

Building back smarter



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Foreword

Although often categorised under ‘modern methods of construction’, volumetric modular buildings have been used for the best part of a century and encompass a wide range of functions. However, modular facilities have really shown their value in recent years, particularly in healthcare. Indeed, the industry has worked non-stop throughout the COVID-19 pandemic; when the NHS needed testing stations, extra facilities and additional wards, many trusts turned to volumetric modular solutions.

It is clear that COVID-19 is not going anywhere, and with mounting pressure to address care backlogs, the need for space in this sector will continue to grow. Meanwhile, plans are being developed for new types of healthcare facilities, including community diagnostic centres and surgical hubs. Modular buildings can provide these spaces at phenomenal speeds that are simply not possible with ‘traditional’ building methods. Although the modular facilities of 30 years ago often had a rustic feel, the high levels of manufacturing quality in today’s modular construction methods means that modular can outperform traditional in terms of fire safety, air-tightness and carbon emissions.

This series of articles takes an in-depth look at how modular facilities are used in healthcare, and their potential to improve efficiency and sustainability in the NHS. For this to be successful, it is vital that the views of those who will actually use these facilities are actively sought. The input of staff and patients is not always valued in healthcare policy—when creating new spaces, we must take the opportunity to change this.

Jackie Maginnis, CEO of the Modular & Portable Building Association (MPBA)

The MPBA is a non-profit trade association that brings together members of the modular industry to enhance building quality, drive innovation and support the development of effective design standards.

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The case for more modular facilities in the NHS

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Abstract

The NHS is facing an unprecedented backlog in both patient care and building maintenance, with severe implications for service delivery, finance and population wellbeing. This article is the first in a series discussing modular healthcare facilities as a potential solution to these issues, providing flexible and cost-effective spaces to allow services to increase capacity without sacrificing care quality. The first of three instalments, this paper will outline the problems facing the NHS estate, many of which have been exacerbated to critical levels by the COVID-19 pandemic, and what this means for service delivery. It will then make the case for modular infrastructure, outlining the potential benefits for healthcare services, staff and patients alike. Using modern methods of construction, this approach to creating physical space in healthcare can provide greater flexibility and a reduced impact on the environment. The next two articles in this series will go on to provide detailed case studies of successful modular implementation in NHS trusts, an analysis of the cost implications and guidance on the commissioning process and building a business case.

Key words: Backlog; Estates; Maintenance; Modular infrastructure

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Introduction

Capacity is becoming an increasingly pressing problem for healthcare services. The Nuffield Trust has estimated that the equivalent of 22 new hospitals with 800 beds each will be needed by 2027 as a result of the increasing population and the rising number of older people (Naylor, 2017). The ageing population has a number of implications; not only are older people more likely to live with multiple long-term conditions, evidence has also shown that hospital bed occupancy increases at the end of life, with up to 55% of lifetime bed occupancy occurring in the last year of life. As a result, it is possible that hospitals will be facing similar bed demand to that experienced during the COVID-19 pandemic by 2028 (Jones, 2021).

This need for capacity comes at a time when hospital services are already under immense strain. In April 2021, the NHS broke its record for the highest number of people waiting for care, with figures reaching over 5 million—since then, that figure has continued to rise, with 5.4 million people waiting for routine procedures and operations by June 2021 (Lane Clark and Peacock, 2021). Of these, 385 000 have been waiting over 1 year for surgery, compared to just 1600 before the COVID-19 pandemic (Gillett, 2021). There have also been concerning reports of patients who are classed as priority two (needing treatment within 1 month) waiting several months for acute care, with some waiting for over 1 year (Illman, 2021). Yet long waiting lists are not a new problem for the NHS. Even before the pandemic, patients who required common procedures, such as cataract surgeries, were waiting as long as 7 months. As well as being distressing for the individual, this delay in surgery can lead to an increased risks of falls, fractures and other adverse events, which can result in even more demand on healthcare services (Peak, 2021).

With the COVID-19 pandemic exacerbating the backlog to a critical level, innovative solutions to increase capacity in NHS hospitals have never been more sorely needed. This is not only about improving practice and increasing staffing levels, but also optimising the physical space available to the NHS. Currently, the UK arguably lacks a long-term, ‘future proof’ health infrastructure plan (Anandaciva, 2019), while unused space across NHS

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estates is estimated to be as high as 1.5 million square feet. With patient and maintenance backlogs mounting, a new approach to creating and configuring space in the healthcare sector is needed.

This article will discuss the issues facing UK healthcare infrastructure and outline the case for modular healthcare facilities, based on modern methods of construction and a flexible approach to space, as a possible solution. The potential benefits of modular facilities will be explored and areas for further research highlighted.

The NHS estate

Integrated care has the potential to increase efficiency and patient-centredness by facilitating greater cohesion between services and more local provision of diagnostics and treatment, allowing patients to access care closer to home. To achieve this model of care, better integration is needed between primary, secondary, tertiary and social care services. However, this has major implications for the UK's healthcare infrastructure.

Many NHS buildings are several decades old, with around 18% having existed longer than the NHS itself and some dating to the Victorian period (Naylor, 2017). Although this is not always an issue if a building has been renovated, it can pose significant problems if sites become run-down. For example, an assessment of Epsom and St Helier hospital found that 40% of its infrastructure was not fit for purpose (Anandaciva, 2019). Older buildings can also lead to technological difficulties, with poor WiFi connection and lack of suitable hardware for remote consultations in many primary care centres becoming particularly problematic during the early stages of the pandemic (Baird and Maguire, 2021). These issues have led to a large maintenance backlog, with refurbishments of older sites requiring a spend of approximately £5 billion across the NHS (Naylor, 2017). Even with well-maintained sites, older buildings mean that the facilities have not been designed for modern patient flow or current clinical practice, the latter of which is constantly evolving.

All of this can have significant consequences for patients, as unsuitable buildings and unreliable equipment can decrease productivity and cause delays in care, or even lead to patient safety issues. For example, there have been reports of mental health trusts having to hire extra staff to watch acute psychiatric patients because they are unable to remove potential ligature points from their buildings (Anandaciva, 2021a).

As well as these potentially dangerous effects, unsuitable infrastructure can act as a barrier to the innovation needed to increase capacity and facilitate integrated care. For example, while technological developments have allowed services such as radiotherapy to be relocated closer to patients' homes, this has also meant that local and district hospitals have had to find space for these services (Gandy, 2020). This can lead to arrangements that are suboptimal for patients and staff alike—one London hospital visited by the author used a lower ground floor room with no windows for their infusions clinic, where patients would often stay for hours on a regular basis without natural light or fresh air.

What are modular healthcare facilities?

Modular health facilities are constructed from individual modules that are built largely off site, then installed on to a site to create a single structure, or series of structures (Figures 1 and 2). They can be used as stand-alone facilities on a particular hospital site, attached to an existing hospital building or used in conjunction with a mobile facility (a mixed-modality approach). With appropriate maintenance, both modular and mobile facilities can last up to 60 years. However, there are several key differences between mobile and modular facilities, as shown in Table 1. Crucially, modular facilities can be designed specifically for the particular healthcare function they are required for.

Modular building methods have been used in social housing and education for several decades, including in structures such as the famous Burj Al Arab Tower in Dubai, as a faster and more cost-effective way of creating space (Geiger, 2017; Kyro et al, 2019; Flyvbjerg, 2021). In a healthcare context, they have typically been used to increase capacity in times of high demand or to provide space to continue services while an existing building is being renovated or refurbished. The healthcare field is well-suited to modular design, as facilities



Figure 1. A modular surgical unit at Queen Mary's Hospital, Roehampton.

Table 1. Key differences between modular/mixed modality and mobile healthcare facilities

Mobile	Modular/mixed modality
<ul style="list-style-type: none"> ■ A ready-made facility that is clinically compliant and contains the appropriate fixtures and fittings for its specific use ■ Available for short-term requirements with flexible leasing contracts, providing a very fast solution to a temporary issue, such as emergency maintenance (flooding, gas leakage etc), refurbishment or a sudden demand increase ■ Able to rapidly move between locations to meet demand variations ■ Delivered fully equipped, with regular quality checks, equipment maintenance and updates when required 	<ul style="list-style-type: none"> ■ Flexible design that can be tailored to meet specific patient or service needs, with potential to reconfigure if those needs change ■ Constructed largely off site to improve quality and efficiency, while reducing the impact on the environment and local community ■ Fully managed maintenance and equipment service with flexible lease contracts, including quality checks and equipment 'refresh' when required ■ Potential to combine with mobile facilities, ensuring a total project solution

Vanguard (2021)

usually include functional elements that have clear pre-existing procedures and standards, which allows for clear planning along the whole supply chain (Doran and Giannakis, 2011).

