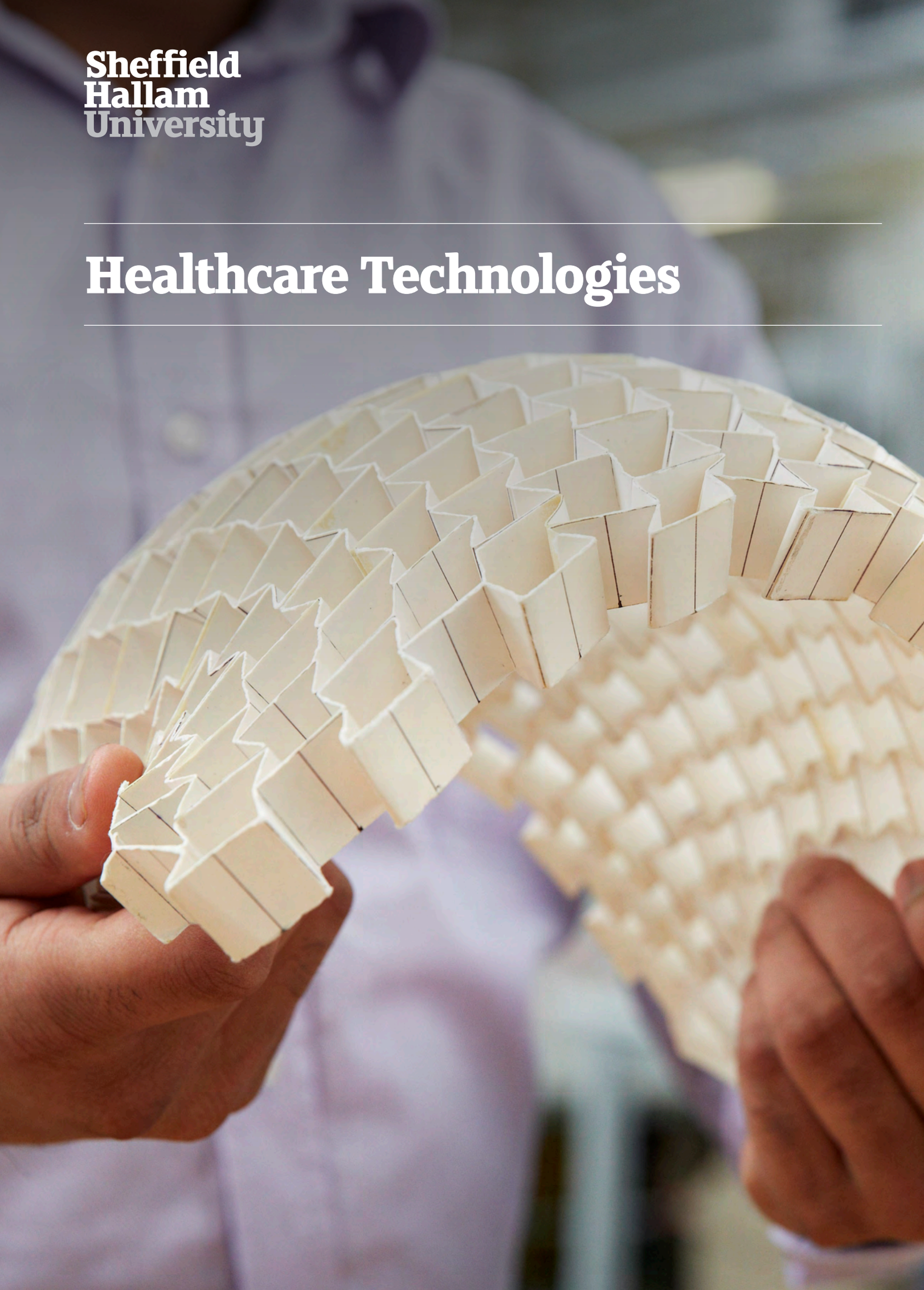
Sheffield Hallam University

Healthcare Technologies



Developing the next generation of healthcare technologies

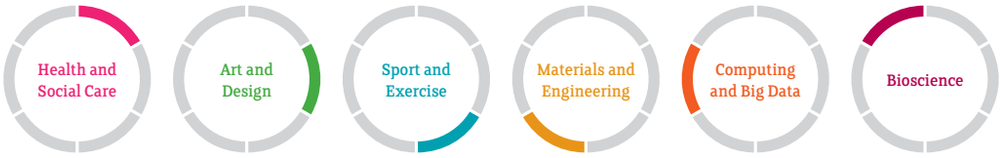
We have a thriving community of academics across a range of disciplines, pioneering facilities, and students who are eager to apply their fresh thinking to new challenges – whether that's affording people with disabilities more independence or developing new products that are tailored to children.

