vaccination affecting hospital admissions and deaths? *BMJ*, p.n2306. 10.1136/bmj.n2306.

11. Jump, R.L., 2013. Clostridium difficile infection in older adults. *Aging health*, 9(4), pp.403–414.

12. Kaji, A., Koenig, K.L. and Bey, T., 2006. Surge capacity for healthcare systems: a conceptual framework. *Academic Emergency Medicine: Official Journal of the Society for Academic Emergency Medicine*, 13(11), pp.1157–1159. 10.1197/j.aem.2006.06.032.

13. Kershaw, 2018. *The perpetual winter's tale*. [online] Available at: https://www.kingsfund.org.uk/blog/2018/04/perpetual-winters-tale .

14. Legido-Quigley, H., Mateos-García, J.T., Campos, V.R., Gea-Sánchez, M., Muntaner, C. and McKee, M., 2020. The resilience of the Spanish health system against the COVID-19 pandemic. *The Lancet Public Health*, 5(5), pp.e251–e252. 10.1016/S2468-2667(20)30060-8.

15. Murray, R., 2023. Under pressure: what will 2023 hold for the health and care system? *The King's Fund*. Available at: https://www.kingsfund.org.uk/blog/2023/01/under-pressure-what-will-2023-hold-health-and-care-system [Accessed 3 Feb. 2023].

16. National Audit Office, 2013. *Emergency admissions to hospital: managing the demand*. [online] Available at: https://www.nao.org.uk/wp-content/uploads/2013/10/10288-001-Emergency-admissions.pdf [Accessed 15 Jan. 2024].

17. NHS Confederation, 2022. *System under pressure*. [online] Available at: https://www.nhsconfed.org/topic/capacity-performance/system-under-pressure [Accessed 3 Feb. 2023].

18. NHS Providers, 2021. *Bed occupancy levels highlight scale of pressure across the NHS*. [online] NHS Providers. Available at: https://nhsproviders.org/news-blogs/news/bed-occupancy-levels-highlight-scale-of-pressure-across-the-nhs [Accessed 3 Feb. 2023].

19. OECD, 2023. *Ready for the Next Crisis? Investing in Health System Resilience*. [online] Available at: https://www.oecd-ilibrary.org/social-issues-migration-health/ready-for-the-next-crisis-investing-in-health-system-resilience_1e53cf80-en [Accessed 15 Jan. 2024].

20. Rahimi, H., Kavosi, Z., Shojaei, P. and Kharazmi, E., 2017. Key performance indicators in hospital based on balanced scorecard model. p.8.

21. Rechel, B., Richardson, E. and McKee, M., 2018. *The organization and delivery of vaccination services in the European Union*. [online] The European Observatory on Health Systems and Policies. Available at: http://www.euro.who.int/__data/assets/pdf_file/0008/386684/vaccination-report-eng.pdf?ua=1 [Accessed 17 Sep. 2019].

22. Robertson, R., Wenzel, L., Thompson, J. and Charles, A., 2017. *Understanding NHS financial pressures: how are they affecting patient care?* London: The King's Fund.

23. Rubinson, L., Hick, J.L., Curtis, J.R., Branson, R.D., Burns, S., Christian, M.D., Devereaux, A.V., Dichter, J.R., Talmor, D., Erstad, B., Medina, J., Geiling, J.A., and Task Force for Mass Critical Care, 2008. Definitive care for the critically ill during a disaster: medical resources for surge capacity: from a Task Force for Mass Critical Care summit meeting, January 26-27, 2007, Chicago, IL. *Chest*, 133(5 Suppl), pp.32S-50S. 10.1378/chest.07-2691.

24. Scheltema, N.M., Gentile, A., Lucion, F., Nokes, D.J., Munywoki, P.K., Madhi, S.A., Groome, M.J., Cohen, C., Moyes, J. and Thorburn, K., 2017. Global respiratory syncytial virus-associated mortality in young children (RSV GOLD): a retrospective case series. *The Lancet Global Health*, 5(10), pp.e984–e991.

25. Schultz, C.H. and Stratton, S.J., 2007. Improving hospital surge capacity: a new concept for emergency credentialing of volunteers. *Annals of Emergency Medicine*, 49(5), pp.602–609. 10.1016/j.annemergmed.2006.10.003.

26. Siettos, C., Anastassopoulou, C., Tsiamis, C., Vrioni, G. and Tsakris, A., 2021. A bulletin from Greece: a health system under the pressure of the second COVID-19 wave. *Pathogens and Global Health*, 115(3), pp.133–134. 10.1080/20477724.2021.1881372.

