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Evidencing built health system reconfiguration policy

Grant Raymond Willton Mills[1] · **Antonio Rojas García**[2] · **Rosalind Raine**[3]

Received: 15 September 2022 / Accepted: 4 November 2022
Published online: 31 January 2023

Abstract

Background Current built health system reconfiguration evidence is insufficient to support policy decisions on the best settings for healthcare provision. As a result, the "built health system" (the buildings, physical environments, engineering infrastructure and the building standards, guidance and evidence that support them) remain misunderstood. We explore several literature review types that have supported built health system policy, and the methodological, interdisciplinary and theoretical challenges of conducting high-impacting systematised reviews. Then establish how they might provide a robust basis for prioritising the reconfiguration of significant capital investments.

Methods/design Five literature reviews undertaken to inform built health system reconfiguration policy are used as an empirical basis to help establish clearer scientific grounds for built health system infrastructure policy. The methods, benefits and empirical limitations of systematic, scoping, narrative, realistic and rapid reviews are compared.

Discussion The methodological, interdisciplinary and theoretical shortcomings of existing evidence on built health system reconfiguration need to be addressed. This paper conceptualises this evidence and offers a new evidence co-production framework.

Keywords Built environment · Evidence · Infrastructure · Reconfiguration · Systematic

1 Background

The infrastructure that supports built health systems require significant levels of finance. Decisions associated with the physical scale, scope and distribution of services across health systems is critical [1–3] and directly impacts a range of issues from quality, safety and workforce to patient flow, equipment location and access. However, the quality of built health system evidence is rarely seen as a key factor in improving outcomes [4], quality [5] or hospital performance [6, 7]. Over time, evidence to inform such decisions has been fragmented into different formats, sources and levels of access [8–15]. Therefore, standard ways are required to interpret the methodological and interdisciplinary variations when undertaking systematic literature reviews to support built health system infrastructure reconfiguration. This article presents a new built health system review framework that will help decision makers to assimilate evidence when (a) developing infrastructure capital budgets and designing input specifications (e.g. questioning how infrastructure will increase productivity, reduce harm, drive innovation or increase sustainable resilience), (b) agreeing infrastructure performance outputs (e.g. questioning how infrastructure will advance experience, build human capital, support prevention

✉ Grant Raymond Willton Mills, g.mills@ucl.ac.uk | [1]Bartlett School of Sustainable Construction, University College London, London, UK. [2]Mental Health Policy Research Unit, Division of Psychiatry, University College London, London, UK. [3]NIHR ARC North Thames, Department of Applied Health Research, University College London, London, UK.

or increase access) and (c) prioritising specific infrastructure health outcomes (e.g. questioning how infrastructure will promote health and create wellbeing).

Healthcare systems, and hence evidence of how they are built, must be kept up to date to meet current and future health challenges. This requires continuous discovery to identify efficiencies, service innovations and new ways to build resilience [14, 16–18]. However, disciplinary boundaries give rise to methodological, interdisciplinary and theoretical issues, necessitating an ongoing process of interpretation. There is interdisciplinary evidence from domains as diverse as economics, evidence-based medicine and design, and issues ranging from how patients access care along a pathway of interventions, to implementation of innovations in telecare, telehealth and eHealth [19], reconfiguration of urgent care services in community settings [20–22], and divestment from outdated assets. Unsurprisingly, with such a diverse evidence base, whole-systems reconfiguration evidence is seldom adequately integrated into capital investment planning and built health system policy.

In this article, we examine five literature review studies that have informed healthcare infrastructure reconfiguration policy. We investigate the application of scoping, systematic, rapid, realistic and narrative reviews to understand their impact, and compare their methods, benefits and limitations. The findings highlight the interdisciplinary nature of the evidence and suggest how such evidence may contribute to both theory [23, 24] and policy [25].

1.1 Need for built health system reconfiguration evidence

We must consider what is meant by evidence and how it is used to inform decisions on built health system infrastructure. A systematic review uses systematic, reproducible, transparent methods to identify, select, critically appraise and analyse data from all available research pertaining to a clearly formulated question [26]. Systematic reviews of healthcare systems typically focus narrowly on a specific place (e.g. school, environment, neighbourhood), setting, building type or characteristic [27–31], and on a range of health outcomes (e.g. health, obesity, harm or physical function) for a specific population group (e.g. students, obese patients, middle-aged to older adults). These studies into public health clearly identify what is known, the quality of that information, and what is not known. However, systematic reviews of built healthcare system reconfiguration are rare. In the building of hospitals for example practical guidelines and expert opinions are more prominent in influencing policy and practice. It is accepted that evidence varies in quality and credibility [32–34], ranging from expert opinions and best practices that perhaps lack scrutiny, to more measurable evidence in terms of its influence on outcomes. What constitutes evidence on infrastructure reconfiguration is much debated, and across all levels of decision making there may be manufactured recommendations, implicitly biased toward self-interest or commissioners' preferences.

In order to enhance the evidence associated with built health system reconfiguration policy, we address the methodological, interdisciplinary and theoretical challenges of systematic reviews of healthcare reconfiguration. This requires an interdisciplinary and integrative process [35] for agreeing actions based on diverse evidence bases, capabilities and methodologies. In addition to impact [36, 37] there is a need for co-production of evidence to support whole-system reconfiguration [14, 38–41] to mediate multiple competing interests [42, 43].

1.2 Use of built health system reconfiguration evidence to inform policymaking

To translate the literature into built health system reconfiguration policy there is a need to encourage the flow of knowledge to move away from a 'decide–announce–defend' approach to policy decisions [44, 45]. This requires collectively agreeing what constitutes 'good' evidence [46–48] and understanding its messy and complex nature [49]. This requires interpretation, because 'good science, even when it is well packaged and accessible, does not guarantee good policy' [50]. A literature review must respond to structural and capability changes [51] and co-evolve over a longer term [52]. In this process, researchers may act as intermediaries (e.g. preparing, briefing, presenting), translators (e.g. formatting, simplifying for the audience, contextualising), brokers (e.g. playing an active role in decision making, using the evidence, co-producing or advising on its use) or system-level facilitators (e.g. innovating, changing conceptual understandings, establishing further funding or new support networks).