The COVID-19 pandemic has highlighted the role that modular facilities can play in healthcare, with reports of rapidly constructed triage and isolation units in Wuhan, China, making headlines in early 2020 (Zhou et al, 2021). As stand-alone buildings, modular facilities can allow patients who test positive for the virus to be kept entirely separate from the main hospital building. This was refined in Singapore in spring 2020, where patients with confirmed or highly suspected COVID-19 were treated in a large, rapidly constructed modular ward just outside of the main hospital. This facility was fitted with high-specification air filtering, oxygen supplies and air conditioning, while one module was customised with lead shielding to allow X-rays to be performed. In 1 month, around 1500 patients were treated in the modular facility, with no breaches of infection prevention



Figure 2. Wider view of the location of the modular surgical unit in the car park of Queen Mary's Hospital, Roehampton.

and control measures, thanks to the practical, bespoke lay out of the building (Wee et al, 2020). With the same approach, a cataract surgical unit at Stoke Mandeville in the UK installed a modular unit to act as a COVID-free zone, allowing the surgical team to become one of the first services to re-start elective procedures after the initial pause during lockdown (Peak, 2021).

However, modular facilities have been used in healthcare since long before the pandemic. Bridges et al (2014) reported on the successful implementation of modular laboratories in Mali and Zambia, providing a cost-effective asset for the public health campaigns against malaria in these developing countries. The researchers noted that off-site building that did not have to rely on local labour produced higher quality facilities and was around half the cost of a traditionally built laboratory in Zambia. Similar results have been seen in developed countries; in Brisbane, Australia, the installation of a mixed-modality colonoscopy unit is allowing 6600 extra screening procedures to be performed per year, facilitating faster detection of one of the country's most common cancers (Q-bital Healthcare Solutions and Bowel Cancer Australia, 2021). Meanwhile, in the UK, the Royal Infirmary of Edinburgh was able to add a bespoke modular facility to a repurposed mobile unit to create a new minor injuries unit to help improve efficiency in emergency care (Vanguard, 2020). Modular facilities have thus already been established as a rapid and cost-effective means of increasing capacity and allowing flexibility across a number of different healthcare services.

The benefits of modular

Flexibility

Several studies and reports have emphasised the importance of flexibility in healthcare infrastructure and spaces (Hignett et al, 2013; Luoma-Halkola et al, 2017; Tantum and Hill, 2017; Wenzel and Evans, 2019). Healthcare technology, clinical practice and policy can develop very quickly, so building projects that take many years are at risk of being out of date before they are even finished (Wenzel et al, 2016; Gandy, 2020). The rapid adoption of healthcare technology during the COVID-19 pandemic further highlighted this need for greater flexibility (Baird and Maguire, 2021). However, many buildings in the NHS estate are over-specified for a particular use, making them inflexible and difficult to repurpose when demand changes (Edwards, 2013).

Many NHS trusts are looking to build more flexible facilities to meet capacity demands and deliver integrated care (Tantum and Hill, 2017). Modular facilities are a potential

solution for this, as they can be developed far more quickly than traditional, bricks and mortar buildings. For example, a project leader who oversaw the construction of four modular operating theatres, a ward and support hub at Queen Mary's Hospital, Roehampton, informed the author that the whole process, from commission to completion and receiving first patients, took 12–14 weeks in total. This was possible, in part, because modular facilities need less in terms of groundworks and other enabling works, and those works that are needed can be undertaken at the same time as the off-site construction of the modules. They can also be removed or repurposed when demand shifts. For example, the modular COVID-19 ward built in Singapore has now been repurposed to treat patients with other infectious conditions, such as tuberculosis and varicella (Wee et al, 2020). This gives trusts more flexibility when making planning decisions as they can judge the value for money over a shorter period of time. Furthermore, as pointed out by Flyvbjerg (2021), fast project delivery is crucial to success in infrastructure construction and expansion, both in terms of cost saving and risk reduction.

This flexibility could be a crucial asset in dealing with the large treatment backlogs facing NHS services. In all the cases of modular healthcare facilities described, the units were operational within a matter of weeks—this could allow extra capacity to address waiting list backlogs to be available with the appropriate level of urgency. Then, if demand decreases, increases or changes, the modular facilities can be either removed or repurposed. Such an approach would allow the NHS estate to fit around patient needs, rather than vice versa.

Quality and value

A key element of a modular facility is that the majority of construction takes place off site. Once ready, the facility will then be delivered to the site, installed and tested for quality so that the trust is left with a completed building that is ready to use immediately. Building infrastructure in a factory environment typically allows for better quality control and more efficient use of labour and resources than would be the case in on-site building (Bridges et al, 2014; Geiger, 2017). Some providers of modular facilities, such as Vanguard Healthcare Solutions in the UK, also offer leasing contracts that include regular quality standard testing, maintenance and full facilities management packages. This means that trusts have set costs that they can budget for, without needing to factor in extra, unknown maintenance costs. These designs are also compliant with health technical memoranda (Department of Health and Social Care, 2014), meaning that hospital staff can trust in the appropriateness and safety of the facilities.

Modular construction can also improve efficiency, with a study in the United States of America finding that a modular, pre-fabricated construction approach resulted in time savings of 45%, cost savings of 16% and an increase in productivity of 30% (Geiger, 2017). These cost savings are continued after construction is complete, as temporary modular facilities can prevent services needing to resort to outsourcing to the private sector. In 2017–18, nearly 20% of common cataract procedures were outsourced to private providers, costing the NHS both money and staff training opportunities. Using modular facilities to create additional capacity, instead of outsourcing, can keep revenue and experience within NHS services (Peak, 2021).

Further discussion of the potential cost benefits and funding models for modular facilities will be included in part three of this series.

Enhanced patient and staff experience

A common misconception about modular facilities is that they are less comfortable or customisable than a traditional hospital building. In fact, given the limitations often placed on older NHS buildings, some of which are grade one or two listed, the opposite is often true (NHS Property Services, 2020). Although the earlier models of modular building used in the 20th century were often relatively basic, more recent models are made to be bright, airy and spacious, with many options for customisation or even bespoke design. An example of the interior of a bespoke, modular surgical theatre can be seen in [Figure 3](#).

In their review of modular diagnostic laboratories, Bridges et al (2014) found that, despite some initial misgivings, almost all of the users became 'converts' after stepping into the modular facilities. Similarly, in a study of three hospitals that had used modular facilities in Finland, Kyro et al (2019) found that across all sites both staff and patients had



Figure 3. Interior view of a bespoke, modular surgical theatre, as delivered by the supplier.

commented favourably on the amount of natural light let into the modular units compared to the main building. In interviews with staff members, one manager who worked across multiple sites states that the hospital's modular unit was the only facility about which they had never had a complaint about comfort.

Kyro et al (2019) also pointed out that the ability to standardise modular facilities can be a significant benefit, as it means that the layout and storage of equipment in each room can be the same, making it easier for staff to work in different rooms. Although more research is needed to gather patient and staff feedback, these initial case studies suggest that modular facilities are just as, if not more, comfortable and easy to use as traditional healthcare buildings.

Environmental benefits

Healthcare services contribute a significant amount of global carbon emissions; if the healthcare sector were a country, it would have the fifth highest carbon emissions in the world, along with a large amount of waste material (Winter, 2020). Because of their flexible nature, modular healthcare facilities can help to facilitate a more circular economy—a regenerative closed loop that prevents waste and promotes optimisation of physical, financial and human resources (Ellen MacArthur Foundation, 2018). By repurposing modular facilities according to need, trusts can avoid waste and cater their buildings to fit patient needs. Off-site manufacturing is also believed to reduce construction waste and facilitate better building insulation, improving energy efficiency. This is in addition to the reduction in emissions from transporting building materials to the hospital site, as well as the noise pollution and disruption to local communities that often occurs during long on-site building projects (Kyro et al, 2019). In this way, modular facilities could help trusts meet the NHS's goal of becoming carbon neutral by 2040 (NHS, 2020).

