

# Child health technology: shaping the future of paediatrics and child health and improving NHS productivity

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## ABSTRACT

In the last decade, technology has revolutionised the way we deliver healthcare. Smartphones, tablets, personal computers and bespoke devices have provided patients with the means to access health information, manage their healthcare and communicate with health professionals remotely. Advances in technology have the potential to change how acute and long-term conditions are diagnosed and managed and how illness is prevented using technological advances in artificial intelligence, virtual and augmented reality, robotics, 3D printing, new materials, biosensor technologies and data analytics. In the future, predictive analytics will help with earlier disease diagnosis in at-risk populations. Historically, development of child health innovation and technology has taken place in a relatively emergent manner with little formal coordination. The aim is to move away from the traditional approach of repurposing adult technologies to provide a large-scale and coordinated approach for the development of bespoke health technology for children that is anatomically, physiologically and developmentally appropriate, versatile and that has been designed with children and young people. The challenge for the National Health Service alongside healthcare systems across the world is to deliver increasingly complex healthcare at lower cost and with better quality of life and greater efficiency.

## INTRODUCTION

Health technology is defined by the WHO as the application of organised knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of lives.<sup>1</sup> Children and young people have embraced technology and incorporated this into their daily lives. Nine-in-ten children in the UK now own a mobile phone,<sup>2</sup> and increasingly children are using health applications (apps) as tools to improve their health.<sup>3–7</sup> Thus, a new generation that views technology as a part of daily life is likely to be responsive to technology that supports investigation and management of their health in areas such as self-management, remote monitoring, point of care testing, imaging and artificial intelligence (AI). This is matched by the need to improve healthcare delivery and efficiency by modifying specialised children's services with limited resources. Sustainable change could be achieved through the greater use of digital technology, with an emphasis on preventative care, and on more integrated care pathways. The impact of new technologies for child

health will need to be measured by improvement in the delivery of care at similar cost or cost savings to the National Health Service (NHS), but should also account for further societal improvements such as improved educational opportunities for children and a reduction in days lost by parents having to attend multiple appointments. Faced with a funding gap of £30 billion by 2010–2021, NHS England has projected potential savings from moving care from hospitals to community, integrating services through Accountable Care Partnerships, increasing the focus on prevention and further development of digital health. The latter encompasses decisional support systems that use algorithms derived through mining clinical datasets, mobile health apps, or m-health which can support and monitor healthy behaviours, connected biometric sensors, such as continuous glucose monitoring, consultations using telemedicine and the use of electronic personal health records accessible to clinicians and patients. While this will offer better access to specialised services for children and young people by reducing the need to visit hospital, the greatest challenge is to ensure that the delivery of these services results in cost savings, increased efficiency but also cross-sector benefit through increased industry productivity in the UK Life Sciences Sector. Fundamentally, it is vital to ensure that the implementation of technology to support prevention, improved quality of life in long-term conditions, addressing unmet needs and new models of healthcare delivery is focused on child health to ensure that health inequalities in early life are addressed for future prosperity.

## THE NEED

The NHS Five Year Forward View sets out the NHS's vision for the future and commits to accelerating the adoption of cost-effective innovation and medical technology stating that 'the future health of millions of children, the sustainability of the NHS, and the economic prosperity of Britain all now depend on a radical upgrade in prevention and public health'.<sup>8</sup> Correspondingly, the Chief Medical Officer's report<sup>9</sup> presents the case for greater paediatric focus in all aspects of health service innovation, outlining the long-term health economic argument, with child health impacting parents' abilities to make economic contributions, the long-term cost of the child's healthcare and loss of the child's potential economic and societal contribution in later life. As stated recently, 'children and young people are a quarter of our



