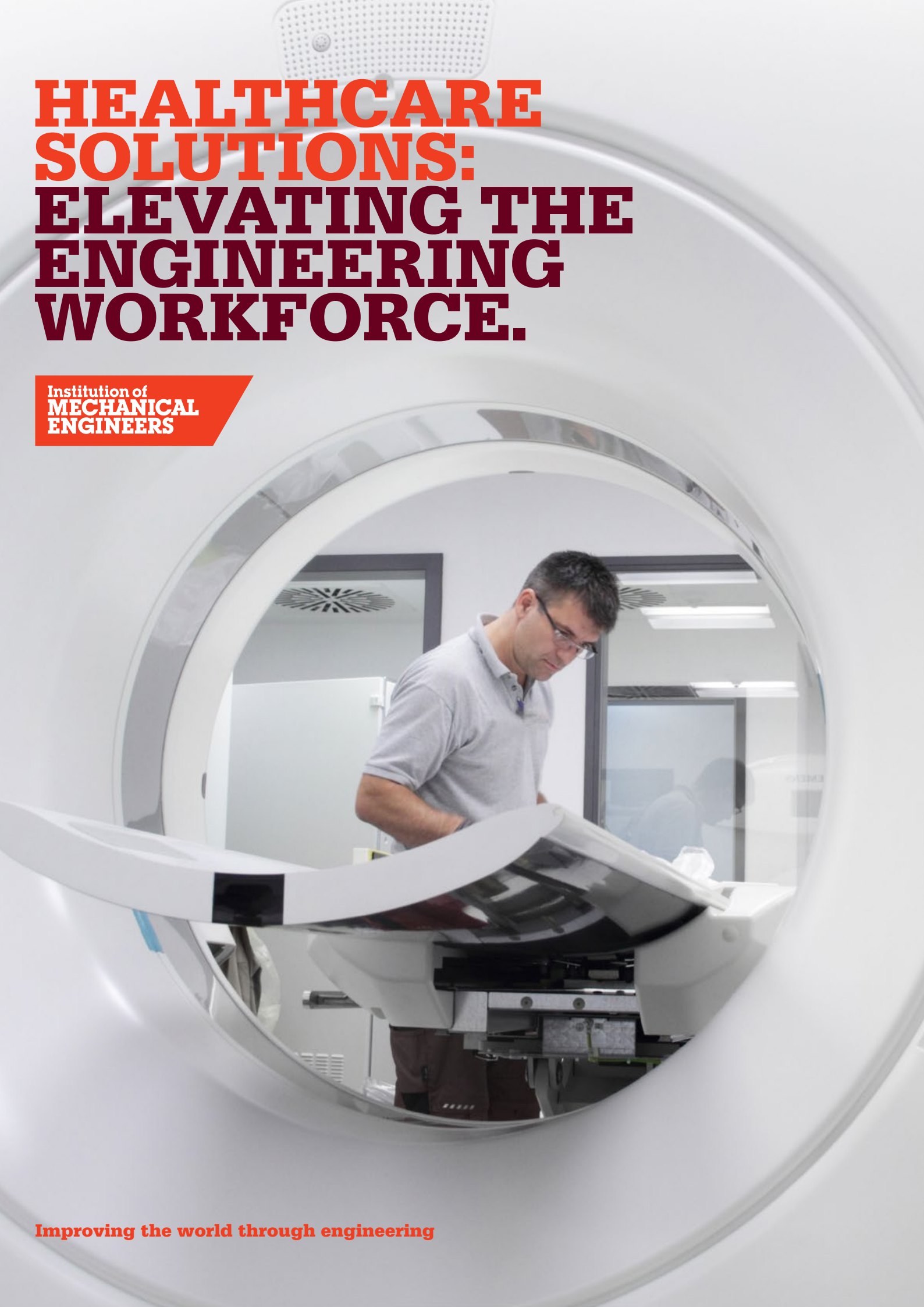
HEALTHCARE SOLUTIONS: ELEVATING THE ENGINEERING WORKFORCE.