In the context of built health system reconfiguration, the process of evidence creation and use is fragmented by the complexity of existing built healthcare systems and configurations. This requires a facilitated flow of knowledge across research and policy environments [53–55], and the rigorous analyses of goals, strategy and policy design and implementation [56] to respond to context [57–59].

Policy formulation on built health system reconfiguration may begin by asking 'how do we achieve the desired policy outcome?' However, the scope of this question is 'big', 'holistic' and integrative, involving many steps, interventions, conditions and interacting solutions [50] that allude to scientific methods and causal demonstration. Policymakers must establish evidence hierarchies and understand levels of caution in recommendations [32]. For example, Stetler [60] defines levels of evidence and Pati [61] do this in relation to healthcare built infrastructure design. To ameliorate overreliance on less trustworthy sources, a homogeneous built health system reconfiguration evidence base is needed [62]. Evidence provides decision makers with more 'deliberate' guidelines and forces the use of so-called 'best available' resources and methods [33]. This requires translation and effort, as non-scientific internal sources are often more readily available and accepted [63].

1.3 Methodological challenges in achieving a homogeneous evidence base

There are methodological problems in integrating built health system reconfiguration evidence for use by policymakers. Scholars are therefore central to facilitating co-production in the interplay between evidence and policy, to address methodological challenges by drawing comparisons across multi-level [27, 28] and multi-intervention [29, 64] healthcare settings. For example, in agreeing resource commitments to infrastructural investments in urgent and emergency care, policymakers will often need to consider evidence from multiple settings and interventions. These settings may be major trauma centres, emergency departments, GP-led urgent treatment centres, minor injury units or nurse-led walk-in centres. Local contexts vary significantly with differing demography and health needs. Furthermore, alternative interventions may be employed across these settings. For example, urgent and emergency care demand management may require less investment in infrastructure. Diversions using telephone services, paramedics, direct referrals or other out-of-hospital interventions (e.g. for the elderly or those with chronic conditions) will not need investment in secondary-care settings, but may require investments elsewhere. Alternatively, policymakers may choose to address ED triaging, fast-tracking or waiting times, or set targets for discharge, point-of-care testing, ICU capacity or bed management. Without homogeneous evidence on built health system reconfiguration, it is almost impossible for policymakers to understand whole-system infrastructure investment decisions and use the most appropriate local, regional or national evidence. This article examines how multi-level, multi-setting and multi-interventional built health system reconfiguration policy might best be supported. This requires us to synthesise the evidence and use various approaches to reviewing it [14, 32, 41, 65–68], and to design research [69], build frameworks and establish methods for systematic evidence reviews [70, 71].

1.4 Evidence review types and processes

In this section, we classify the various types of evidence-based literature review and identify ways in which evidence can be simplified for use. Then we propose a new framework using questions to support evidence-based policy. Given the heterogeneity of evidence on reconfiguration, it is critical to select a review design that facilitates integration of the various interdisciplinary sources, including quantitative, experimental and systematic approaches and more pragmatic reviews [69, 72, 73] and to learn about the merits and limitations of their use and capabilities required to deliver them [74].

Irrespective of its source, evidence must be deemed credible if it is to have any influence. However, expert opinions and views on the robustness of research designs are likely to differ, raising the need for interdisciplinary research [75] and theorisation [76]. In the field of evidence-based policy [65], Pawson [77] prioritises the process of evidence review and use during the design phase [62, 78, 79], and highlights a need for evidence that is context-specific, stakeholder-relevant and explicit about the evidence-use community [80]. Furthermore, the cost-effectiveness of impacts, such as return on investment, and incentives must be agreed [80].

Miller and Jones-Harris [81] link the suitability of study methodologies with the types of question being asked. They outline an alternative evidence framework based on eight categories of questions typical in clinical practice [82–84]. Simplifying evidence into pathways provides a useful means to integrate it with patient care and classify its strength. Such an approach may provide a conceptual basis for structuring the evidence on built health system reconfiguration, by revealing intrinsic links between the built environment of healthcare (physical building sites, buildings, departments and rooms) and health gains in the healthcare system or in the population more broadly.

1.4.1 Evidence-based literature review study design and policy impact

The research design of five evidence-based built health system literature reviews are now described. Each had various infrastructure reconfiguration impacts and Appendix 1 contains a fuller description of the outcomes of these studies. Figure 1 illustrates emergent interactions between policy, literature review evidence and built health system reconfiguration interventions and theory development.

In literature review Study A, an interdisciplinary and integrated approach was taken to the development of Department for Health policy, informed by the literature, and this effective empirical investigation drove a new clinical intervention relating to dementia. Critical to this review was an interactive and abductive approach to evidence and impact co-production. Literature review Study B indirectly informed hospital lending policy in an Investment Bank. The literature review commissioning process was relatively linear, with few clinical interventions specified and limited measurable impacts. Literature review Study C directly influenced a National department for healthcare facilities, and involved interdisciplinary