This resource, joined with that of our partners, provides us with considerable knowledge and capability to develop meaningful and effective healthcare technologies – for which there is escalating demand.

A growing population with heightened expectations, coupled with mounting pressure to reduce spending, requires considerable address. Traditional services alone cannot keep pace with this need for change so the development of healthcare technologies is vital. Alongside this, a deeper understanding of our health, lifestyles and demographic differences, further highlights the magnitude of our need to evolve.

At Sheffield Hallam we recognise the urgency of this seismic shift in provision. We're working closely with businesses, clinicians and patients to develop innovative products and get them to market quickly. We're committed to delivering real impact through research, teaching and collaborative innovation, as evidenced through our many examples.

Image opposite: We worked with Trulife UK to redesign their carbon fibre ankle foot orthoses range.
Read the case study on pages 26/27



Interdisciplinary, applied expertise

We have a diverse range of expertise relevant to the development of healthcare technologies. Alongside this depth of knowledge our strong internal networks enable our academics and students to work across disciplines to develop highly effective healthcare solutions.

Art and Design

Having started out as the Sheffield School of Design in 1843, we have a long track record of design activity with industry, incorporating product, packaging and interactive design. Our design specialists work closely with businesses to develop exciting new healthcare products. Meanwhile, our students are regularly set design challenges by clinicians in the NHS to provide an alternative perspective on patient needs.

Health and Social Care

We are one of the largest providers of health and social care education in the UK and have fantastic networks across the clinical landscape, which also provides us with access to patients to identify challenges and test ideas. Our healthcare experts regularly broker relationships between clinicians and colleagues across the University to source specialist knowledge and skills.

Sport and Exercise Science

Our sport provision comprises three dedicated research centres with specialists in exercise science, wellbeing and sport engineering. Our sport academics regularly apply their knowledge to develop healthcare technologies, particularly those that help people to become more active. We were recently awarded £14 million from the UK government to develop an Advanced Wellbeing Research Centre. The University is also a founding partner of the National Centre for Sport and Exercise Medicine, and the National Institute for Child Sport and Exercise Medicine, both based in Sheffield.

Materials and Engineering

Our Materials and Engineering Research Institute is developing advanced applications such as novel equipment for bone density scanning and innovative coatings for hip joint replacements using world-leading technology developed here at Sheffield Hallam.

Biomolecular Science

Meanwhile, the Biomolecular Sciences Research Centre is working in collaboration with the Materials and Engineering Research Institute on regenerative medicine applications such as active wound dressings and injectable hydrogels for musculoskeletal tissue regeneration.

Computing and Big Data

We also have experts in the emerging area of big data who are working with our healthcare experts to help organisations understand the real challenges and opportunities around healthcare information systems management.

The beauty of having so much diverse expertise within one organisation is that we can approach situations from multiple angles. As a result we can create devices that are practical, effective and commercially viable in the eyes of both clinicians and business.

Image opposite: Joe Langley, senior research fellow and design engineer at the University.

Partnerships

Working closely with clinicians, businesses and patients we ensure we're considering challenges from all angles.

We have a considerable network of partners and clients, particularly within the region. We often collaborate with Devices for Dignity, one of eight National Institute for Health Research (NIHR) funded healthcare technology co-operatives (HTCs), and we are developing collaborations with other HTCs.

We're part of the Collaboration for Leadership in Applied Health Research and Care (CLAHRC) Yorkshire and Humberside. Funded by the NIHR, this programme translates healthcare research into practice, with a specific focus on the self-management of long-term conditions.

Child health is a key area for Sheffield Hallam and we're passionate about developing healthcare technologies that are tailor-made for children. The majority of products currently on the market are smaller versions of the adult counterpart, which don't consider the different physiological characteristics of children. As such, we're an active member of the South Yorkshire Institute for Innovation and Research in Child Health (SIIRCH) – an organisation developing cross-sector partnerships and collaborations to support future research that improves child health.

We are one of the founding members of the Technology Innovation Transforming Child Health (TITCH) network: a national healthcare technology co-operative network for children that brings together England's five designated children's hospitals of Alder Hey, Birmingham, Great Ormond Street, Royal Manchester and Sheffield together with the network of HTCs and the University.

Working closely with the Sheffield Local Enterprise Partnership Medical Technology group, a sector advisory group with local businesses, we recognise that all devices need to be manufactured by an industry partner in a commercially viable way.

Design is a powerful tool and plays a significant role in the communication of science to potential investors. We're working with the Design Council's Leadership Programme to create the right environment for science innovation, smoothing the journey from research insight to practical, marketable applications.