Limitations

Although modular facilities have the potential to be a great asset to NHS trusts as they tackle their patient and maintenance backlogs, it has been rightly pointed out that creating more space cannot solve the chronic shortage of health and social care staff. This was one of the major criticisms levelled at the Nightingale Hospitals, which arguably highlighted the issues associated with having 100 000 NHS vacancies going into the pandemic (Anandaciva, 2021b). However, it is possible that the more practical and pleasant environment provided by modular facilities could go some way in addressing this issue; research has shown that

Key points

- NHS buildings can be a hindrance to effective management of patient demand, with maintenance backlogs and shortages of space creating a barrier to efficiency and capacity expansion.
- Modular healthcare facilities have been used for several years, and particularly during the COVID-19 pandemic, as a cost-effective solution to capacity issues in the NHS and abroad.
- There are a number of benefits to modular facilities, including greater flexibility, faster delivery, enhanced patient and staff experience, and a reduced environmental impact.
- Healthcare trusts experiencing capacity issues should seriously consider modular or mixed-modality facilities as an effective means of increasing capacity and/or continuing services during periods of refurbishment.

positive work environments, particularly those that encompass natural elements, such as plenty of natural light, can improve cognitive functioning, reduce stress and even contribute to faster healing (Terrapin Bright Green, 2014; Sterkenberg, 2017). Not only does this ‘biophilic’ design have implications for patient wellbeing, it could also improve the experience and morale of staff, which could, in turn, increase staff retention (Amaliyah and Tukimin, 2021).

It is also true that, although existing research and case studies have demonstrated the safety and efficacy of a modular unit, further investigation into the long-term benefits, costing models, and patient and staff experiences of these facilities would be useful. As healthcare infrastructure struggles to cope with increasing demand, this already-flourishing field of research is likely to continue to grow.

Conclusions

There is no silver bullet that can solve all the issues facing the UK healthcare systems, many of which, including patient backlogs, have been exacerbated to unprecedented levels as a result of the COVID-19 pandemic. However, innovative solutions that can help to create capacity and allow more efficient working are key to facilitating a recovery process that not only restores the NHS to pre-pandemic functioning, but also improves and prepares it for future challenges. Modular facilities, with their flexible and cost-effective nature, should be a serious consideration for trusts facing capacity issues.

This article has outlined the case for modular healthcare facilities; the second article in this series will provide detailed case studies exploring the processes involved in commissioning and acquiring a modular facility from the perspective of NHS trust managers.

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Practical considerations for the commissioning and delivery of modular facilities

Abstract

The process of commissioning and planning a new building can be complex, requiring a combination of skills, expertise and motivation from several different stakeholders. The first article in this series on healthcare infrastructure made the case for more modular facilities in the NHS, to increase capacity and help services address the growing care backlog. This article, the second in a series of three, will discuss the process of commissioning a modular facility, drawing on two in-depth case studies to provide insight from healthcare managers who have successfully completed such a project. This includes exploration of the circumstances that led the trusts to consider a modular solution, the challenges they faced, how they overcame those challenges and the benefits they have observed in their services so far. A guide to the key considerations and recommendations for commissioning and planning a modular facility is also provided for trusts looking for ways to expand their service capacity.

Key words: Commissioning; Estates; Modular infrastructure; Surgery

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Introduction

Healthcare services in the UK are under ever-growing pressure. Not only must they continue to treat new cases of COVID-19, there is also an increasing need to address the backlog of existing patients waiting for routine and acute care. Since the outbreak of the pandemic, the number of patients on an NHS waiting list has grown to record highs, exceeding 5.6 million people in July 2021. Clearly, COVID-19 has played a significant role in exacerbating this issue, but it should also be noted that waiting list numbers were high even before the pandemic, reaching over 4.5 million in January 2020 (Lane Clark and Peacock, 2021). Alongside this is an ageing population and a rising incidence of chronic conditions and multimorbidity (Economic and Social Research Council, 2018), which will likely see demand for NHS services increase further.

Evidently, a reduction in cases of severe COVID-19 alone would not be enough to relieve the pressure on healthcare services. Instead, innovative solutions are required to expand capacity in a way that is sustainable, safe and cost-effective. Part one of this series made the case for modular facilities as such a solution, creating space to expand services while also providing a high-quality clinical environment for patients and staff. Modular buildings can be completely standalone (Figure 1) or connected to an existing building and/or mobile facility (known as ‘mixed modality’). Crucially, they can be made bespoke for a service’s specific needs and installed much faster than a traditional bricks-and-mortar development (Clough, 2021). Figure 1. A modular surgical facility installed outside of the main building at Queen Mary’s Hospital, London.

This article will discuss the practical aspects of commissioning a modular facility for a healthcare trust, from the initial business case to the opening of the service. This discussion will be based around two in-depth case studies of NHS trusts that have recently had modular facilities installed on their sites, one in London and one in Newcastle. Information on these case studies was gathered using interviews with key stakeholders and early outcome reports, including the challenges faced and how these were overcome. Practical guidance on the commissioning process is also included to help teams that are considering a modular solution to gain a strong understanding of the key considerations and recommendations for such a project.

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Figure 1. A modular surgical facility installed outside of the main building at Queen Mary's Hospital, London.

Case study one: Queen Mary's Hospital, London

The problem

In early 2021, St George's University Hospital NHS Foundation Trust was tasked with finding a solution for the growing surgical backlog in south-west London. This backlog represented a long-standing problem with surgical capacity that had been exacerbated by the COVID-19 pandemic, with the hospital performing 10 608 fewer operations than expected between March 2020 and May 2021. The trust stated that the number of patients needing routine surgery in south-west London could have increased by as much as 30 000 since the outbreak of the pandemic. As day-case surgeries were a large part of this backlog, the trust decided to focus on creating additional capacity for day-case procedures. They required a stand-alone facility at Queen Mary's Hospital, one of the trust's sites, that would provide the space needed for the entire patient journey, from arrival to discharge home, with minimal risk of COVID-19 transmission.

The solution

One of the primary drivers of the trust's decision to choose a modular solution was timescales—it was recognised that capacity was needed to start addressing the backlog in a matter of months, rather than years. The bespoke modular facility developed includes four high-specification operating theatre rooms, plus a recovery ward, consulting rooms, staff facilities and utility areas (Figure 1). Crucially, the facility was designed to promote maximum efficiency in terms of patient flow, ensuring that the patient's journey through the space is linear. This was done to make the patient experience as easy and straightforward as possible, while reducing the risk of COVID-19 transmission by allowing a one-way system to be implemented.

Commissioning and delivery

From the initial decision to launch an initiative to create capacity in February 2021, a functional modular theatre complex was delivered in 5 months, a significantly shorter timeframe than would be expected for the development of a traditional building.

The design of the facility was based on a basic brief given to the provider, Vanguard Healthcare Solutions Ltd, who came back to the trust with an initial set of plans within 10 days. These designs were then discussed by clinical staff—including the head of surgery, head of theatres and theatre manager—to ensure that aspects such as the overall layout, electrical points, built-in furniture and data points were optimal for staff use. Overall, the clinical staff were happy with the majority of the original designs, including those for the four operating theatre rooms, and were able to make changes to other areas, such as the consulting rooms and staff area, as required. Collaboration between the provider, trust management and clinical staff was one of the key aspects of this process that allowed such

efficient delivery. Once the plans were signed off, construction began the next working day. The first individual modular units arrived on the site on 15 March 2021 and the first patient was treated at the completed facility on 14 June 2021, representing an installation time of just under 3 months.

Challenges

The relaxation of planning permission requirements during the COVID-19 pandemic meant that the trust did not have to seek planning permission before the facility could be installed. However, like many NHS trusts, ownership of the estate is a complex issue, with the site being managed by NHS Property Services but owned by a private company through a private finance initiative. To ensure that they had full control over the development of a modular facility, the trust had to gain the approval of the private company to redline the required area. The ability of the trust to make a compelling case regarding the need to expand surgical capacity and the potential efficacy of the modular facility for this purpose was key to gaining this permission.

In terms of the building process, the only challenge that arose was the need to level the car park in order to install the facility. However, because the units are manufactured off site, this could be done while they were being built, thus no time was lost.