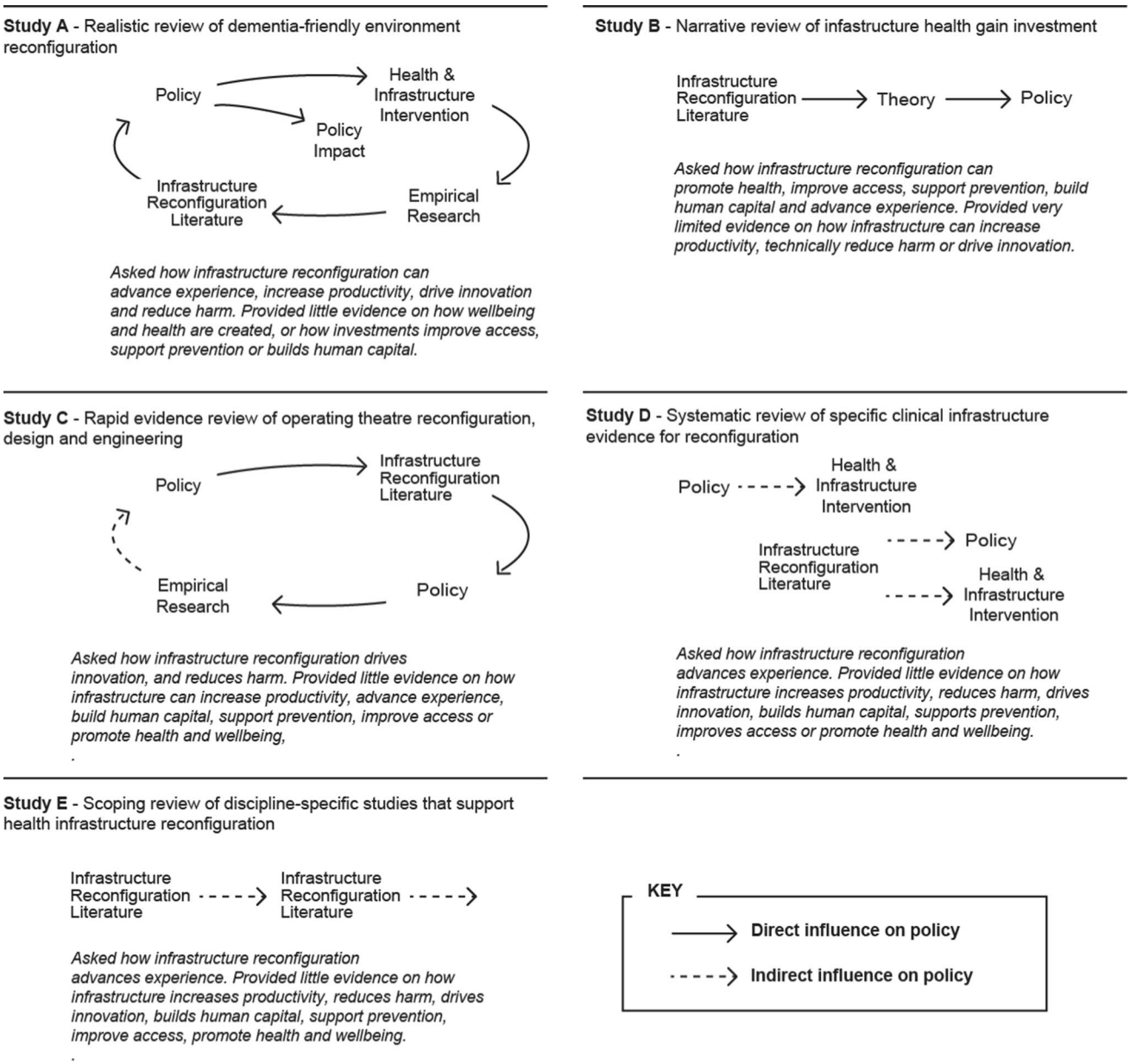

Fig. 1 Interface between policy, literature review evidence, health and infrastructure interventions and theory development

working and translation into policy and practice. Literature reviews D and E were performed for academic purposes and so indirectly impacted policy and deductively narrowed the literature sources based on specific methodological grounds.

Having described the literature review study design and its influence on impact, the next sections summarise the various literature reviews method types, which were dependent on the research questions and policy need [72]. Definitions of the systematic, scoping, rapid, realistic, narrative review types are contained in Appendix 2.

1.4.2 Study A: realistic review of dementia-friendly environment reconfiguration

This realistic review was focused on a specific intervention—dementia, using and creating evidence by combining literature and primary data collection. The review supported a £50 million 'Improving the environment of care for people with dementia' programme, which custom-designed care facilities in health and social care environments for people with dementia. A multi-method research methodology was adopted, using a rapid literature review as a basis for creating an evaluation tool, which was then used to analyse 115 nationally coordinated pilot projects [85]. The review considered the expert opinions of policymakers, architects, social scientists and dementia and clinical stakeholders, and led to the co-production of a new national standard [86] on dementia-friendly health and social care environments.

Many international sources were reviewed, including research articles, reports, and government and non-governmental codes of practice [15], with the intention of enabling consistent measurement of expected outcomes [87, 88]. The aim was to understand how design of the built environment might mitigate the escalating costs of dementia care. The results were enriched with primary data collected to understand built-environment interventions and their costs [15].

This realistic review revealed opportunities for interdisciplinary and integrated evidence-based built health system reconfiguration, and supported the development of costed policy support tools.

1.4.3 Study B: narrative review of infrastructural investment to support health gains

This narrative review provided evidence of the contribution of investments in built health systems to health gains, with particular reference to hospitals. The review team, which included a healthcare planner, an economist, an investor and social scientists, worked together to select literature and build a logic between the fields of evidence. The review was descriptive and user-friendly to enable funders to understand the evidence, and drew together various fragmentary evidence, including from economic infrastructure investment appraisals, evidence-based medicine and design.

A review of 25 systematic reviews, a PubMed keyword search (revealing 521 additional publications), a cited reference search (producing an additional 211 cited articles), and a subjective quality evaluation, resulting in the selection of 160 studies for full review.

Although evidence from the various sources was not directly comparable, and some sources were outdated, the results revealed a need to develop a more generic health-gain measure and a future-oriented view on capital investment scenarios. This narrative review highlighted the importance of establishing a theoretical framework that would provide a strong integrative basis for subsequent research.