Institution of MECHANICAL ENGINEERS



Improving the world through engineering

Like doctors, chartered professional engineers and technicians have a 'Statement of Ethical Principles' in which we aspire to "do no harm", by ensuring we do not compromise where society's welfare and safety is concerned, and that we listen and work with society to create transformative technology for the right reasons. It follows then, that caring for society forms a fundamental imperative for engineers in healthcare and is at the forefront of all we do.

Despite WHO calling upon all countries to "recognise engineers working in healthcare settings as an essential professional role for the future of clinical and social care", there continues to be disparity between healthcare engineers and clinicians.

By adopting a more allied approach and creating professional parity between engineers and their clinical counterparts, healthcare 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 or business models. This, however, could only be achieved with the creation of engineers with a more diverse range of skills, responsibilities and training.

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Executive Summary

Healthcare services across the globe are under increasing technical, financial, societal and political pressures, regardless of size or wealth of the nation. This pressure is being driven by an increasingly ageing population with expectations of continuing health and independence into old age. At the same time, we are witnessing a rapid expansion in healthcare coverage in developing nations and the advancement of medical technology that has enabled previously intractable conditions to be treated.

While challenging, such pressures often create new opportunities for better, safer and more universally accessible care, which the engineering community, alongside clinicians, is well placed to tackle.

If we are to learn from global crises such as the recent pandemic, it is that 21st century medicine can only be delivered with significant amounts of technology and that care at home is just as critical as care in hospitals.

Working side-by-side with clinicians, engineers in healthcare can help to ensure the highest levels of care and safety for patients and guarantee that where medical technology and services are being implemented, they are the right tools for the job.

The Institution of Mechanical Engineers believes that to deliver safe and affordable care in this fast-changing environment, healthcare engineers need to have increased authority and decision-making powers, as well as a wider range of skills.

The Institution is calling for the creation of a new position of Chief Healthcare Engineer and a new healthcare engineering role in Social Care. In a parallel report, "Healthcare Solutions: Improving Technology Adoption" we look at the role of engineers in improving technology use and innovation.

Chief Healthcare Engineer with Strategic Oversight

Every hospital should have a Chief Healthcare Engineer, a position of professional parity with roles such as the Head of Surgery, Chief Nurse and Chief Pharmacist. These engineers would have consistent qualifications, level of authority, decision-making abilities and connectivity with other hospitals. This would not only promote best practice in the procurement, maintenance and use of medical equipment but increase the opportunity for cost savings across the healthcare service. In many hospitals, the concept of Chief Healthcare Engineer may already exist, albeit under different titles, departments and levels of authority. The cost of creating this board-level position would be recovered from the long-term benefits to patients, services, budgets and healthcare providers.

Patient-Enablement Engineers and Technicians in Social Care

The growing desire to move long-term care and treatment out of the clinical setting, is creating a new dilemma for already overwhelmed social care systems. Steps should be taken to build on the well-proven techniques of rehabilitation and assistive technology engineering to create the patient care pathway at home. Patient-Enablement Engineers and Technicians would work exclusively in the space between acute care and social care with their clinical colleagues. They would not only require the full remit of engineering qualifications and skills but in-depth clinical and social care knowledge as well as management and customer service experience.

Professional Engineering Institutions should work with healthcare providers, and healthcare engineering leadership organisations such as the Academy for Healthcare Science and National School of Healthcare Science in the UK, to create new training programmes in areas such as process flow, procurement and purchasing, and strategic planning, to support engineers working in social care.

Introduction

In 2016, the Institution called for the creation of the role of Chief Healthcare Engineer in every NHS Trust. The Institution is renewing this campaign which aims to raise awareness of the work and value of engineers within the NHS. This has become even more important given the recent global healthcare crisis and rapid developments in healthcare technology in the past few years.

