**The Institution of Mechanical Engineers' submission to the Policy Exchange call for evidence on building hospitals in the post-Covid era**

**September 2020**

## About the Institution of Mechanical Engineers

The Institution of Mechanical Engineers (IMechE) represents 120,000 engineering professionals and students in the UK and across the world.

The Engineering Policy Unit of the IMechE informs and responds to UK policy developments by drawing on the expertise of our members and partners.

## About the IMechE COVID-19 Taskforce

The COVID-19 Taskforce is formed of members from across the Institution's special interest groups and regions who can provide specialist input and advice on subjects where the impact of COVID-19 can be reduced through engineering applications.

## BIG ISSUES IN POST-COVID HOSPITAL DESIGN

### Preparing for future pandemics

New hospital design and operation must consider current and future pandemic infections. COVID-19 is currently impacting upon hospitals and causing many problems, including delays to booked procedures, re-allocation of facilities, and postponement of "non-critical" cases. It has also created the need for new time consuming and expensive infection management, security, and medical processes.

The impact of such diseases could be considerably lessened by a combination of better management of hospitals during a pandemic emergency and engineering measures to reduce risks. Key considerations include.

- **Ventilation**. Most diseases are either airborne or have an airborne component, i.e. may be surface spread but can move between surfaces in airstreams. Installing UVC Air Sterilisation as HEPA filtration would dramatically reduce viral load and therefore reduce viral risk. The use of "in-room"- units would allow these measures to be installed as and when needed and into critical areas.[1]
- The emerging technology of **remote patient monitoring** is key. Not only to reduce the frequency of exposure of healthcare staff to infectious patients, but importantly to provide a much higher frequency of reading of patients' vitals than through the traditional "doing the rounds", thus

[1] SAQN, UKIEG, and AQN UK (2020), *Co-ordinating Research Action: Air Quality & COVID-19*.

enabling early spotting of trends in any patient's condition and resulting in a much enhanced standard of care. As well as investing in remote monitoring capable equipment, the wards need to be built with remote monitoring in mind. Sufficient networking capabilities are already achieved in most of today's hospitals. A monitoring station needs to be planned in, which could be part of the ward nurses' office and designed to give a clear and immediate view of the condition of all the patients on the ward.

- **Hospital capacity planning.** The planning of which services will be built into the hospital and to what capacity needs to also embrace how technology is changing care. A prime example of the opportunity is rehabilitation particularly lends itself to remote consultations, remote monitoring, and remote interventions, enabling transfer of care from acute to community settings and delivering that care as close to home as possible. This of course needs to be done in concert with community settings to mitigate risks of discontinuity of care.
- The current pandemic has demonstrated that the demand on hospitals can vary quickly suggesting the need for **flexible purpose wards**. Building hospitals where the purpose of wards can be changed at short notice can make them more adaptable.
- **Provision for a wide range of equipment.** While not strictly speaking being about hospital specification, the first wave of the pandemic has shown that simpler equipment could be used for patients with less advanced symptoms. Ensuring new hospitals have room to store and maintain a range of equipment is recommended.

## BUILDING HOSPITALS FOR THE FUTURE

### Engineering expertise

Clinical engineers are the custodians of technology within the hospital. Consulting them to design and plan the hospital is highly recommended to ensure adequate equipment storage and maintenance facilities are provided.

The existing clinical engineering workforce has the capability to take on greater responsibility for technology innovation and patient care at the present time. However, if we continue on a path of high technological demand and with yet fewer and fewer engineers with clinical expertise to design, manufacture and implement that technology, we will be unable to meet patient need.

By adopting a more allied approach and creating professional parity between engineers and their clinical counterparts, clinical engineers could become more involved in the direct delivery of care to patients. This would provide a broader “end-to-end” operational perspective, which traverses the more specialised “vertical” expertise of typical clinical models.