1.4.4 Study C: rapid evidence review of reconfiguration of operating theatre design and engineering

This rapid review summarised and synthesised research evidence to support national repeatability in operating theatre engineering and design. A research team, which included a building services engineer, an architect, a procurement specialist and a social scientist, conducted a comprehensive and systematised review. They examined academic and grey literature on the design of operating theatre suites for both emergency and elective use, and how this related to patient outcomes since 2000.

The review followed Centre for Review Dissemination guidance as far as possible [73], relating to identification of the research question and search strategy, the selection of studies, quality assessment, extraction and synthesis, with expert journal searches of *BMJ* and *HERD*. The search resulted in the identification of 147 articles that appeared to be relevant based on their title and abstract. Following more detailed examination, 55 were discarded either because they focused entirely on medical and surgical practices, or because they were guidance notes for patients. Much of the literature related to surgical operating-room procedures written by medical staff, with very few on architectural or building design. Of the latter, the majority concerned environmental studies, including heating, ventilation and air conditioning (HVAC). Terminologies and care models differed significantly between countries.

Table 1 Nature of the interdisciplinary evidence on built health system infrastructure reconfiguration

Levels of place-based policymaking	Interdisciplinary nature of evidence
Healthcare system	Healthcare planning and management, epidemiology, ethics, sociology, nursing, medicine (emergency and gastroenterology), infection, property construction and operations, design/engineering, thermal sciences
Building/hospital	Patient safety and quality, design, planning and services management, engineering, psychology, infectious diseases, sustainability, professional development, construction and facilities management and various specialties (e.g. hearing, arthritis, midwifery, oncology, children, aging, chest, arthroplasty, surgery, critical care and radiology)
Department/unit	Health planning and management, design, building systems engineering, nursing, various care settings (e.g., emergency, critical care, mental health, anaesthesiology, microbiome, perinatology, neonatal, gerontology, arthroplasty, complementary therapies, obstetrics and gynaecology, disaster medicine, dementia and alzheimer's, cardiology and midwifery)
Room	Infection control, hospital epidemiology, complementary therapies, intensive and critical care, occupational hygiene, surgery, nursing, design, ergonomics, mental health, social science, medical research, quality and safety management

This rapid review revealed a complex array of product engineering solutions providing potential evidence for infrastructure reconfiguration, and highlighted the need for generalisation across the reconfiguration evidence to enable policymakers to make sense of the complex fields.

1.4.5 Study D: systematic review of specific clinical built health system evidence for reconfiguration

This systematic review was conducted to explore the impact of built health systems infrastructure investment on costs, patients' health and staff experiences, to inform regional responses to national policy changes. It was limited to reconfigurations of services relating to A&E, mental health, cancer and stroke, which were receiving significant capital investment. A specific search strategy was developed to collect data from seven databases for the period 2011–2019. Quantitative and qualitative evidence was synthesised and organised to identify clusters of literature.

The evidence compiled from this systematic review provided indicative evidence, although the search strategy looked for direct causalities. Rationalising quantitative and observational studies based on their methodological quality [89–91] simplified the review process, but perhaps removed nuances and more generalisable findings. The exclusion of pre-2011 studies contributed to the fragmented and heterogeneous nature of the evidence. This systematic review also revealed fragmentation of the built health system infrastructure reconfiguration evidence across various clinical fields and interventions.

1.4.6 Study E: scoping review of discipline-specific studies supporting built health system infrastructure reconfiguration

This scoping review was organised to understand the need for interdisciplinary evidence in policymaking when prioritising annual capital funding for new-build schemes and hospital upgrades. The evidence was categorised into four place-specific levels: whole-system, building, department and room. Abstracts from 543 studies were reviewed, including economic and quantitative analyses, formal evaluations, qualitative studies and simulations. At the whole healthcare system reconfiguration level, 54 studies involved economic, qualitative and NHS service reviews. Reconfiguration at the scale of hospital buildings was supported by 235 disciplinary studies, including economic, post-occupancy, qualitative and simulation evidence from a wide range of fields. At the hospital department scale, 110 studies involved economic, post-occupancy, qualitative, service review and simulation research. At the room scale, 106 studies drew qualitative, quantitative, simulation and review evidence from diverse domains, including ergonomics and social sciences. Table 1 details the disciplinary domains.

This scoping review revealed the interdisciplinary and heterogeneous nature of the reconfiguration evidence, and the complex array of settings and places that must be taken into account when providing evidence to support policy on built health system infrastructure reconfiguration design. It showed the influence of diverse scientific disciplines and

their fragmentation across settings, and the criticality of establishing a common framework for evidence-based policy decision making in relation to built health system infrastructure reconfiguration.

2 Discussion

The evidence base for built health system infrastructure reconfiguration policy must be developed to deliver policy impacts. However, first we must address evidence co-production and its methodological, interdisciplinary and theoretical challenges.

2.1 Conceptualising a new theoretical foundation for built health system infrastructure reconfiguration

There is a need for a more homogeneous basis for evidence-based policy on built health system infrastructure reconfiguration. Figure 2 shows components of the healthcare reconfiguration evidence that emerged from the five literature reviews. It sets out high-level policy questions to be addressed (relating to wellbeing and health outcomes), potential performance output strategies (relating to public health, access or human capital) and infrastructural capital, design and engineering inputs. The problem of attributing causality to particular evidence in order to inform policy is well-known [92], as is the very basis of causality [93], however studies A to E contributed to our understanding of how the built health system can reduce harm, drive innovation, use its physical infrastructure assets efficiently and productively, and improve patients' experience. Ultimately, the purpose of built health system infrastructure is to enhance wellbeing and promote health, so its roles in building human capital, supporting prevention and improving access must be prioritised.