This new decade is expected see further sizeable transformations in the way healthcare is delivered. At the same time, the Government faces the continuing challenge of supporting a rapidly ageing population with limited financial and material resources. This is not a phenomenon unique to the UK. Similar challenges exist across many of the world's healthcare systems, in both developed and developing nations.

Global crises such as the recent pandemic have highlighted that that 21st century medicine can only be delivered with significant technology input and that care at home is as important as care in hospitals.

Healthcare services in the UK and across the globe are under growing pressure both demographically and technologically. The recent Topol Report[1] on the 'Healthcare Workforce in the UK' recognised that a new type of clinician will be needed in the hospitals of the future; one who can embrace both medical and technical skills.

Engineers working in the healthcare sector today are already trained and prepared for this way of working. However, unlike clinicians there is little uniform recognition of their contribution, particularly in the hospital environment. Engineers are often assigned to non-clinical departments, operate at varying levels of authority and have limited input into critical decision-making.

In the UK, an isolated approach to procurement and inconsistent distribution of innovation within and between NHS trusts, in part due to poor operational management decisions, is a key reason for the slow uptake of technology[2,3]. Entrenched approaches to innovation have resulted in money being wasted on unsuitable or poorly specified devices. In some cases, technology is being incorrectly used[4] or disposed of because it fails to meet the needs of the clinicians and patients.

At a time of financial constraints within the healthcare sector, the lack of co-operation and co-ordination between engineers and clinicians could have a long-term impact on the ability of healthcare providers to make cost savings on technical resources and improve process effectiveness in front-line services.

The Institution is well-placed to support healthcare engineers to provide workable and cost-effective solutions that will inform decision-making at all levels of Government and care provision. It is the Institution's opinion that an appropriately trained workforce is key to ensuring the delivery of safe, affordable care on a global scale. Failure to act on these requirements will increase the risk to patients' health in the long term.

The Institution of Mechanical Engineers believes that:

1. Healthcare engineers should have professional parity with their clinical counterparts.
2. The healthcare engineering workforce will need new skillsets to adapt to the changing healthcare landscape.

Engineers in Healthcare

Whatever an engineer's role and responsibility in the healthcare sector, their training will have involved taking the principles of applied sciences and physical sciences and combining them with biology and medicine. These engineers are able to mimic even the most complex aspects of human physiology and anatomy[5] by applying a systems principles, diagnostic measurements and therapeutic tools.

The subjects and disciplines these engineers might train in include:

- Mechanical
- Physics
- Fluid mechanics
- Electrical
- Mathematics
- Biotribology
- Electronics
- Informatics
- Medicine
- Mechatronics
- Biomechanics
- Physiology & Anatomy
- IT & software development
- Biomaterials
- Sports Exercise & Technology
- Civil & Building Services
- Robotics and Automaton

Engineers' titles vary depending on their role, or whether they are in industrial or clinical (hospital) settings. Typical titles include:

- Biomedical Engineer
- Rehabilitation Engineer
- Medical Engineer
- Estate and Facilities Management Engineer
- Bioengineer
- Health Systems Engineer
- Clinical Engineer
- Medical Design Engineer

Biomedical and Clinical Engineer are the most common titles in the UK.

In 2014 the World Health Organisation defined the role of Biomedical Engineers as those people who are "trained and qualified…professionals… required to design, evaluate, regulate, maintain and manage medical devices, and train on their safe use in health systems around the world"[6]. The European Economic and Social Committee and the European Alliance for Medical and Biological Engineering and Science went on to state that "Biomedical engineering is not a subset of modern medicine; modern medicine is the product of biomedical engineering".[7]

The Hidden Faces of Engineering in Healthcare

Medicine would not be as advanced as it is today, if it were not for the 'life-affecting' contribution of engineers in healthcare. These engineers develop devices which diagnose, treat and rehabilitate patients. They create technologies which help measure, model and simulate human physiology and anatomy; enabling doctors to make ever-more precise diagnosis. They are the pioneers of artificial joints and organs, and robotic surgical equipment which has facilitated minimally invasive procedures. They have explored the growing area of monitoring personal health via mobile communications, allowing patients to be connected with their doctor 24/7, and they ensure the vital supply of gas and air arrives in theatre when the surgeon needs it.