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population but 100% of our future.<sup>10</sup> Given the fact that many of the diseases that account for a significant proportion of the NHS budget in adulthood have their origins in childhood, this provides a compelling argument for developing novel technological approaches to prevention in childhood. Heart disease results in 73 000 deaths each year<sup>11</sup>; over 2.1 million people under the age of 45 had high blood pressure in England in 2015<sup>12</sup>; more than 100 000 people per year have a stroke,<sup>13</sup> deaths from chronic liver disease have risen by 20% in the last decade in part due to the rise in obesity and alcohol consumption<sup>14</sup>; and it is estimated that by 2030, four million people in the UK will have had a form of cancer.<sup>15</sup> Unhealthy lifestyles have their origins in childhood and are a major contributing factor to adult diseases. Despite this, development of child health innovation and technology has taken place in a relatively emergent manner with little formal coordination. The relatively diminutive numbers of children with certain diseases means that a scalable approach on a national or international level is required to ensure that industry has a viable commercial offering to drive digital and device development for child health, thus collaboration between UK and international centres may be required. Moreover, the development of technology for children's healthcare has been blighted with complications due to the insufficient/inappropriate repurposing of technologies from adult healthcare, thus establishing the need for bespoke technology developments for child health.

The need for new and innovative approaches to prevention in childhood to ensure that our population remains healthy well into adult life is matched by a compelling argument for developing new methodologies and technologies to manage long-term conditions. The delivery of healthcare in the community and homes provides greater opportunities for children to benefit from education and peer-group integration. Improving the health of children and young people leads to an improvement in educational attainment. Where poor school attendance and poor achievement are present, the risk of ill-health is 4.5 times higher in adulthood.<sup>16</sup> Thirty-one per cent of school pupils aged 11–15 years in 2012 who reported having a long-term illness, disability or medical condition felt it impacted negatively on their ability to participate in education.<sup>17</sup> Technologies are now being developed that have the potential to deliver and support healthcare in the community and home setting, reducing the number of hospital attendances, and allowing children to attend full-time education and helping parents to maintain employment. These technologies include those that allow better self-management of long-term conditions through biometric feedback, point-of-care testing and m-health digital platforms, and remote monitoring and sensor technology to transfer information to clinicians in real-time or near real-time without the need for the patient to directly access services. The use of telemedicine in conjunction with remote biometric feedback has the potential to reduce the need for hospital consultations and deal with escalation of clinical symptoms at an earlier stage to prevent hospital admission. The paediatric healthcare of the future may transition to a more 'command and control' approach by which monitoring of parameters is carried out centrally but children and young people remain in the community. The Mercy Virtual Center in Chesterfield, Missouri (<http://www.mercyvirtual.net>), described as 'a hospital without beds or patients', is a revolutionary example of the virtual adjunct to conventional healthcare by using telehealth and monitoring to deliver real-time information to medical professionals across the USA and internationally to support 44 hospitals in the Midwest, USA.

## New solutions

Advances in technology are moving at pace. Understanding how these technological advances will address unmet needs in paediatrics and child health is matched with the challenge of supporting the adoption of new technologies at pace over a wide geography, within the complex NHS environment. Technology solutions for child health problems are already attempting to address unmet needs in large patient groups. Gamification and virtual reality (VR) systems are now supporting neurorehabilitation allowing the transfer of rehabilitation technologies into the home environment.<sup>18–20</sup> Prosthetic limbs are now being developed that are light-weight, customised and use the latest sensor technology to control movement (eg, <https://openbionics.com>). Advances in speech recognition software now support children with significant speech impairment in articulating their needs (eg, <http://www.catch.org.uk/current-project/vocatempo/>). New technological approaches are now being trialled for paediatric surgery to improve the patient experience, adapt the environment and advance surgical techniques. 3D printing provides physical three-dimensional print models to facilitate perception of complex anatomy and clarity of imaging in assisting surgical intervention,<sup>21 22</sup> and VR simulation of an operating theatre is now being used to alleviate preoperative anxiety and increase compliance during anaesthesia.<sup>23</sup> VR is also now being incorporated into training packages for surgical interventions with several Cochrane reviews in different surgical disciplines, highlighting the need for randomised clinical trials with high methodological quality.<sup>24–26</sup> Virtual and augmented reality environments are currently undergoing investigation to determine the value of these novel modalities in postsurgical rehabilitation. Digital health interventions, including computer-assisted therapy, mobile technologies and wearable technologies, have great potential to improve uptake and accessibility, efficiency, clinical effectiveness and personalisation of mental health interventions in children and young people and are potentially cost-effective.<sup>27–29</sup> Technology-based mental health interventions for children and young people reduce the costs of office-based infrastructure, reduce family travel (particularly in more remote areas), reduce the stigma of visiting mental health services in the community and hospital, and help to manage already challenged child and adolescent mental health services.<sup>21</sup> The NHS digital child health record (Digital Child Health Transformation Programme—NHS England) will open in 2021 to provide better monitoring and personalised care for children including an online record of children's health and development, a means of communicating with healthcare professionals to set goals for health and well-being, and a system that allows healthcare professionals access to key health information to improve decision-making.