Benefits

As of August 2021, over 300 procedures had been performed in the modular facility, with an average of around 120 being carried out per week. This is helping to both address the day-case surgical backlog and free up space for more complex or high-risk procedures to be performed at other south-west London sites that have intensive or emergency care facilities. Given the urgency of the backlog and the number of patients whose health and wellbeing are at risk because of long waits for routine surgery, this extra capacity is crucial for both patients and NHS services. The trust also highlighted the flexibility of the modular facility as a major advantage, as the knowledge that it can be removed or repurposed when needed provides reassurance for the future.

Patient feedback about the facility has also been very positive, with many commenting on the benefits of having each stage of their care take place in one area, including increased confidence about attending the service during the COVID-19 pandemic. The unit has been designed with large rooms, wide corridors and solid concrete flooring, so that, from the inside, it is indistinguishable from a traditionally-built hospital, increasing patient confidence. Staff feedback has also been overwhelmingly positive, particularly in relation to the quality of the space and the staff facilities (Figure 2). The legacy estate issues with the main hospital building mean that it has been difficult in the past for the trust to provide sufficient spaces for staff breaks, changing and cycle parking, whereas in the modular facility, these spaces were included in the design.

When asked what advice they would give to other trusts facing similar capacity issues, the director of estates and facilities at St George's University Hospitals NHS Foundation Trust said 'come and have a look around... it really is very surprising.'

Case study two: Newcastle Westgate Cataract Centre, Newcastle

The problem

At the Newcastle upon Tyne Hospitals NHS Foundation Trust, a significant backlog in patients needing cataract surgery had been accelerated by the COVID-19 pandemic. Cataract surgery is the most commonly performed surgery in the NHS, with demand predicted to rise by 50% in the next 20 years (Royal College of Ophthalmologists, 2015). Living with cataracts can have a significant impact on an individual's quality of life, limiting their independence and leading to a greater risk of falls or accidents (Palagyi et al, 2016). Cataract surgery is a short procedure, taking only about 10 minutes, but the extent of the backlog meant that many patients face waiting times of over 1 year. This was particularly significant for the trust at Newcastle, which provides cataract services to much of the north-east of England. Therefore, the trust were seeking a solution that could help to enhance not just the quantity of procedures they could perform, but also the quality of the patient experience.



Figure 2. The staff wellbeing area in the modular theatre hub at Queen Mary's Hospital, St George's University Hospitals NHS Foundation Trust, London.

The solution

After extensive research, the trust chose a modular design for a new cataract centre with three procedure rooms at the Campus for Ageing and Vitality site, which was part of the trust's estate. The area chosen had previously held a building that had fallen out of use and been demolished. The new cataract centre was designed with a one-way system for patients, making their journey as smooth as possible and allowing the average time spent in the facility to decrease from 3–4 hours to between 45 minutes and 1 hour. Patients are pre-assessed before being booked for the procedure, with those who are considered higher risk being treated in the main hospital building.

Patients enter the centre on the south side of the building to a reception room, are checked in by a designated nurse who stays with them throughout their journey, then go through the building to a consulting room before being taken to the operating theatre for their procedure. They are then taken to a recovery room, briefed on aftercare by the nurse, before leaving through the north side of the building to the designed pick-up area outside (Figure 3). The facility was named the Newcastle Westgate Cataract Centre and was built to perform up to 1000 cataract procedures per month. There are also two staff wellbeing areas to help facilitate social distancing, as well as storage and utility rooms.

Commissioning and delivery

The trust decided to undertake this project in August 2020. After the initial research and business case, they approached the provider and design work began in October 2020, then installation started in early December 2020. The Newcastle Westgate Cataract Centre officially opened on 6 April 2021, representing a total turnaround time of 7–8 months, despite the challenges described below.

Clinical staff were deeply involved in the design process, working with the provider in weekly meetings to ensure that the space was optimal for their specific purpose. Staff also participated in training exercises involving role-playing the new facility's procedures to ensure that all equipment was in the appropriate place. To ensure safety, procedures for circumstances such as a fire or a patient medical emergency were planned, role-played by staff and confirmed before the facility opening.

Challenges

The winter period and the third UK lockdown in early 2021 meant that the number of construction staff allowed on site was limited to allow social distancing. This, plus the Christmas break in the first month of installation, meant that this part of the process was slightly delayed. Despite this, the facility was installed in just 4 months, a far shorter time than would be expected for a traditional building. Another challenge arose when additional, unforeseen changes to the plans were requested by staff after construction had started.



Figure 3. Exterior of the Newcastle Westgate Cataract Centre at Newcastle upon Tyne Hospitals NHS Foundation Trust, showing the designated pick-up spot for patients, the patient entrance to the south of the building (left) and exit at the north of the building (right).

However, the provider was able to incorporate these changes into the design as installation took place to ensure that the final building was optimal for staff.

Benefits

Since April 2021, the trust has received a large amount of positive feedback from patients and their families regarding the high quality of the new building. The professional atmosphere has been noted as a particular positive, helping patients feel at ease. However, one of the greatest benefits has been the reduction in time spent at the facility by the patients as a result of the improved flow. The shorter waiting time has reduced patient anxiety before their procedure and helped them feel more protected from COVID-19 infection.

For staff, the benefits have also been pronounced. The consistent communication with the provider and trust management meant staff felt engaged and that their needs were being heard. Having a unit manager on site for 8 weeks after construction also helped staff feel reassured when beginning to work in the new environment. Since opening, feedback from staff has emphasised the positive working atmosphere in the facility, as it fits their specific needs. For example, during the design stage it was noted that the amount of natural in surgical wards can often be lacking, so plenty of windows were installed in the facility where appropriate. Finally, the new cataract centre is helping the trust to work through the care backlog in cataract surgery by giving them the capacity to perform 200–250 procedures per week. One of the matrons who had been involved throughout the project highlighted how rewarding this was for staff, who she had seen ‘flourish’ in the new building.

The commissioning process

Planning and commissioning a new facility requires research and can comprise a considerable amount of the total time spent on a project, particularly when the building stage is quick, as with modular units. A business case is usually required when scoping and pitching a service improvement idea, including the installation of a modular facility. As aptly put by Henriksson et al (2021), ‘a business case is to decisions on the investment of funds what an evidence-based study is to decisions on appropriate patient care.’ The requirements and considerations for a start-to-finish commissioning process is outside the scope of this article, but comprehensive guidance is available from HM Treasury (2018, 2020) and NHS England (2018). The following section covers some of the key points that are particularly relevant to scoping and commissioning a modular facility.

Scoping the need

Throughout the commissioning process, and indeed the entire project, it is important to ensure that all stakeholder groups have a strong understanding of the overarching purpose of the project. It is often useful to start by identifying the key problem (or problems) that need to be addressed and gathering data on the impact of that problem on services, staff and/or patients (Disney, 2021). Modular facilities are often used to create capacity, either to cope with increasing demand or to provide space to continue services while carrying out building maintenance (Clough, 2021). Evidence regarding capacity issues across the NHS is not difficult to find but, when scoping need for a modular facility on a site, the impact of those issues on the specific trust, hospital or site will need to be understood.

NHS England's (2018) guidance on gaining approval for a project emphasised that NHS resources are finite, thus all proposals must be aligned with national priorities for health and social care. The UK Government's (2021) plan for autumn and winter 2021–22 highlights the importance of addressing the growing NHS treatment backlog, particularly in elective surgery, so a project aiming to increase capacity through a modular solution will likely be seen as in alignment with this priority. An example of a modular facility being installed to address the treatment backlog can be seen in the Queen Mary's Hospital case study, where a day-case surgery backlog following the first lockdown of spring 2020, as well as a historical backlog in this field across south London, was identified. Long waits for surgery can have a significant impact on patient outcomes and quality of life (Gagliardi et al, 2021), which gives a strong rationale for projects that increase capacity, such as the installation of modular facilities.

Lifespan and flexibility considerations

When commissioning a building, lifespan is a crucial factor to consider, particularly as it usually affects both funding and planning permission. With modular facilities, unlike traditional buildings, it is possible to obtain planning permission for periods of 5 years or even less, as modular buildings can be moved or repurposed with relative ease. Because of this, modular facilities are not always subject to the same rigorous planning approval processes as traditional buildings (Powell, 2020). This was taken advantage of at the Newcastle Westgate Cataract Centre, which obtained planning permission and a lease of 1 year, with the option of extending.