From Sir Godfrey Hounsfield and Sir Peter Mansfield; the early pioneers of Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) to the life-saving cerebral blood flow techniques conceived by Prof. David Delpy, engineers have been changing the way healthcare is provided for decades.

Prof. Chris Toumazou has received over 25 awards for his pioneering advances in DNA sensing and vital-signs monitoring, the latter of which is estimated to reduce hospitalisation by up to 4 days and save over £3,000 per patient.

Below are a few of the many people working at the cutting edge of healthcare engineering, yet their faces go largely unrecognised by the patients they help care for.

This progress could slow due to the world-wide shortage of engineers which has been well documented for the last decade. According to the 'Create the Future' Report[8], the US, China, Germany and South Africa all agree that the supply of qualified engineers' lags behind employer demand. In the UK, the Royal Academy of Engineering estimates 124,000 engineers and technicians are needed per year to address the shortfall[9]. The same can be said of clinical roles, where 1 in 12 acute and primary care jobs in the UK is vacant.

The existing healthcare 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.

Robert Jarvik
Artificial heart

Earl Bakken
Battery operated external pacemaker

John Charnley
Artificial hip replacement

Molly Stevens
Regenerative medicine

Ioannis Yannas & Dr John Burke
Artificial skin

Graeme Clarke
Cochlear implant

Willem Kolff
Kidney dialysis machine

Rebecca Richards-Kortum
Low-cost, portable imaging system

“”

Prof. Chris Toumazou has received over 25 awards for his pioneering advances in DNA sensing and vital-signs monitoring, the latter of which is estimated to reduce hospitalisation by up to 4 days and save over £3,000 per patient.

Healthcare Engineers' Professional Commitment to Society

The Institution is committed to ensuring that the views of engineers are well represented in the public domain and that its members embody the Institution's vision to "Improve the World through Engineering".

In response to international healthcare challenges, the Institution has defined a professional commitment for healthcare engineers. It urges all healthcare engineers across the globe to ensure that every hospital has professionally recognised engineers and technicians with consistent qualifications, levels of authority and decision-making abilities.

Such harmonised approaches across the healthcare engineering profession would raise the profile and level of importance of engineering in both clinical and medical technology manufacturing sectors; aiding recruitment and retention of engineers across the sector.

THE PROFESSIONAL COMMITMENT OF HEALTHCARE ENGINEERS

1. **Guarantees Patient Safety**
   Overseeing quality of clinical care by analysing and reporting on incidents involving medical devices to improve patient safety
2. **Facilitates Patient-Centric Care**
   Providing direct patient services by applying innovative technologies and facilitating the manufacture of patient-specific equipment
3. **Ensures Value for Money**
   Achieve maximum value from investments in technology by benchmarking data across the whole health sector to secure cost-efficient procurement and sustainable maintenance of key equipment
4. **Expedites faster Access to Medtech**
   Supporting medical device clinical trials and providing a unique skill-set to bring industry-led product development and academic research into clinical practice in a timely manner
5. **Creates Long-Term Strategy**
   Delivering a sustainable and well-defined plan to maximise patient safety, clinical efficacy and overall value from medical technology through understanding the needs of the clinician, patient and wider healthcare provision

The Impact of Healthcare

UK HEALTHCARE

For nearly 70 years, residents of the UK have enjoyed the security of a national healthcare service, providing 'free at the point of service' universal care to all members of the population, regardless of income, social status or illness.

The National Health Service (NHS) is one of the most admired services in the country. Indeed, the services provided by the NHS, and the commitment and dedication of its 1.5m employees, are particularly valued by people across the UK, with the public consistently voting the NHS as the thing that makes them most proud to be British.