A number of key areas in child and adult healthcare are set for future development. Exoskeletons designed to provide better mobility may soon support rehabilitation in children with neuropathic and myopathic disorders. AI platforms will be used to support diagnostics in digital pathology and imaging. Data innovation hubs will be established across the UK to analyse large amounts of clinical data to predict future ill health and complications and redesign service delivery in the greatest areas of need. The publication of the National Institute for Health and Care Excellence guidance on transition<sup>22</sup> points to an opportunity to develop bespoke technology solutions that meet the needs of young people with long-term conditions through transition. This has become more important as increasing numbers of young people are moving away from home for educational and employment opportunities.

However, while a number of areas of child health will advance and improve as a result of technology, there are greater challenges ahead in addressing social determinants of child health and child health inequalities. The application of technology in these areas to implement change will require collaborative working between health, social care, education and policy-makers. A life-course approach to these changes is required starting with improvements in maternal and child health (in-utero health), with due consideration given to child and adolescent mental and physical health.

### Changing the way healthcare is delivered

Three factors have been cited as driving innovative change in healthcare: the changing pattern of disease that has occurred over the past century, the need for new ways of organising and delivering services, and overcoming resistance to change from within the healthcare system for whom a shift from the status quo is threatening.<sup>30</sup> Development of cutting-edge child health technology thus needs to be supported by 'innovation systems' that focus on the immediate and wider environment adopting the technology, with a strong focus on networks and institutions that shape and introduce innovation. Child health innovation systems require a focus on improving patient outcomes and promoting health through prevention, underpinned by efficiency and improved financial returns that consider the individual and the family unit, care and service provision, and the healthcare environment. None of these categories are mutually exclusive, and changes in one will have an impact on the other. For example, improved rehabilitation through adaptive technology will involve the development of bespoke specialist equipment for children, but will also need modification in the service pathway, training of current or new staff, and a willingness to use new technology and may require a shift in the delivery of care from the hospital to home. Similarly, in an era in which biometric feedback can now be derived from biosensors and communication with patients and families is improved through telemedicine, new models of care will need to evolve to modify the delivery of specialist paediatric management from hospital to home.

Fundamental to the innovation process and central to the innovation system is the interaction, integration and collaboration with patients and their families through user-centred participatory design. Patients and their families need to be involved at every step of the innovation pipeline to ensure that products are not only fit-for purpose but have a strong chance of being accepted, commissioned and incorporated into healthcare services. A collaborative interchange surrounding the patient and their families should develop between industry, academics