This evidence-based framework allows evidence to be 'un-packed' and 're-packed' during policy formation [94]. We need a homogeneous basis for built health system infrastructure reconfiguration evidence [76, 95] and we must design critical research, which moves beyond a fragmented intervention-led approach [23, 64, 76, 96], and provides a means to generalise, weigh and integrate evidence to support built health system infrastructure reconfiguration. This framework will focus interdisciplinary attention on the evidence, and challenge gaps between those who generate scientific evidence and the practitioners who must use it [81]. Questions can be used to evaluate the status of evidence on interdisciplinary built health system infrastructure reconfiguration (see Appendix 3). Taking each question in turn, evidence of harm is most prevalent and shows a direct causality on outcomes, although it is fragmented across disciplines, specialties and specific building and room types. Place-based evidence on built health system infrastructure for prevention (e.g. health-screening centres, diagnostic clinics and institutes of exercise medicine), equitable access (e.g. number of in-patient beds per 10,000 population or MRIs per million persons) and capability distribution (e.g. staffing of nurse-led walk-in centres versus polyclinics or GP-led emergency department triage) is perhaps more limited and requires associative (rather than causal) interpretation. Evidence on performance, productivity and experience is of moderate quality and is highly dependent on the context and purpose of individual studies. This shows the importance of classifying built health system infrastructure reconfiguration evidence more rigorously, asking questions about the evidence required and its quality.

2.2 Selection of review type and impact

Literature review studies A and C were part of a social process of learning that built sense between researchers, policymakers and wider stakeholders (e.g. to create a 'web of influence'[97]). But perhaps could not claim to have been entirely independent or neutral [52, 98, 99], unlike systematic and scoping reviews (Literature reviews Studies D and E). Each review had different impacts, as shown in Table 2. Study A created an evolving process of learning, and built sense through a process of review that drew together actors across organisational levels and stakeholders. In contrast, in Study B there was a separation between the evidence and its use in influencing lending for hospitals. Study C involved an interdisciplinary research team operating as broker for a policymaker who translated and co-curated the evidence. This resulted in an ongoing process of interdisciplinary learning, and the researchers and policymakers subsequently developed, won and delivered a funded research proposal and extended the network of impacts. In contrast, Study D and E were independent reviews.

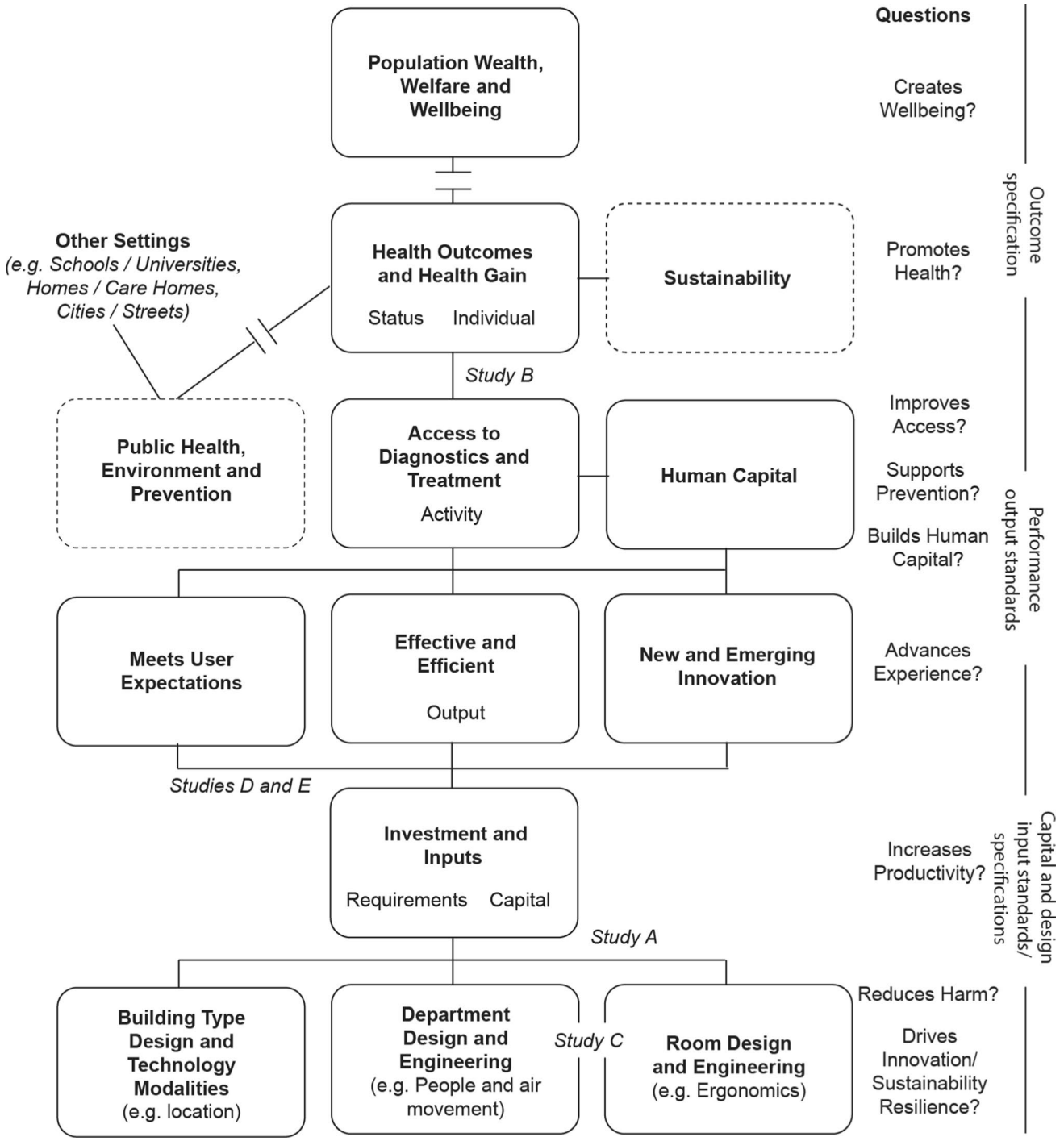

Fig. 2 Proposed evidence co-production framework for homogeneous built health system infrastructure reconfiguration