To deliver safe and affordable care in this fast-changing environment, clinical engineers need to have increased authority and decision-making powers, as well as a wider range of skills. In a recent report, the Institution made the case for the creation of a new position of Chief Healthcare Engineer.[2]

To initiate national technology lifecycle strategies, the Institution recommends focusing on two key areas of care provision: remote monitoring of patients in the community and the provision of primary care services through GP surgeries (see below). These offer the best and most widespread opportunity for technology adoption and a reduction in pressure on acute care provision.[3] [4]

**Rethinking outpatient care to lighten the loads on hospitals**
With many countries shifting healthcare focus to prevention rather than just cure, greater pressure is being placed on primary care services. There is an opportunity to establish national technology procurement and adoption strategies specifically aimed at GP surgeries to enable prevention programmes to be supported before patients end up in acute care. This is not endorsing a two-tier GP system, however, this should be a government-driven national strategy to up-grade all GP service provision as part of outpatient care.

These "Advanced GP Surgeries" would contain in-house early diagnostic technologies for liver, lung and bowel cancer for example, as well as general blood testing and other preventative health technologies. By enabling patients to be tested in their community, waiting times, test turnaround and referrals could be reduced to days not weeks, saving thousands of pounds per patient and billions of pounds in long-term acute care costs.

A technology adoption strategy to address the management and support of medical devices used in social care settings, such as remote patient monitoring and home diagnostics applications, will be fundamental to addressing lifestyle diseases such as obesity and diabetes, ageing conditions such as Alzheimer's and frailty, as well as end-of-life palliative care.

**Medical equipment**
The design, manufacture and selection of medical equipment should follow an integrated approach taking account of the usage and operation of hospital facilities. Usage will take account of the needs of patients who require the equipment and the ways in which medical practitioners want to operate various items of equipment during procedures and the cleaning and disinfection of equipment between and during each patient session.

Operation should consider how medical equipment can operate effectively, efficiently, and reliably. For example, the installation of water-cooled CT Scanners instead of air cooled will integrate the equipment into central chilled water systems which can: -

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[2] IMechE (2020), Healthcare Solutions: Elevating the Engineering Workforce, Institution of Mechanical Engineers. Online: https://www.imeche.org/policy-and-press/reports/detail/healthcare-solutions-elevating-the-engineering-workforce

[3] IMechE (2017), *Remote Health Management: Reducing Bed Blocking in the NHS*, Institution of Mechanical Engineers. Online: https://www.imeche.org/policy-and-press/reports/detail/remote-health-management-reducing-bed-blocking-in-the-nhs

[4] IMechE (2018), Engineering and Dementia: Intelligent Assistive Technologies, Institution of Mechanical Engineers. Online: https://www.imeche.org/policy-and-press/reports/detail/engineering-and-dementia-intelligent-assistive-technologies

a) Achieve reliable and effective cooling
b) Achieve optimum machine performance
c) Provide heat at the central chiller plant which can be recovered and used for hot water heating and space heating.

This approach applies to all major items of medical equipment.

## BUILDING GREENER, BEAUTIFUL HOSPITALS

### Improving patient recovery

Hospitals exist to provide healthcare and so whilst they are full of complex engineering equipment their prime focus is on the health and well-being of people who have many thoughts and feelings which must be considered alongside their medical needs. It is important to create an environment in which a patient feels positive and has belief in the treatment they are receiving. Without the patients' "buy-in" and desire to get well, more formal medical processes may not succeed.

Research carried out in Philadelphia recorded that patients who had a view of a tree, outside their window, who could connect with nature, recuperated at a better rate and were able to leave the hospital sooner. In fact, the report suggested a day earlier based on a one week stay. If this research is applied widely it would improve bed availability, hospital efficiency and obviously support patient improvement. Some hospitals have taken this design concept and applied it to atrium spaces, such as Guys Hospital London where four atria provide patients with views of trees in the area around London Bridge station.