This flexibility is added to by the fact that modular facilities can be reconfigured to suit changing needs in healthcare, which aligns with NHS Property Services' (2021) requirement for flexibility in new buildings. However, the complex ownership structures of NHS estates mean that obstacles to securing an appropriate site and gaining planning permission can still arise, so it is important to be aware of these issues and how they can be overcome when scoping the project.

Finding an appropriate location for a modular facility is also key to this stage of the process. There are a number of factors to take into consideration for this, perhaps the most obvious of which being how big the facility needs to be and where this space can be found on a trust site. However, there are also other factors to address, such as:

- Is the ground suitable for a modular building?
- How close does the modular unit need to be to the main building?
- Do any clinically adjacent need to be easily accessible from the modular unit, such as intensive care or anaesthesiology?
- How feasible is it to provide mains services (such as electricity) to the new building?
- Is additional parking needed for the modular unit?

Some of these issues were encountered at the Queen Mary's Hospital site. For example, as the site does not have an intensive care unit or emergency facilities, it was decided that the modular surgical facility would be for day-case procedures only, so that space could be freed up for more complex, high-risk procedures at other hospitals in the area. Another advantage of modular units is that, as much of the building takes place off-site, less material needs to be delivered and stored on site (Kyro et al, 2019), reducing the logistical burden.

The role of key stakeholders

Identifying and involving all relevant stakeholders from the outset of a project, particularly one on this scale, can be useful in ensuring that any reservations they may have are addressed early in the process (Disney, 2021). Indeed, at the Newcastle Westgate Cataract Centre, the clinical stakeholder interviewed stated that the continuous communication with clinical staff throughout the project was crucial to its success. Some common misconceptions about modular facilities that stakeholders may have, and how to reassure them, are shown in **Table 1**.

NHS England's (2011) guidance on improving service quality recommends starting by gaining a consensus among stakeholders about the problem facing the trust and the impact that problem is having on patients, services and staff. Once the extent of the problem is universally recognised, the importance of finding a solution will become more apparent across stakeholder groups. Using specific metrics for success is a key part of making a sound case for a solution (Henriksson et al, 2021), such as providing estimates of how many additional procedures per week could be performed if a certain number of additional theatre

Table 1. Common misconceptions about modular facilities and how to counter them

Misconception	Research
Modular buildings are lower quality than traditional buildings	Modular buildings are usually made off-site by specialists, which means better quality control and resource efficiency (Bridges et al, 2014; Kyro et al, 2019). Providers, such as Vanguard, also carry out full quality checks to ensure that air, water, electricity and equipment all meet required standards (Healthcare Spaces, 2021)
Having a facility situated away from the main hospital site is unsafe	Action plans for any medical emergency are made in advance to ensure safety and can be practiced by staff through role-play, as done at the Newcastle Westgate Cataract Centre. Standalone facilities can also reduce the risk of COVID-19 transmission, as they are separate from the main building, with optimal patient flow. This increases safety and patient confidence (Peak, 2021)
Modular facilities will not be a good working environment for staff	Feedback from staff working in the modular facilities at the Queen Mary's Hospital and Newcastle Westgate Cataract Centre case study sites has been overwhelmingly positive. Other studies report high staff satisfaction, with clinicians noting that modular facilities were spacious, airy, bright and indistinguishable from traditional hospitals on the inside (Bridges et al, 2014; Healthcare Spaces, 2021). It is also possible to include facilities such as staff areas and bike storage in modular designs.
Patients will feel less comfortable in a modular unit	Patient feedback from modular facilities has been overwhelmingly positive; at the latter site, patients noted that being treated in a standalone facility made them feel more protected against COVID-19 (Peak, 2021). Modular facilities can also be laid out to make the patient journey as simple and easy as possible (Hignett et al, 2010), with the possibility of customising the interior to promote patient relaxation
The off-site method of construction limits the ability to customise modular facilities	Although this was the case with early modular buildings, with modern methods of construction there are a wide range of customisation options for modular facilities (Bridges et al, 2014). The project lead at Queen Mary's Hospital stated that the set dimensions of the individual modular units that make up the facility made the planning easier and quicker, without compromising their ability to deliver a bespoke surgery complex

spaces were made available through the installation of a modular facility. Disney (2021) also pointed out that involving key stakeholders from the outset of the project can provide a wider pool of skills and expertise to make the commissioning and delivery process easier.

Creating a design specification

Both case studies highlight the importance of having the input of clinicians when creating and approving a design specification for a modular healthcare facility. In the design of the modular facility at Queen Mary's Hospital, engagement with clinicians was key to ensuring that the unit was clinically effective and safe with an efficient patient flow system. Meanwhile, at the Newcastle Westgate Cataract Centre, the weekly meetings with the provider of the facility, trust management and staff were emphasised as a particularly useful part of the design process, allowing the construction of a facility that is based on optimising both the patient experience and the staff's working environment.

There are many regulations that must be complied with when creating a new building; some of these are generic, while others are specific to healthcare services. The latter include ventilation systems, medical gas pipeline systems and safe water. Comprehensive guidance regarding these requirements can be found in the Health Technical Memoranda (NHS, 2021a) and Health Building Notes (NHS, 2021b), which all healthcare buildings must comply with. The extent of these requirements can be daunting, but working with a specialist provider of modular facilities can help to ensure that all requirements are built into the initial designs. For example, at Queen Mary's Hospital, the majority of the initial designs made by the provider, Vanguard Healthcare Solutions Limited, were approved by the clinicians and project lead, and incorporated into the final designs, reducing the time spent at this stage of the process. Meanwhile, at the Newcastle Westgate Cataract Centre, the provider posted a unit manager on site for 8 weeks after construction to ensure that everything was working at optimal level. This was cited as a particularly positive part of the experience by the trust.

In terms of interior design, NHS Property Services (2021) state that features must balance the need to meet infection prevention requirements with the promotion of patient relaxation. There are a number of ways in which this can be achieved. For example, research has shown that having surroundings that remind us of nature can improve both mental and even physical wellbeing (Sterkenberg, 2017). It is not always possible to have real plants in a healthcare environment, but a sense of nature can still be achieved by painting the walls, using fake plants or even simply ensuring that patient waiting and recovery areas get plenty of natural light. With modular facilities, it is possible to include these features in the design specification or add them in later.

Limitations

This study is largely based on two case studies in the UK, so the circumstances and outcomes of the modular facilities at these sites may not be generalisable to other sites in the UK or internationally. However, the main challenges faced by these trusts with capacity, particularly in the wake of COVID-19, are likely to be experienced by other NHS trusts and healthcare systems generally. Furthermore, as the modular facilities described in both cases studies opened relatively recently, full analyses of their clinical and cost effectiveness have not yet been completed. Further research to give a more comprehensive picture of the impact and efficacy of this solution is thus recommended.

Conclusions

The idea of commissioning a new building can seem daunting, but in the face of such large-scale and rapidly developing challenges, it seems necessary to employ large-scale and flexible solutions. The case studies discussed in this article demonstrate the speed at which high-quality and fully bespoke modular facilities can be planned and created at NHS sites, for different healthcare services, in different areas of the UK. Although further evaluation of the outcomes of these facilities is needed, early outcomes and feedback from patients, families and staff have all indicated benefits for patient care, staff working environment and service efficiency. The commissioning and design process for a modular facility is not

Key points

- The case studies presented in this article illustrate the speed and efficiency at which fully bespoke modular facilities can be constructed for different healthcare services in different areas of the UK.
- Both patient and staff feedback at these sites has been overwhelmingly positive, highlighting how the facilities have helped to make services more streamlined, provide reassurance regarding COVID-19 and start to work through care backlogs.
- It is crucial to involve all stakeholders as early on in the process as possible when commissioning this kind of project.
- Although there are many factors to consider when planning a modular facility, it is possible to deliver a high-quality result in a relatively short period of time by creating a strong business case, choosing a reliable provider and practicing good communication throughout.

without challenges, particularly as ownership of NHS estates is often complex. However, the urgency of the care backlog and the need for greater capacity in the NHS allows a compelling case to be built for such a project. This, along with strong communication with all stakeholders, particularly staff, is key to facilitating the smooth and rapid installation of a modular facility that can potentially lead to considerable benefits for patients, staff and services.