Further comparing these five studies reveals that each has specific benefits (Table 3). But that these are dependent on the context, purpose and involvement of the various research, expert and stakeholder teams [74]. The scoping literature review identified the size and nature of the evidence base but, perhaps because of the systematic approach to data extraction, quality and synthesis methods, may have excluded intuitively relevant literature. Rapid, realistic and narrative literature review designs achieved a spread of built health system infrastructure reconfiguration evidence and

Table 2 Comparison of studies' impacts on built health system infrastructure reconfiguration policy

Review Studies	Policy Impacts
Study A: Realistic review of dementia-friendly environment reconfiguration	Framed debates and got issues on to the political agenda (e.g. affecting key stakeholders' awareness, attitudes or perceptions) Discursive policy actor commitments (e.g. affecting language, recognition and endorsement) Changed procurement and service improvement delivery Collective behavioural change/indistinct contributions Increased knowledge of an issue Increased number/alignment of partners in support of an issue Strategic alliances with important partners and stakeholder coalitions
Study B: Narrative review of infrastructural investment to support health gains	Affected policy content Increased knowledge of an issue
Study C: Rapid evidence review of reconfiguration of operating theatre design and engineering	Expert interdisciplinary moderation clarifying policy options Influence on national programme of repeatable theatre design and national guidelines Directly attributable impacts (because without the research there would have been no demonstrable impacts) Substantive advice (e.g. policymakers using a body of evidence to inform action) Increased knowledge of an issue Increased number/alignment of partners in support of an issue
Study D: Systematic review of specific clinical built health system evidence for reconfiguration	Increased knowledge of an issue
Study E: Scoping review of discipline-specific studies supporting built health system infrastructure reconfiguration	Clarified concepts and aided understanding of complex challenges Increased knowledge of an issue

effectively utilised strategies such as expert opinions, expert tools and news analysis methods, although these may be viewed as less credible than other types of review.

Decision makers' need for rapid and efficient synthesis of the evidence (e.g. co-produced, useful and accessible) must be balanced against the time and resources required for rigorous systematic reviews [100]. Therefore, it is critical to use such reviews appropriately.

2.3 Multi-stakeholder co-production of evidence-based policy

According to Baldwin et al. [101] the best policy outcome will involve multiple institutions and instruments. One such instrument is the evidence provided by systematic literature review. This is 'smart regulation' [13] for built health system infrastructure reconfiguration. We have shown that a reflexive and adaptive approach will see evidence, and action (decision making and interventions) proceed simultaneously [102] to create adaptive evidence and policy [102]. There are important lessons on how evidence and intervention co-emerge in the social practice of health system infrastructure reconfiguration, and how evidence-making and intervention proceed through dialogue, incorporating multiple forms of evidence and expertise, and resulting in more mutually beneficial evidence creation, capture and use. We reflect on the ways to bring academics who perform systematic literature review together with those who deliver healthcare output performance (health systems regulators and providers), those who can best judge outcomes (patients and public health professionals) and those who develop design standards and specifications (usually consultants and private infrastructure providers) -see Fig. 2 (right label).

2.4 Methodological, interdisciplinary and theoretical implications of selecting a systematic review

Co-producers must understand the methodological issues when designing the comprehensiveness of a literature review. We shed light on the nature of review methods and their use to inform evidence-based policy in built health system

Table 3 Comparison of review type and weighting of built health system infrastructure reconfiguration evidence

Review Type	Study	Benefits/drawbacks	Weight of infrastructure reconfiguration evidence
Realistic	Study A: Realistic review of dementia-friendly environment reconfiguration	Combined literature and primary data collection to produce evidence of impact of infrastructure intervention Directly applicable and usable outcomes (e.g. evaluation tool) Complex integration of evidence sources	Identified silver and bronze studies answering questions about harm, experience, performance and productivity
Narrative	Study B: Narrative review of infrastructural health-gain investment	Intuitive integration of various fragmented evidence types to inform discussion Complex integration of evidence sources	Identified silver and bronze studies answering questions about harm, prevention, equitable access, capability, experience, performance and productivity
Rapid	Study C: Rapid evidence review of operating theatre reconfiguration and design	Clinical/procedural focus, with few academic articles referring specifically to infrastructure Provided clear and highly useful recommendations that informed policy	Identified silver and bronze studies answering questions about harm, capability, experience, performance and productivity
Systematic	Study D: Systematic review of reconfiguration relating to A&E, mental health, cancer and stroke	Effective/specific search strategy and clear inclusion/exclusion criteria Created fragmentation and limited indirect or intuitive associations. Few generalisable findings	Identified silver and bronze studies answering questions about experience, performance and productivity
Scoping	Study E: Scoping review of discipline-specific studies that support reconfiguration	Broad/general, with no clear synthesis Showed the interdisciplinary/non-heterogeneous nature of reconfiguration evidence	Identified silver and bronze studies answering questions about harm, experience, performance and productivity

infrastructure reconfiguration. Co-production of evidence is critical; however, key methodological, interdisciplinary and theoretical decisions must be taken when co-producing a review. Choices of the nature of the evidence and review type (e.g. heterogeneous versus homogeneous), between the substantive setting and the evidence nature (e.g. interpretation versus specificity), and between review type and substantive setting (e.g. exploration versus impact) must be carefully considered. Scholarship plays a key role in the co-production of evidence synthesis as a knowledge broker across different disciplinary perspectives.