Other sources of guidance can be found in these footnotes.[5] [6] [7] [8]

### Improving air quality

The current NHS Codes of Practice for hospital ventilation encourages maximum usage of fresh air. Health technical memoranda (HTM) 03[9] tends toward:

a) Natural ventilation wherever possible and compliant with healthcare standards. Recent research initiated by the Department for Health and Social Care (DHSC) and carried out by University of Cambridge indicated that approximately 50% of the floor area of a modern hospital could be naturally ventilated whilst the other 50% requires mechanical ventilation, mechanical ventilation with cooling, and/or air conditioning. This research also suggested that careful design and construction using "Advanced Natural Ventilation" could *increase* the proportion of naturally

[5] Duncan, J. (2011), "The effect of colour and design in labour delivery: A scientific approach", *Optics & Laser Technology*, Volume 43, Issue 2, March 2011, Pages 420-424.
[6] Dalke, H. et al (2004), *Lighting and Colour in Hospital Designs*, TSO.
[7] Nanda, U. et al (2012), "Impact of visual art on patient behavior in the emergency department waiting room", *Journal of Emergency Medicine*, VOLUME 43, ISSUE 1, P172-181.
[8] Bosch, S.J. et al (2012), *The Application of Color in Healthcare Settings*, The Centre for Health Design.
[9] DHSC (2007), "Guidance Heating and ventilation of health sector buildings (HTM 03-01)". Online: https://www.gov.uk/government/publications/guidance-on-specialised-ventilation-for-healthcare-premises-parts-a-and-b

ventilated spaces and reduce the mechanically ventilated and/or air-conditioned spaces.[10]

b) Full fresh air in order to purge spaces of any gases or infectious pathogens and use of heat recovery devices for energy efficiency – rather than recirculation of air. This is highly energy intensive and should be changed to allow recirculation. DHSC must undertake research to show recirculation is acceptable. Other countries already allow recirculation (up to 80% in US and others).

**Protecting the environment**

The release of medication received by hospital patients into the wastewater is a huge environmental problem and needs addressing with modern hospital design. There are principally two approaches at present:

1. Dedicated modern wastewater filtration systems that filter out the main drugs like antibiotics and painkillers such diclofenac before they go into the main wastewater system. Such a test wastewater filtration system was successfully installed in the Marienhospital in Gelsenkirchen, Germany.

2. Use of bio-filtration techniques to filter out these waste substances from cleaned wastewater. The University of Dresden are developing a bio-filtration technique using xenobiotic fungi to filter this medication waste from cleaned wastewater.

**Improving sustainability**

In terms of human acceptance and satisfaction, many building owners and operators claim that green buildings provide better health and wellbeing for occupants and can even improve productivity and innovation. This requires building designs which support human interactions and empathy towards a positive and supportive culture, at one with nature and providing enduring impact.

Seattle's Bullitt Centre is one example of a modern building which is occupied by leading edge researchers and provides leadership in energy and environment. The office building is Net Zero Carbon – in fact "positive" with a solar panel PV array across its roof.

The NHS has declared its intent to "green" the NHS Estate and outlines its strategies in HTM 07.[11] However, in practice there is a big gap between the aspirations set out in this HTM and existing facilities.

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[10] Lomas, K.J. et al (2012), "Resilience of 'Nightingale' hospital wards in a changing climate", *Building Services Engineering Research and Technology*, Volume: 33 issue: 1, page(s): 81-103.

[11] DHSC (2013), "Guidance: Management and disposal of healthcare waste (HTM 07-01)". Online: https://www.gov.uk/government/publications/guidance-on-the-safe-management-of-healthcare-waste

The case for "green" hospitals has been made many times.[12] [13] [14] [15]

The gap between intent and practice is due to a range of factors, but often there is a perception of a lack of commitment.

However, the actual reason may be the inability to develop integrated solutions which embody environmental, economic and social interests. Such an approach would see hospitals integrated into the communities they serve in every way possible. For example, the desire expressed by MHCLG and BEIS to see local heat networks emerge as a replacement to gas networks, using waste heat and/or renewable energy to heat buildings would most easily emerge in areas where hospital energy centers were used as the Stage 1 energy supply allowing heat supply Energy Service Company (ESCo) to start at relatively low costs and grow by extending heat pipework and new energy centers. The benefits to the hospital would be extra income received from sale of waste heat, improved resilience by use of continuously running CHP plant rather than reliance on idle stand-by generators (which are a latent cost burden) and the supply of low cost, low carbon heat to local residential areas providing much needed heat to combat health issues related to cold, damp homes.