27. The Health Foundation, 2020. Over 160,000 people now waiting longer than a year for routine hospital treatment. Available at: https://www.health.org.uk/news-and-comment/news/over-160000-people-now-waiting-longer-than-a-year-for-routi .

28. Thorlby, R., Gardner, T. and Turton, C., 2019. *NHS performance and waiting times*. [online] London, United Kingdom: The Health Foundation. Available at: https://www.health.org.uk/publications/long-reads/nhs-performance-and-waiting-times [Accessed 5 Oct. 2021].

29. Vissers, J. and Beech, R., 2005. *Health operations management: patient flow logistics in health care*. Routledge health management series. London ; New York: Routledge.

30. Walker, G., 2022. *Immense pressure on health services | Royal College of Nursing*. [online] The Royal College of Nursing. Available at: https://www.rcn.org.uk/news-and-events/Blogs/immense-pressure-on-health-services [Accessed 3 Feb. 2023].

7 Appendix

TABLE 1 QUERIES INFORMING PUBMED SEARCH

#	QUERY for PubMed Search	RESULTS
1	Search ((Pressure[Title]) OR utilization[Title] OR utilisation[Title] OR capacity[Title] OR constraint[Title] OR sustain*[Title])	322,167
2	Search Health*[Title/Abstract]	1,964,925
3	Search (Defin*[Title] OR Meas*[Title] OR Conc*[Title])	740,763
4	Search (#1 AND #2 AND #3)	1,223
5	Search ((Blood pressure[Title]) OR (pressure ulcer[Title]))	61,481
6	Search (#4 NOT #5)	771

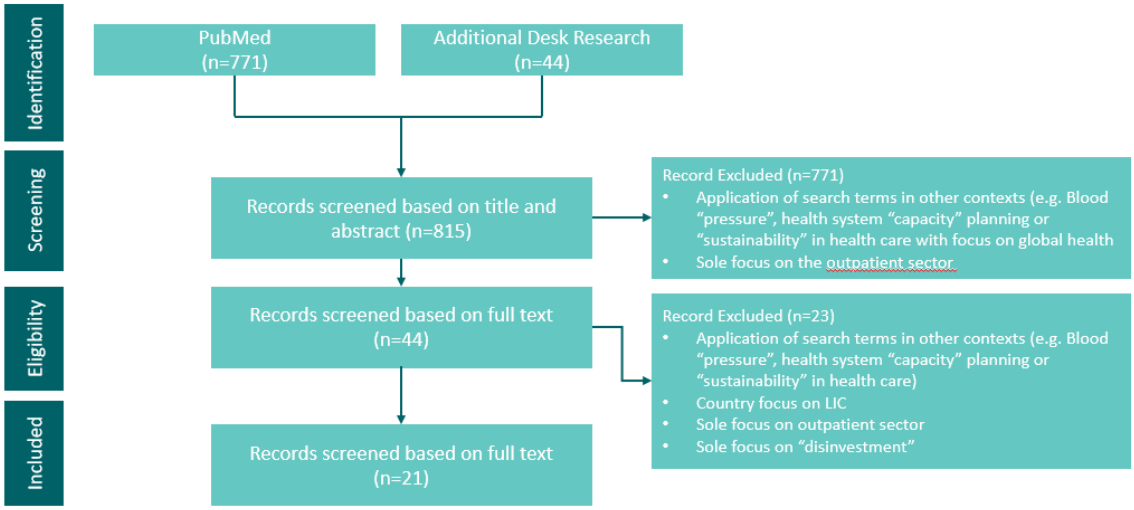


FIGURE 2 RECORDS SELECTION PROCESS

7.1 Interview Questions focussing on RSV (or C. *difficile*) infections

INTRODUCTION

1. Please state your job title and provide a short description of your position and hospital department.

2. How would you describe your position within the management structure of your hospital?

STEP 0: DEFINITION AND IMPACT OF HEALTH SYSTEM PRESSURE

1. How would you define (or describe) health system pressure?

    a. Would you expect that RSV (or C. *difficile*) contribute to such pressure? If so, please elaborate on the predictability, frequency and intensity of events causing such pressure, and if they are associated to winter seasonality.

4. How do you perceive health system pressure due to RSV (or C. *difficile*)?

    a. What is the impact on the financial, operational or quality of care performance of the hospital?

    b. Which resources (e.g. staff, stuff, or structure) are impacted by this pressure?