Various scientific enquiry and review types will be required to focus policymakers on directed, closed review questions that test specific variables derived from clear hypotheses, in addition to more interpretative and open-ended reviews to simplify complex literature for use by policymakers [103–105]. Together, review co-producers must 'carve out', and address 'tensions' and manage the dynamic 'flux' in a vast and scattered literature [106] to enable it to be directly applied and 'adjusted' to practice and policy [105].

3 Conclusions

There is a need to build a homogeneous evidence base for built health system infrastructure reconfiguration. An enduring problem is the many fields, numerous types of evidence and different disciplinary ways of looking at the evidence. We provide a generalised theoretical starting point for future literature reviews. We pose specific questions that will make evidence useful for policymakers and those seeking to deliver infrastructure reconfiguration. Such as how can reconfiguration improve health promotion, access, prevention, human capital development, patient experience, productivity and reduce harms?

Due to the rapid-shifting and complex nature of built health system infrastructure reconfiguration, a range of review types and interdisciplinary interpretative understanding is needed. We have shown how we might bring together evidence from across healthcare settings (such as acute hospitals versus community hospitals, walk-in centres versus expanded A&E departments) and incorporating multiple interventions and institutional perspectives to make policy decision.

Given recent policy and major investments in the reconfiguration of built health system infrastructure, the need for an evidence base is clear. In this article, we have weighed evidence types and methods, and have asked what review approaches should be used to inform healthcare infrastructure reconfiguration policy. The impact of this evidence will be the assurance that healthcare infrastructure investment will improve health outcomes.

Acknowledgements This work is independent research supported by the National Institute for Health Research ARC North Thames and UCL Bartlett School of Sustainable Construction. The views expressed in this publication are those of the authors and are not necessarily those of the National Institute for Health Research or the Department of Health and Social Care.

Author contributions GM, AG, RR conceived the design, GM provided the literature acquisition for study B & C. AG provided the literature acquisition for study D & E. GM, AG and RR provided the analysis and interpretation. GM provided the first draft of the manuscript, with comments from AG and RR. GM, AG, RR agreed and approved the version to be published. All authors read and approved the final manuscript.

Data availability Literature review studies B, C, D and E are available from the corresponding author on reasonable request. Study A was the review of an existing literature review, which is openly available at locations cited in the reference section.

Declarations

Competing interests The authors declare no competing interests.

Appendix

1: Systematic literature review outcomes

Literature Review Study A: Realistic review of dementia-friendly environment reconfiguration	This review shows how the built environment impacts the quality of life of those living with dementia [15]. Specifically, lighting on sleep patterns and falls, of noise on patient outcomes, and of multi-sensory environments on wellbeing (activeness, agitation, mood and behaviour). Pantzartzis et al. [15] describes the impact of way-finding, interior design and furniture on falls, medication use, behaviour, social engagement and eating, and of sensory gardens on wellbeing, satisfaction and post-stroke restoration. This review highlights the importance of quantitative tools (combining clinical, environmental and behavioural aspects), and their combination with cost monitoring
Literature Review Study B: Narrative review of infrastructural investment to support health gains	This review develops an evidence classification that shows the mediation between infrastructure investment and health outcomes or gains. The findings lead to the development of five categories: (1) asset scale, scope and distribution (38 studies showing optimal hospital size, hospital/surgeon volume and geographical access); (2) decentralised care model/outside hospital (26 sources showing impacts on chronic disease, maternity and the elderly, and the use of polyclinics, walk-in-centres and different hospital types); (3) care flow pathway (18 studies providing evidence on lean patient flow, emergency and urgent care attendance and flow); (4) therapeutic design (78 studies on evidence-based design, single rooms and acuity adaptability); and (5) flexibility and adaptability (four studies)
Literature Review Study C: Rapid evidence review of reconfiguration of operating theatre design and engineering	This study provides evidence on approaches to care (e.g. bariatrics, day surgery, working practices and future trends), health and safety (e.g. surgical site infections, infection control and manual handling), design and spatial requirements (e.g. room adjacencies, layout and area, ceilings, height, structure and finishes, walls, doors, windows and floors), equipment (fixed and mobile), and environmental services (e.g. acoustics, HVAC, laminar flow and general room lighting). Much of the literature relates to surgical operating-room procedures written by medical staff, with very few on architectural or building design. Of the latter, the majority concern environmental studies, including HVAC. Terminologies and care models differ significantly between countries
Literature Review Study D: Systematic review of specific clinical built health system evidence for reconfiguration	Quantitative and qualitative evidence are synthesised and organised to identify clusters of literature around, for example, A&E waiting room impacts on waiting times, quality of care, anxiety and space utilisation (4 studies), the design of private mental health rooms to reduce aggressive behaviours and stress (3 studies), and the impact of outdoor gardens on cancer patients' and staff satisfaction, quality of care and privacy (8 studies). The last decade had seen no economic studies of reconfigurations of services relating to A&E, mental health, cancer or stroke

Literature Review Study E: Scoping review of discipline-specific studies supporting built health system infrastructure reconfiguration	This reveals multi-level evidence in the literature to support system reorganisation, including building type, quality and backlog maintenance [14], green hospitals buildings (2 studies), urgent and emergency care (e.g. qualitative, quantitative, economic and simulation), outcomes (costs, experience, etc.), geographies, health settings (e.g. hospitals, general practitioners, mental health services), patient groups (e.g. elderly) and various case management, education, triaging, paramedic and diversion interventions (3 studies). 60 studies focus on single bedrooms. The evidence points to issues associated with isolation, infection and multi-drug resistance, patient- and family group-specific satisfaction, sound (e.g. conversations), wellbeing and design, handedness, technology implementation, medical errors, falls, early discharge, en-suite facilities, nursing protocols and capacity reduction. Multi-use, acuity-adaptable rooms or universal rooms are seen as justified on the grounds of reduced medical errors on transfer