The Royal Free Hospital is an example of how this can be easily achieved with the hospital supplying heat to the Camden Housing Estate.

Watford Hospital is an example of a failure to apply an integrated approach. At the time they were planning to install a CHP plant to their energy center, Watford Council had embarked upon ambitious plans to construct a £500m "Watford Campus" mixed use and residential development, adjacent to the energy center. A shared ESCo using the Hospital Energy Center as its Stage 1 heat supply would have created one of the first net-zero carbon developments in the UK and provided the Hospital with additional capital funds for CHP plant and a continuing income stream. Unfortunately, this strategy was not followed and the now Watford Campus went ahead on traditional carbon intensive lines.

Internationally, a greener approach to hospital design has been demonstrated. For example, new hospitals constructed in Rwanda, designed by Mezzatti, opted to use natural ventilation instead of the expected "sealed, air-conditioned box" and resulted in an attractive, pleasant and comfortable patient experience leading to better clinical outcomes.

Sustainable development in the UK has generally been poor, but there is now an opportunity to take the lead. A recent report by the Royal Academy of Engineering entitled *Sustainable Living Spaces – a systems perspective on planning, housing*

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[12] Health Care Without Harm (2019), *Health care's climate footprint: How the health sector contributes to the global climate crisis and opportunities for action*, Health Care Without Harm in collaboration with Arup.

[13] ASHRAE/REHVA NZ hospital guide – currently at final draft stage 2020. The new design guide is a joint collaboration between ASHRAE and REHVA and provides leadership in the quest for a net zero carbon future by showing how hospitals which are intense users of energy can become net zero.

[14] Healthier Hospitals Initiative, "Leaner Energy," Online: http://healthierhospitals.org/hhi-challenges/leaner-energy#resources.

[15] Health Care Climate Council (2017), Climate Action Playbook for Hospitals. Online: https://climatecouncil.noharm.org

*and infrastructure*, set out a strategic approach to community sustainability in which hospitals can play a leading role.[16]

**Transport**

The hospitals that we use today have grown up over the last few centuries. In Newcastle the Royal Victoria Infirmary was built over 100 years ago on a site of an Infirmary founded in 1751. In the last 250 years the way that we use hospitals has changed dramatically and we need to understand the logistics of how the staff and patients use the hospital facilities today.

The traditional city centre sites were appropriate when many of the hospitals were built but as society changes so do the requirements of the facilities. The staff and patients come from a large catchment area and arrive using many different forms of transport. Ideally, these groups could walk or cycle to the hospital or failing this they could use an integrated transport system. There would be adequate and easy to use parking for those that were unable to use mass transit systems and it would be easy for those that needed special help to use the patient transport services.

The conflicting requirements of the local authorities and the hospitals often create an impasse where the people who suffer are the people who use the facilities. For the hospitals of the future it is essential that the different user groups are considered and a series of practical solutions are made available. These should take into account a number of issues:

- Is it essential for the staff and patients to be physically present in the facility?
- How do we minimise the number of people who are queuing in the facility? Perhaps the use of "Just in Time" techniques could reduce the time that people needed to spend in the facility with the corresponding reduction in parking utilisation and the subsequent reduction in the pressures on infection control.

It is incumbent on the hospital to provide access solutions for users. The current non-integrated transport systems place the burden on the facility users leaving them feeling unhappy and stressed. Indeed, they have little control over what transport systems exist, how easy it is to use the city centre road network or how far they have to come to use the buildings. The typical users should be considered and the eventual access solutions should make the system of interacting with the facility as satisfying as possible. It would be relatively easy to "wargame" how individuals use the hospital and to ensure that the vast majority of people were catered for.

[16] National Engineering Policy Centre (2020), *Sustainable living places – a systems perspective on planning, housing and infrastructure*, Royal Academy of Engineering.

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