IN THE FOLLOWING PART OF THE INTERVIEW, WE WOULD LIKE TO DISCUSS THE RESPONSE OF HOSPITALS TO HEALTH SYSTEM PRESSURE. WE WILL START WITH PREVENTIVE STRATEGIES THAT ARE AVAILABLE BEFORE EPISODES OF HEALTH SYSTEM PRESSURE OCCUR, AND THEN TALK ABOUT MITIGATING STRATEGIES DURING EPISODES OF HEALTH SYSTEM PRESSURE. PLEASE ANSWER THE QUESTION WITH REFERENCE TO THE PRE-COVID-19 PRACTICES UNLESS PROMPTED OTHERWISE.

STEP 1: HOSPITAL STRATEGIES TO PREVENT HEALTH SYSTEM PRESSURE BEFORE THE RSV (OR C. DIFFICILE) WINTER SEASONALITY

5. Does your hospital undertake **any preventive actions** to prepare for health system pressure due to RSV (or C. *difficile*)?

    a. What is the nature of these actions (e.g., financial or operational/organisational)?

    b. When do these actions occur?

    c. Which resources (e.g. from the categories "staff, stuff, structure") are affected by these actions?

6. Have any of these preventative actions changed **during** the COVID-19 period? Will any of these strategies look different in a **post**-COVID-19 period?

STEP 2: HOSPITAL STRATEGIES TO MITIGATE HEALTH SYSTEM PRESSURE DURING THE RSV (OR C. *DIFFICILE*) WINTER SEASONALITY

7. What kinds of mitigation actions does your hospital undertake to cope during the winter respiratory season, beyond the usual activities?

    a. What is the nature of these actions (e.g., financial or operational/organisational)?

8. Which resources (e.g. from the categories "staff, stuff, structure") are affected by these strategies?

    a. Does the hospital temporarily over-utilise existing resources or temporarily expand the available resources?

    b. Do shared resources or innovative solutions (e.g., digital health) play any role in mitigating health system pressure (e.g., from other hospital departments, other hospitals or outside the hospital)?

9. Does the hospital temporarily ration services in case of a pressure event (e.g., treatment delay, referral to other hospitals/ departments, foregoing treatment)?

STEP 3: INFORMATION ON METRICS OF HEALTH SYSTEM PRESSURE AND THE ROLE OF PAYMENT SYSTEMS

10. Are any metrics (e.g., key performance indicators) available to capture the impact of health system pressure on the resources discussed in step 3? If yes, what are they?

    - What other performance indicators or metrics do you think should be used?

11. How would you measure the impact of this pressure on (health-related) outcomes?

12. How is your hospital reimbursed for episodes of RSV (or C. *difficile*) infections?

13. Does the existing reimbursement system in your hospital cover the (additional) costs associated to actions to prevent or mitigate health system pressure due to RSV (or C. *difficile*)?

    - Does your hospital receive any extra payments?

    - Who, in your opinion, absorbs the main costs of health system pressure?

CLOSING REMARKS

Do you want to make any additional comments related to this topic?

About us
With over 60 years of expertise, the Office of Health Economics (OHE) is the world's oldest independent health economics research organisation. Every day we work to improve health care through pioneering and innovative research, analysis, and education.

As a global thought leader and publisher in the economics of health, health care, and life sciences, we partner with Universities, Government, health systems and the pharmaceutical industry to research and respond to global health challenges.

As a government-recognised Independent Research Organisation and not-for-profit, our international reputation for the quality and independence of our research is at the forefront of all we do. OHE provides independent and pioneering resources, research and analyses in health economics, health policy and health statistics. Our work informs decision-making about health care and pharmaceutical issues at a global level.

All of our work is available for free online at www.ohe.org.

Areas of expertise

- Evaluation of health policy
- The economics of health care systems
- Health technology assessment (HTA) methodology and approaches
- HTA's impact on decision making, health care spending and the delivery of care
- Pricing and reimbursement for biologics and pharmaceuticals, including value-based pricing, risk sharing and biosimilars market competition
- The costs of treating, or failing to treat, specific diseases and conditions
- Drivers of, and incentives for, the uptake of pharmaceuticals and prescription medicines
- Competition and incentives for improving the quality and efficiency of health care
- Incentives, disincentives, regulation and the costs of R&D for pharmaceuticals and innovation in medicine
- Capturing preferences using patient-reported outcomes measures (PROMs) and time trade-off (TTO) methodology
- Roles of the private and charity sectors in health care and research
- Health and health care statistics

CONTRACT RESEARCH REPORT
FEBRUARY 2024

ohe.org

The Office of Health Economics A Company Limited by Guarantee of Registered No.09848965
OHE Consulting Ltd Registered Company No.09853113
OHE is a Charity Registration No.1170829
Registered Office 2nd Floor Goldings House, Hay's Galleria, 2 Hay's Lane, London, SE1 2HB