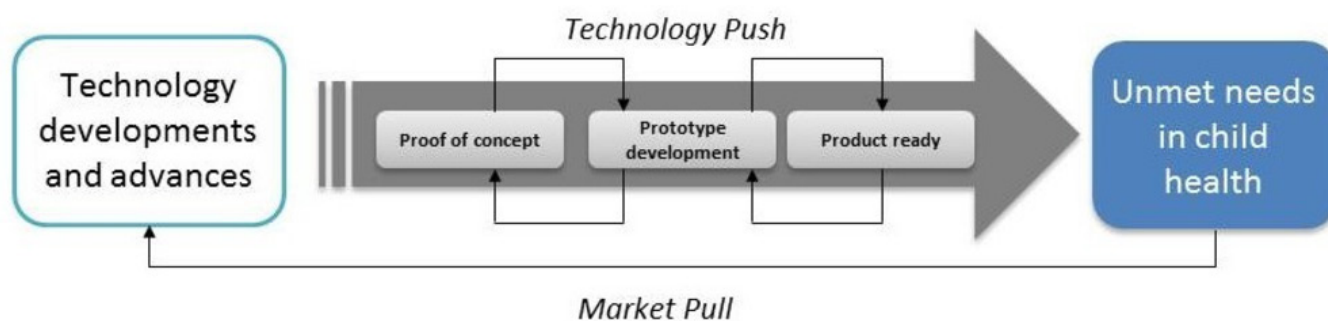
and clinicians through which transactions support prototype and product development with each of these partners benefiting from the innovation process, but at the same time ensuring that the patient remains the primary focus of the interaction. User-centred design must also extend to the involvement of those delivering a service to facilitate modification of processes or services to allow optimum integration and use of the technologies.<sup>31</sup> Enabling clinical staff as key users of the technology to engage in the technology development process allows their own needs and expectations to be considered and future-proofs technology integration within the designated service. Health systems must also be flexible to technology integration, and early focus on strict regulatory frameworks within child health must be considered to ensure that these do not hinder the integration of technology into established systems and practices.

From a patient and clinician perspective, identifying unmet needs to drive technology development provides a 'market pull' for industry and academics—when products are produced in response to market forces. Aligned with this is the principle of 'technology push'—when research and development supporting new technological advances drive the development of new products.

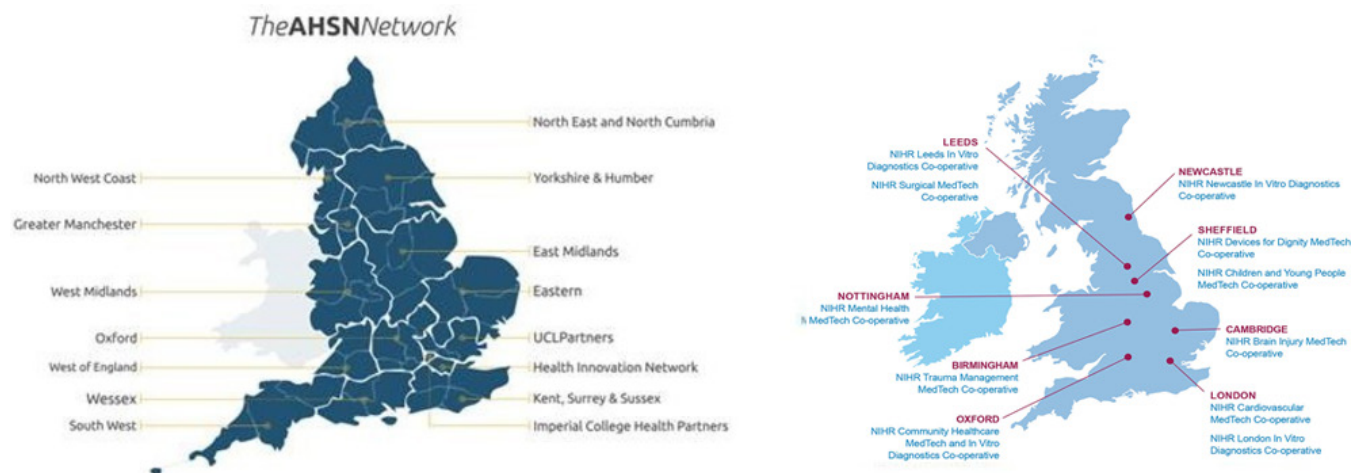
Thus, for a successful innovation system to evolve to drive the development of bespoke child health technology, market pull derived by defining areas of need in child health should be underpinned by a knowledge of available technologies to drive new innovation—'technology push'. Collaboration between industry, health, academics and patients promotes 'market pull' and 'technology push' in this system. Industry and academics provide knowledge of the latest scientific advances to catalyse the development of new technologies; conversely, clinicians provide industry and academics with a catalogue of unmet needs that can be addressed through advanced technology (figure 1).