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Conflicts of interest

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Placing modular facilities in a resource-limited healthcare system

Abstract

Land should be one of the greatest assets of the UK healthcare system, as a result of its large estates portfolio. However, the current state of many of the NHS's buildings means that physical spaces are often more of a burden, with maintenance backlogs costing billions. However, as a resource-limited public institution, it is crucial that all investments into NHS infrastructure are as effective and future-proof as possible. The previous two articles in this series have focused on the potential benefits of modular facilities to healthcare staff, services and patients, drawing on case studies of NHS trusts that have implemented modular facilities on their sites. This article, the third and final instalment of this series, discusses the health economic impact of current NHS infrastructure, and explores the ways in which modular facilities could provide a flexible and cost-effective means of expanding capacity and improving services in a resource-limited environment.

Key words: Cost-effectiveness; Estates; Investment; Maintenance; Modular infrastructure

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Introduction

In most industries, when demand outstrips supply, the result is an increase in price. This is the case in many healthcare systems that rely primarily on private providers. However, in the NHS, the majority of services are free at the point of delivery, making the law of supply and demand inapplicable. Instead, when demand outstrips supply, the outcomes include increased waiting times and, sometimes, a decline in service quality, as limited resources are stretched to cover a growing patient load (Propper et al, 2020). This has both human and economic implications. The former include poorer patient outcomes and quality of life, as well as burnout among staff (NHS Providers, 2017). The latter include greater financial costs and, more broadly, loss of population productivity as a result of patients being unable to work while waiting for treatment (Campbell and Duncan, 2021).

Before March 2020, the NHS was already under strain, but the COVID-19 pandemic has exacerbated many of the pre-existing issues to an unprecedented level, with the secretary for health and social care warning that the number of patients on NHS waiting lists could grow to over 13 million in the near future (Stoye et al, 2021). Many of the 5.61 million people currently waiting in England require surgery, of which around 400 000 have been waiting for over 1 year (British Medical Association, 2021; Jimenez, 2021). Alongside the care backlog is a significant maintenance backlog, with many NHS-occupied buildings being unfit for purpose, inflexible or otherwise unsuitable for modern healthcare, particularly during a global pandemic (Naylor, 2017).

This series of articles has focused on the use of modular facilities to help healthcare services expand their capacity and address these backlogs, without sacrificing quality of care. Part one made the case for modular facilities in healthcare, outlining current challenges regarding physical space in the NHS and discussing existing evidence for the potential benefits of modular facilities (Clough, 2021a). Part two focused on two case studies of NHS trusts that had installed modular facilities on their sites, exploring the commissioning and design processes, as well as the challenges and early outcomes of these projects (Clough, 2021b). This article will delve further into the space-related challenges currently facing the NHS, with a greater focus on the health economic burden that these issues create. It will then discuss the ways in which modular facilities could

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support the future direction of NHS service provision while also providing a cost-effective solution in a resource-limited environment.

Maintenance and development of hospital buildings

Key challenges

In theory, physical space and buildings are one of the greatest assets of the NHS. Provider trusts occupy around 1200 sites, including buildings with a gross internal area of 26 million square metres, and most trusts own the buildings that they occupy (Naylor, 2017; Wenzel and Evans, 2019). However, not all of this space is in use, with around 1.5 million square metres of the NHS estate completely unoccupied, and much more space under-used (Edwards, 2013). The reasons for this are varied. Some buildings are simply too run-down to use optimally and safely, whereas others are in a usable condition but do not fit the needs of their owning trust. For example, although new buildings have been developed to help the NHS cope with growing demand over the past 30 years, many of these are over-specified for certain services and largely inflexible. This is a logistical and financial risk, as it means that the buildings cannot be adapted to changing need and are prone to falling out of use when demand changes (Edwards, 2013).

This lack of flexibility in NHS spaces also causes difficulties when services develop. For instance, improvements in radiotherapy technology have led to increasing availability of radiotherapy facilities in general hospitals, allowing patients to undergo treatment closer to home, rather than in specialist centres that may be far away. However, this has put pressure on general hospitals to find the space for these facilities in buildings that were not made with this kind of technology in mind, or suitable for adaptation (Gandy, 2020).

In some ways, these issues with NHS estates may seem inevitable as, since the founding of the NHS in 1948, the size and location of NHS buildings has largely been based on what was available rather than strategic, future-oriented planning. Continuous reforms and insufficient investment into healthcare spaces have also limited the capabilities of NHS estates and increased reliance on the private sector, adding more cost to services (Naylor, 2017). Meanwhile, the over-specified nature of many NHS spaces gives them a low residual value compared with their original cost, making them expensive to finance and difficult to dispose of (Tantum and Hill, 2017). Therefore, in some ways NHS estates, which could be a major asset, can become more of a burden, both practically and financially.

The need to expand service capacity and the difficulty in adapting existing buildings for new purposes can make the idea of building new hospitals seem appealing, but this is a time-consuming and highly expensive enterprise, with rapid developments in practice, technology and demand meaning that projects can become out-of-date before they are even finished. An infamous example of this is the Royal Liverpool Hospital, where plans for redevelopment began in 2002 but are still yet to be completed nearly 20 years later (Gandy, 2020).

The health economic burden

These issues with the NHS estate are associated with an increased health economic burden on the NHS. The cost of repairing, updating and maintaining healthcare spaces is very high and continues to grow, with the influential report by Naylor (2017) estimating the maintenance backlog to be worth around £5 billion in 2015–16, representing a 9% increase on the year before, of which around £1.5 million was in London alone. Since then, this cost has continued to rise at an accelerated pace, reaching an estimated £6.46 billion in 2018–19, then increasing by 40% to £9 billion in 2019–20. This is almost equal to the cost of running the entire NHS estate, which was estimated at £9.7 billion in 2019–20 (Garratt, 2021). It should also be noted that these are likely conservative estimates since, as Naylor (2017) pointed out, there is little incentive for trusts to accurately gauge and report this data.

The practical implications of these figures in terms of the daily functioning of NHS services have not yet been fully evaluated, but research has indicated that out-of-date or suboptimal buildings limit the range and quality of services that trusts are able to provide (Williams et al, 2019). The disparity between the amount of funding needed to eradicate

the backlog and the amount available also means that managers are forced to ‘fight fires’ in maintenance, focusing on operational urgency, often at the expense of strategic planning (Tantum and Hill, 2017). This has serious implications for patient care and safety, with one estates director stating that the high-risk maintenance backlog at his trust would cost over £1 million to fix, but even if that were resolved it would not leave them with an estate that was fit for purpose (Williams et al, 2019). Meanwhile, in one hospital in the south-east of England, an unreliable lift that often breaks down means that the trust has had to hire ambulances to transfer paediatric patients across the 20 yards between the main hospital and the children’s hospital, costing both time and money (Anandaciva, 2019).

There has been much discussion around the need to increase efficiency in NHS services to improve care and save resources (Alderwick et al, 2015). However, this will require strategic investment and innovation in the infrastructure of the NHS.

Modular facilities as a cost-effective solution

Choosing a viable option

In any project where investment is needed to make a change in a healthcare trust, it is often useful to start by establishing the problem (or problems) that need to be addressed (Disney, 2021). In both case studies described in part two of this series, based in St George’s Hospitals NHS Foundation Trust and the Newcastle Westgate Cataract Centre, the stakeholders and project leads highlighted how the extent and urgency of the NHS care backlog had helped them to unite the relevant stakeholders in favour of an innovative modular solution (Clough, 2021b).

Once the problem has been established, the next step in a business case is often to present the options available, including the ‘do-nothing’ approach. For example, a trust facing a severe backlog in day-case cataract surgical procedures, as was the case at Newcastle upon Tyne NHS Foundation Trust, may compare a do-nothing approach with a number of capacity-expanding options, such as increasing theatre days, outsourcing to the private sector or choosing a modular approach (**Box 1**) (Clough, 2021b).