Globally, the NHS is the envy of many nations in terms of service and delivery. In 2014 the Commonwealth Fund reported that the NHS, when compared to many of the leading healthcare services in the world, such as Australia, France, Sweden and the United States, was "the most impressive overall". In particular, the NHS was rated as the best system in terms of efficiency, effective care, safe care, co-ordinated care, patient-centred care and cost-related problems. However, offering this universal healthcare service comes at a cost. Today the NHS consumes over £135bn a year of taxpayers' money. This cost is inevitably going to grow as our population grows, our life spans increase, and more advanced and expensive treatments become available.

UK Healthcare

The NHS employs approximately **1.5m people**[10]

The NHS sees about **1 million patients** every 24 hours[11]

There are more than **150,000 beds** in UK hospitals[12]

Average cost per person[13]

England	**£2,168**
Scotland	**£2,353**
Wales	**£2,310**
N. Ireland	**£2,306**

The NHS workforce includes about **3,000 clinical engineers**

NHS land/estates **650 hectares (66km² or 25mi²)** (twice the size of Lincoln)[14]

Global Healthcare

The World Health Organization estimates, worldwide there are:[15]

9.2 million physicians

19.4 million nurses and midwives

1.9 million dentists and other dentistry personnel

2.6 million pharmacists and other pharmaceutical personnel

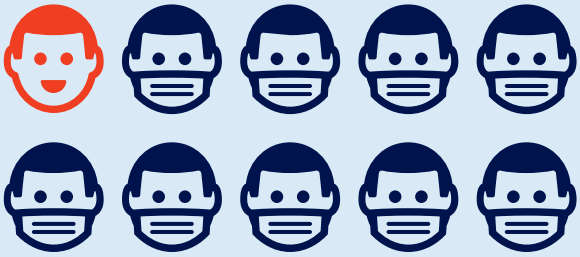
1.3 million+ community health workers

WHO reported that, by 2020, almost half of the global healthcare expenditures – **about $4 trillion** – will be spent on three leading causes of death: **cardiovascular diseases**, **cancer** and **respiratory diseases**.[16]

The global healthcare market reached a value of nearly **$8,452 billion** in 2018, having grown at a Compound Annual Growth Rate (CAGR) of 7.3% since 2014, and is expected to grow at a CAGR of 8.9% to nearly **$11,908.9 billion** by 2022.[17]

At least half of the world's population (7.3 billion people) do not have full coverage of essential health services.(18)

The WHO Global Strategy on Human Resources for Health: Workforce 2030 (GSHRH) estimates **a global shortfall of almost 18 million health workers by 2030**, primarily in low-income and lower-middle-income countries.(19)



It is estimated that, globally, **9 out of 10** people dwelling in urban areas are exposed to air pollution. Poor air quality is associated with increasing risk of stroke, heart disease, lung cancer, and chronic and acute respiratory diseases.(20)

Conclusion

The Institution is well-placed to support healthcare engineers to provide workable and cost-effective solutions that will inform decision-making at all levels of Government and care provision. It is the Institution's opinion that an appropriately trained workforce is key to ensuring the delivery of safe, affordable care on a global scale.

The Institution of Mechanical Engineers believes that:

- Healthcare engineers should have professional parity with their clinical counterparts
- The healthcare engineering workforce will need new skillsets to adapt to the changing healthcare landscape.

To achieve this, two key roles must be created:

Chief Healthcare Engineer with Strategic Oversight

Every hospital should have a Chief Healthcare Engineer, a position of professional parity with roles such as the Head of Surgery, Chief Nurse and Chief Pharmacist. These engineers would have consistent qualifications, level of authority, decision-making abilities and connectivity with other hospitals. This would not only promote best practice in the procurement, maintenance and use of medical equipment but increase the opportunity for cost savings across the healthcare service. In many hospitals, the concept of Chief Healthcare Engineer may already exist, albeit under different titles, departments and levels of authority. The cost of creating this board-level position would be recovered from the long-term benefits to patients, services, budgets and healthcare providers.

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