### Supporting the development and delivery of technology in the NHS

Given the need to provide a scalable opportunity for industry to work with clinicians to develop technology for child health, in 2014 a National Network was established called Technology Innovation Transforming Child Health (TITCH). Since its inception, the National TITCH Network has brought together the independent English Specialist Children's Trusts, Specialist Children's Centres and Hospitals and District General Hospitals to support child health technology development. The Network has been supported by the National Institute for Health Research (NIHR), the Academic Health Science Networks (AHSNs) and the NIHR Devices for Dignity Medical Technology Co-operative.



**Figure 1** Market pull and technology push in child health technology development: technological advances provide the catalyst for novel technology developments in children's healthcare; unmet needs in children's healthcare inform the development of novel technologies to meet healthcare requirements.



**Figure 2** The AHSN (from <http://www.ahsnnetwork.com>) and NIHR MICs (from <https://www.nihr.ac.uk/about-us/how-we-are-managed/our-structure/infrastructure/Documents/medtech-and-in-vitro-diagnostic-co-operatives.htm>). AHSN, Academic Health Science Network; MIC, Medtech and In-vitro Diagnostic Co-operative.

In 2018, the first paediatric UK medical technology co-operative was established named the NIHR Children and Young People Medical Technology Co-operative (NIHR CYP MedTech). NIHR CYP-MedTech led by Sheffield Children's NHS Foundation Trust brings together seven specialist centres to focus on areas of high disease burden and unmet need. This is 1 of 11 NIHR MedTech and In-vitro Diagnostic Co-operatives established by NIHR to build expertise and capacity in the NHS to develop new medical technologies and provide evidence on commercially supplied in-vitro diagnostic tests (figure 2).

Other organisations, networks and processes have been established to support and promote health technology development and adoption. The Clinical Entrepreneur Training programme (<http://www.innovation.england.nhs.uk/en/clinical-entrepreneur>), codesigned by NHS England and Health Education England, has been developed to provide clinicians with the skills, knowledge, experience and leadership capacity needed to deliver digital health, genomics, data analytics and advanced technology. The NHS Innovation Accelerator (NIA) has been developed to support the delivery of the Five Year Forward View<sup>8</sup> by accelerating uptake of high-impact innovations for patient, population and NHS staff benefit, and the recent introduction of the NHS Innovation and Technology tariff provides Trusts with an incentive to adopt technology through commissioning. The NIA is an NHS England Initiative delivered in partnership with all AHSNs across England. There are 15 AHSNs across England established by NHS England in 2013 to facilitate adoption of health technology by working with commissioners to improve health and generate economic growth. Each AHSN works across a distinct geography serving a different population in each region (figure 2).

Funding for technology development comes from a number of funding bodies, including Innovate UK, NIHR i4i (Invention for Innovation), NHS England Small Business Research Initiative Healthcare, Medical Research Council and Engineering and Physical Sciences Research Council. More recently, the Accelerated Access Review has been established to speed up access to innovative drugs, devices and diagnostics for NHS patients.

## SUMMARY

There is a greater need for a life-course approach to technology development that focuses on early life to ensure that

healthcare technology rapidly advances and improves healthcare delivery now and in the future. Collaboration between industry, academics and clinicians is key to ensuring that unmet needs in child health are addressed by the latest technological advances. Newly established networks and consortia to support child health technology development provide industry with a commercially viable opportunity to focus on child health formed by a greater understanding of unmet need. Bespoke technologies for child health could revolutionise the way healthcare is delivered, with the potential that a greater proportion of paediatric specialist care will be delivered in the community. The biggest challenge is ensuring that new technologies can meet the demand for cost saving in the NHS.

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