Box 1. Example of options that could be compared by a hypothetical healthcare trust looking for a solution for a high level of service demand

- **Option one:** the ‘do-nothing’ approach. A consideration of the consequences should no change be made to current practice, including how many procedures the trust is currently able to carry out in a given time period, and how long it would take to work through the backlog while dealing with new referrals in this period. This could include the financial costs, the potential detriments to patients and staff, and the possible impact on the service’s wider functioning, finances and reputation
- **Option two:** outsource services to private healthcare providers as a means of working through cases more quickly. This avoids having to create more space or extend staff working hours at the trust, but is very expensive, often unsustainable and takes training away from trust staff (Peak, 2021)
- **Option three:** expand current capacity at the trust by increasing theatre days, using other departments’ facilities at the hospital (if possible) and/or increasing staff working hours, possibly over weekends. This may be effective in the short term, but could lead to logistical difficulties, increased running costs and reduced opportunities for planned preventative maintenance
- **Option four:** installing a modular or mixed modality (modular and mobile) facility to perform additional procedures. This requires initial investment or recurrent rental fees, but could expand capacity both by providing more physical space and allowing that space to be made bespoke to maximise efficiency. If demand changes and the facility is no longer needed for its original function, it can be repurposed or removed, depending on the trust’s needs and goals

As the pricing of both modular facilities and traditional construction works and/or conversions varies widely across projects and circumstances, it is difficult to make a direct general comparison, as costs will vary from trust to trust. However, modular facilities can provide a means of expanding clinical capacity in a way that is both clinically and cost-effective, both during the development stage and afterwards.

Resource savings during the building stage

Building in a factory setting as much as possible, rather than on site, is likely to result in a higher-quality product (Bridges et al, 2014; Geiger, 2017; Kyro et al, 2019). A number of factors contribute to this, including the ability to enforce greater quality control, better resource efficiency, improved health and safety, and more efficient labour management. There can also be environmental benefits, as off-site construction is linked with less waste and fewer emissions from transporting materials in multiple shipments to the site (Kyro et al, 2019). The speed with which modular facilities can be installed also means that the amount of disruption to the local environment from a large-scale building project can be minimised (Construction, 2020). Additionally, facilities built largely off site, including modular buildings, carry less risk of running over time and over budget (NHS Shared Business Services, 2021). In fact, modular design and construction methods have been shown to deliver 45% time savings, 16% cost savings and a 30% increase in productivity during the building process alone. For example, at St Joseph's Hospital in Denver, Colorado, the use of off-site construction reduced the time needed to complete the project by 72 days and saved an estimated \$4.3 million (Geiger, 2017).

Despite this, procuring a modular facility inevitably requires the use of financial resources which, with constrained NHS budgets, means that a solid business case must be made. Further guidance on this can be seen in part two of this series (Clough, 2021b). In terms of funding, several frameworks have become available in recent years to help healthcare trusts to procure modular facilities (Table 1). Some, such as NHS Commercial Solutions, are specific to health and education, while others are open to all providers of public services. These frameworks are designed to provide an assured and rapid route to the procurement of a modular facility, to make expanding service capacity as easy and accessible as possible to NHS trusts. To achieve this, they offer flexible funding options, such as the choice to either buy or rent through a wide range of contract lengths, as well as the potential to fund the procurement of a modular facility using both the trust's capital and revenue budget (NHS Shared Business Services, 2021).

Table 1. Frameworks for streamlined access to modular facility procurement for NHS trusts

Framework	Services included	Framework expiration (extension period)	Website link
NHS Supply Chain*	Health	January 2025	https://www.supplychain.nhs.uk/product-information/contract-launch-brief/mobile-and-strategic-clinical-solutions/
NHS Commercial Solutions	Health and education	February 2025 (+0 years)	https://www.commercialsolutions-sec.nhs.uk/frameworks/modular-buildings
Shared Business Services	Public sector	July 2023 (+2 years)	https://www.sbs.nhs.uk/article/6557/Modular-Buildings
London Healthcare Consortium	Public sector	April 2024 (+1 year)	https://www.lhc.gov.uk/frameworks/construction-extension-and-refurbishment/modular-buildings-mb2/
Crown Commercial Services	Public sector	April 2023 (+0 years)	https://www.crowncommercial.gov.uk/agreements/RM6014
ESPO	Health and education	February 2025 (+0 years)	https://www.espo.org/modular-buildings-953-18.html

*Modular facilities will be included in this framework from January 2022

These frameworks can be used to procure buildings for a variety of healthcare-related purposes, including direct patient care, laboratories, morgues, education and catering. By collaborating with trusted providers, the frameworks can also give NHS trusts reassurance that their resources will be used optimally by a reliable provider company. Some, such as the London Healthcare Consortium's (2021) MB2 framework, work with trusts to ensure that their modular facility meets social and environmental values, offering further benefits to the local community.

The development of these procurement pathways reflects both the growing demand for and increasing trust in modular facilities in healthcare (Clough, 2021a). In addition to the frameworks already in place, NHS Supply Chain, who currently provide a framework for the procurement of mobile facilities, will be expanding their scope to include modular facilities specifically for healthcare services from January 2022 (Government Online, 2021).

Therefore, although a new building is always a considerable investment, it is possible to save time and resources when developing a modular facility, without sacrificing quality.

Resource savings after the building stage

One of the current challenges in NHS estates management is that limited resources lead to difficulties in balancing short-term and long-term needs, with the latter often being disrupted, or sometimes completely hindered, by the former (Wenzel et al, 2016; Williams et al, 2019). This makes flexibility a key asset for new NHS spaces, as it allows short-term goals to be met while also providing the adaptability to meet future needs (Hignett et al, 2013). For example, there is evidence that the shift to integrated care could lead to both improved services for patients and potential cost savings for the NHS as a whole (Rocks et al, 2020). The flexibility of modular facilities could be pivotal to providing the physical space needed to achieve these benefits of integrated care.

Many NHS buildings were created using traditional bricks-and-mortar methods, when services still operated largely in silos, and are often difficult to reconfigure to adapt to this change in the structure of healthcare (Wenzel et al, 2016). Modular facilities, on the other hand, are designed to be adaptable, with the option of repurposing the building as needed. This provides an element of 'future-proofing' that may help to prevent challenges later on. Additionally, it essentially makes modular buildings 'recyclable', contributing to a circular economy whereby the end of a facility's original use does not have to be the end of its lifespan; instead, it can be reconfigured and/or moved to fulfil a new purpose (Figure 1). Research suggests that shifting to a circular economy in this way could have myriad benefits. For example, the Circular Economy Action Agenda, created with the input of over 200 experts from 100 different organisations, demonstrated that a circular economy could not only reduce emissions, but also provide a boost to the economy, create green jobs and ensure more efficient use of finite materials (Platform for Accelerating the Circular Economy, 2021). Therefore, modular facilities present an opportunity for resource savings at both an individual trust level and on a wider scale.

This flexibility can also be seen in funding models for modular facilities. The decision regarding whether to buy or rent a modular unit will largely depend on the specific circumstances of the trust, such as how long the facility is likely to be needed and whether capital is available to make the purchase, as well as considerations regarding planning permission. In either case, one of the benefits of installing a modular facility, as a new, standalone building, is that services can continue as normal on the main hospital site while the construction is taking place. This can prevent services being paused, reduced or outsourced (all of which can be costly) because of disruption to the main building (Geiger, 2017). Furthermore, once the modular facility is established, it may be possible to sell (or cease renting) more expensive assets, such as old or underused buildings, that are no longer needed (Tantum and Hill, 2017).