2: Systematic literature review study types

The following provide the definitions of the systematic, scoping, rapid, realistic, narrative review types that were selected based on the research questions and policy need of each literature review study. These definition are commonly understood, but adapted here from Grant et al. [72]

- *Systematic review*: Adheres to guidelines to systematically search for, appraise and synthesis literature. Exhaustively and comprehensively evaluates and summarizes the findings of all relevant individual studies. Quality assessment determines inclusion/exclusion criteria. If appropriate, combines the results of several studies to provide more reliable results.
- *Scoping review*: Preliminary assessment of potential size and scope. Identifies the nature of the evidence base for a particular topic area as extensively as possible, but typically without a synthesis (e.g. research in progress and no formal quality assessment).
- *Rapid evidence assessment*: Time-limited Assessment of what is already known about a policy or practice issue. Summarizes and synthesizes research and provides a narrative of the findings within the constraints of time and resources. The review must be as comprehensive as possible within the given constraints, and undertaken systematically.
- *Realistic or Systematised review*: Attempts to include elements of systematic review, while stopping short of a full and systematic review. It might be an Intervention-based description of mechanisms and how they work (or not) under specific conditions. Requires a clear scope and clear aim to effectively synthesize the evidence and provide explanations.
- *Narrative review*: Examines recent and current literature and can cover a wide range of subjects at various levels of completeness and comprehensiveness. Known as an unsystematic review, this is selective, descriptive and user-friendly in synthesizing and appraising the evidence. The narrative is often unreproducible.

3: Levels of evidence quality

	Evidence-levels		
	Gold evidence[1] (e.g. meta-analysis, cross-sectional)	Silver evidence[2] (e.g. systematic review of cohort studies)	Bronze evidence[3] (e.g. expert opinions, case studies)
What is the best evidence for infrastructure to assure against harm?	Limited: there are likely to be system-wide responses to pandemics and other international responses such as climate change	Limited: there is infection prevention across clinical specialties and building/space types. Studies of specific room types, e.g., single rooms	Many: national standards (although often out-dated) and expert institutions. Opportunities for more case control studies

	Evidence-levels		
	Gold evidence[1] (e.g. meta-analysis, cross-sectional)	Silver evidence[2] (e.g. systematic review of cohort studies)	Bronze evidence[3] (e.g. expert opinions, case studies)
What is the best evidence on the impact of preventative infrastructure?	None: primary health and diagnostic/screening studies are available for specific care pathways, but the influence of infrastructure reconfiguration/location has not been studied	None: there are systematic reviews of specific country approaches to primary health and diagnostic/screening. Significant opportunities around disruptive technologies and new modalities for specific disease groups	Limited: expert opinions often by service providers and manufacturers potentially with vested interests. National policies and standards
What is the best evidence on access to diagnostics and treatment infrastructure for the most prevalent conditions?	None: high-quality evidence is not yet widely available in relation to specific infrastructure assets. Specific building types, such as treatment centres, have been evaluated	None: significant opportunities to apply prevalence data to infrastructure reconfiguration, which must be analyzed against complex building/room types. Single service facilities have been evaluated, such as remote diagnostic clinics and specific treatment centres	Many: nationally required for business cases, needs assessment, patient and stakeholder involvement during infrastructure reconfiguration. Expert opinion is often driven by a desire to win funding or to support political objectives
What is the evidence that infrastructure will be supported by human capital?[4]	None: high-quality evidence is not yet widely available in relation to specific asset types, although perhaps exists in relation to specific technologies and care pathways	Limited: studies focus on specific roles or disciplines (e.g., community health nurses). Significant opportunities exist to apply capabilities data to infrastructure reconfiguration, e.g. in relation to surgeon volumes and clinical college CPD guidelines	Many: nationally required during infrastructure reconfiguration, although expert opinion is often driven by a desire to win funding or to support political objectives
What is the evidence that infrastructure is effective and efficient?	Limited: applications of data envelopment analysis to provide cross-country comparisons	Many: applications of data envelopment analysis, before-and-after studies, lean studies involving infrastructure interventions	Many: although contained within individual organizational archives, infrequently shared. Data often collected by outsourced service providers
What evidence is there on how infrastructure is experienced, or to what extent it meets user expectations?	None: studies of experience are often limited to a specific care setting or building type. High-quality evidence is not yet widely available	Many: these are applied using various single and mixed-methods approaches across various case study settings	Many: although contained within individual organizational archives, infrequently shared to establish best practice. Data often collected by outsourced service providers and perhaps sensitive
What evidence is there of other emerging theories on infrastructure?	None: studies are often systematic in nature and constrained by existing data sets or known metrics	Many: studies are often limited by sample size and associated with specific settings and case studies	Many: although use of this data is constrained by methodological inconsistencies and quality

[1] e.g., systematic review of randomized control trial ± meta-analysis, cross-sectional prevalence studies, systematic cross-sectional workforce analysis, systematic review of longitudinal social science studies, ethnographic studies.

[2] e.g., systematic review of cohort studies, randomized control trials, diagnostic studies, ergonomics studies, quasi-experimental studies, natural experiments, patient records, capability mapping studies, technology through-put studies, economic studies, building productivity, independent experiment and simulation studies, independent building performance, evidence-based design studies, descriptive qualitative studies, single non-causal quantitative studies, qualitative, phenomenological and ethnographical studies.

[3] e.g., cohort studies, case control studies, scientific case studies, expert opinions, industry case studies, needs assessments, business case development, expert tools (e.g. SHAPE and Dr Foster), volume, capacity, demand and referral analysis, standards and guidance, backlog maintenance, technology capability assessments, operations and training plans, lean studies, staff occupancy and room utilization, staff satisfaction studies, published post-occupancy evaluations, mock-up studies.

[4] e.g., nurse numbers, technology-dependent expertise and surgeon volumes.

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