As well as flexibility, modular facilities can facilitate more efficient, high-quality care, with benefits to patients, staff and services. For example, at the Newcastle Westgate Cataract Centre, where a standalone modular facility for cataract surgery was developed, the trust worked with the provider to create a bespoke unit with a one-way system to streamline the patient journey as much as possible. This initiative has reduced the average amount

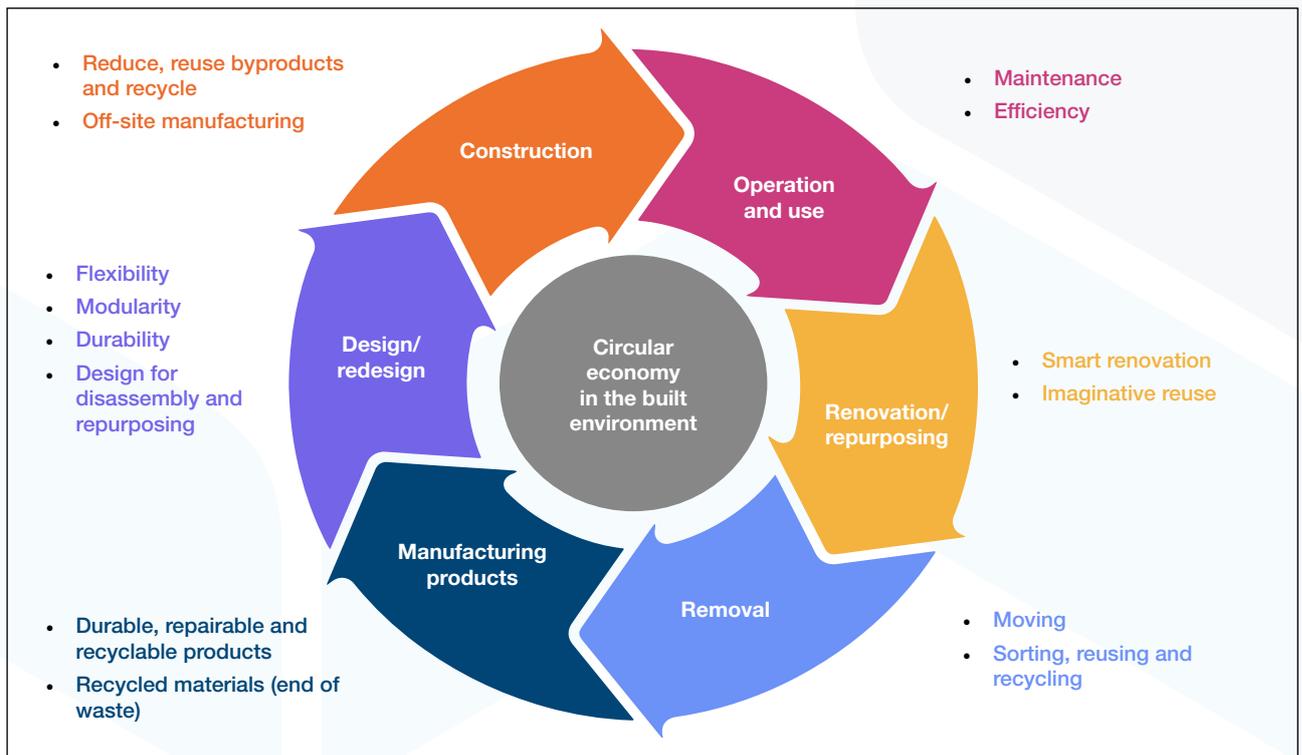


Figure 1. Applying the circular economy model to buildings.

of time patients spend at the site from between 3 and 4 hours to less than 1 hour. As the facility opened recently (April 2021), the cost benefits have yet to be fully analysed but, as well as improving the patient experience, it seems likely that this increased efficiency will save both time and resources (Clough, 2021b).

Finally, the practicalities and costs of maintaining any new healthcare space must be factored in, as the nature of these services mean that buildings are subject to rigorous quality standards to ensure patient safety. Research into the use of modular facilities in the education sector, another field that is largely publicly funded, has suggested that renting is particularly beneficial from a financial perspective, partly because maintenance costs are usually included (Vihola and Edelman, 2016). This means that the financial and logistical burden of arranging routine and emergency maintenance is removed from the trust. It also means that all costs of running the facility can be amalgamated into one regular payment to the provider, which may make financial planning easier.

A national strategic approach to NHS infrastructure?

Although NHS buildings are regulated by various policies and guidelines from central government, there is no national strategy for NHS estates, with individual trusts required to develop their own approaches. This can be advantageous as it allows trusts to tailor their estates arrangements to their specific needs. However, without a strategy it can be difficult to focus on broader, long-term goals. This is particularly relevant in an environment of chronic shortages, where managers are often forced to focus on short-term operational needs (Wenzel et al, 2016).

That said, the NHS does have long-term goals for its infrastructure, with the NHS (2019) Long Term Plan setting the aim of reducing non-clinical space by 5%, freeing up 1 million square feet for clinical use. The plan also emphasises the need to improve energy efficiency, increase productivity through better use of land, and dispose of unnecessary spaces to enable investment in new facilities. This may open up opportunities to create space for modular facilities, which are typically built to be well-insulated and energy efficient, and can be designed bespoke for the optimal productivity of the services operating in them (Construction, 2020; Clough, 2021b).

Box 2. Types of real investment in infrastructure

- Replacement: updating or replacing existing capital, usually because existing assets are either worn out or no longer useful
- Expansion: creating more physical space, with the primary aim of increasing capacity
- Diversification: a distinct form of expansion, where the aim is to improve the range of services offered. This may include adding complimentary facilities, such as a physiotherapy room
- New lines/products: in a healthcare context, this may include developing a new building to provide the necessary space to expand and/or improve service provision



Figure 2. Floorplan of the modular surgical hub at Queen Mary's Hospital in south-west London, providing optimal space to implement the Royal College of Surgeons' (2021) 'new deal for surgery'.

Similarly, the Department of Health (2014a, b) has placed a significant emphasis on the need to increase the efficiency of the NHS estate, both in terms of energy use and the streamlining of services. They stated that cost savings and increased efficiency could be achieved by the provision of a healthcare workplace that enables productivity and collaboration between teams, but highlighted that this is likely to require an initial investment, if the solution is to be adequate. Increasing NHS property resources in this way would be an application of the concept of 'real' investment in healthcare infrastructure (Box 2).

The COVID-19 pandemic and the subsequent increase in the patient care backlog, particularly in surgical specialties, has led to calls for real investment and larger-scale solutions in NHS infrastructure. For example, the Royal College of Surgeons (2021) has advocated for a 'new deal for surgery', including the widespread development of surgical 'hubs' that can provide separation between elective surgery and acute or emergency surgery. These surgical hubs, such as the modular facility seen at Queen Mary's Hospital in south-west London, have already been effective in expanding capacity and improving efficiency, as well as providing an essential asset to reassure patients and help services keep or resume running during the pandemic (Royal College of Surgeons, 2021) (Figure 2). However, the hub model is not possible without the appropriate infrastructure, once again emphasising the need to invest in sustainable building solutions, such as modular facilities, if the NHS really is to 'build back better' in the wake of the COVID-19 pandemic.

Key points

- The NHS estate should be an asset, but the current maintenance backlog and challenges associated with improving buildings often makes it more of a burden.
- Modular facilities can produce considerable cost and resource savings, both during and after the building process, particularly if new funding frameworks are used to facilitate them.
- A national strategic approach to healthcare infrastructure, particularly in the wake of COVID-19, may help trusts to access innovative modular solutions and ensure that the most cost-effective, collaborative approach is taken.

The case studies discussed in part two of this series (Clough, 2021b) demonstrated how the emergency planning legislation introduced following the outbreak of COVID-19, plus the capital injections into the NHS, helped trusts to rapidly implement modular facilities in a faster and more efficient manner than a traditional building. As planning permission is often one of the greatest barriers to overcome in this process, a national strategy to help trusts gain permission and make effective cases for commissioning modular facilities could help to make this process even more efficient, and encourage more uniformity across trusts. The frameworks provided to streamline the procurement process (Table 1) indicate that the need for building innovation in healthcare is being increasingly recognised, and will likely help trusts to access modular facilities. However, further research into the clinical and finance outcomes of modular facilities is also key to driving this innovative approach forward in future.

Conclusions

All three articles in this series have cited the NHS care backlog figures, but it is crucial to remember that behind these numbers are real people waiting for healthcare, many of whom are experiencing a significantly reduced quality of life as a result of their condition. The physical and mental health complications of waiting for care should not be underestimated, and it is likely that the true cost of the backlog to patients, healthcare services and wider society will not be fully realised for several years. Although COVID-19 has undoubtedly exacerbated this issue to unprecedented levels, long waits for NHS healthcare pre-date the pandemic. Therefore, simply returning to ‘the way things were’ will not be enough—real investment into effective, flexible and innovative solutions to increase capacity, without sacrificing care quality, are needed.

This series has highlighted modular facilities as such a solution, with promising early results from NHS trusts that have embarked on these projects. Thus far, benefits have been seen across stakeholder groups, including patients and staff. This article has emphasised the ways in which modular facilities can meet NHS goals to improve cost-effectiveness, increase efficiency and save resources through more strategic management of the NHS estate. Of course, there is more to NHS services than physical space, but creating an optimal environment for patient care can have significant benefits for patients, staff and services.

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