We are also founding members of the Centre for Big Data in Sheffield (C-BiDiS) and the newly created Sheffield Digital trade association. Following a partnership of almost 20 years with enterprise software giant SAP, we were confirmed as SAP's UK Centre of Excellence in 2014 and are part of the research consortium working on the REMEDIES (RE-configuring MEDIcines End-to-end Supply) project led by GlaxoSmithKline and Astra Zeneca.

SAS, the world's leading provider of statistical software solutions, has worked with us to develop a range of business intelligence and big data courses. Internal and external collaboration, primarily with Sheffield Teaching Hospitals, another founder member of C-BiDiS, had led to data-centred research in a number of clinical and operational areas within healthcare.

We engage with clients and partners in a range of different ways including

- collaborative research and development
- PhD projects
- consultancy
- undergraduate and postgraduate student projects and placements
- Knowledge Transfer Partnerships
- course validation
- continuing professional development (CPD) and training
- guest lectures
- curriculum development

‘For years I have worked closely with Sheffield Hallam to deliver world-class children’s research and to develop market viable healthcare technology products, and we have jointly developed several networks to support this. The University shares my ambition and drive to create a better world for children, and they have the expertise and facilities to help make this a reality.’

Paul Dimitri, Consultant in Paediatric Endocrinology and Director of Research and Innovation at Sheffield Children’s Hospital

Founding member of TITCH, SIIRCH and the National Institute for Children’s Sport and Exercise Medicine



Technical services and applications

We work at all phases of the product development life cycle, from conception to management and training.

Identifying patient and clinical need

- user and clinician insights
- health economics

Research and analysis

- market positioning and validation
- materials analysis including trace metal, drug and metabolite analysis
- qualitative analysis of volatile and non-volatile organic compounds

Concept development

- new product development (NPD)
- interaction design
- graphic and packaging design
- participatory design
- service design
- engineering design
- materials engineering and modelling
- programming and simulation
- determination of molecular structure

Design development and prototyping

- product prototyping
- computer aided design (CAD) modelling and simulation
- coatings
- organic synthesis of specialty chemical compounds

Testing and evaluation

- appearance and ergonomics
- accurate mass measurement
- bio-analytical testing of products, components and materials
- microbiological testing of products
- biocompatibility of materials
- mass spectrometry analysis of materials
- x-ray fluorescence (XRF) surface analysis

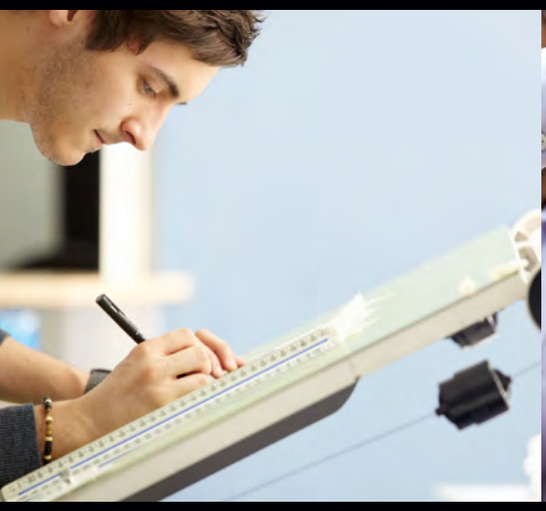
Final design and optimisation

- finite element analysis (FEA)
- design for manufacture (DFM)
- product evaluation
- quality assurance
- commercialisation

We can also help businesses recruit graduates or placement students, train staff on specialist equipment and deliver leadership and management training.

Recruitment, training and development

- continued professional development (CPD)
- leadership and management training
- training staff on specialist equipment
- placement students
- graduate recruitment



Facilities

We have a vast range of facilities and equipment within the University that we use in teaching, research and collaboration with partners, including

- motion capture suites
- high-speed video capture (up to 60,000 fps)
- rapid prototyping including various 3D printing techniques and CNC machining
- 3D virtual suite
- simulation facilities including operating theatres, scrub room and hospital wards
- user lab to reconstruct any domestic scenario, including all utilities
- matrix-assisted laser desorption/ ionisation (MALDI) mass spectrometry imaging
- XRF surface analysis
- electromyography (EMG) to monitor muscle activity and co-ordination of muscles
- differential scanning calorimetry (DSC)
- 3D scanning
- Oculus Rift virtual reality technology
- a suite of mechanical testing facilities
- thermal analysis (TG, TG-MS, and TG-GC-MS)
- SIMS and Mossbauer spectroscopy
- SEM, optical imaging and analysis systems
- HIPIMS and PVD coatings facilities
- UNIX workstations housed in a purpose-built dedicated computing laboratory
- a Beowulf Cluster, currently comprising in excess of 150 CPUs
- mammalian cell culture facilities to mimic the in vivo environment in vitro

Health and Social Care

Art and Design

Materials and Engineering

New snood developed for Motor Neurone Disease sufferers

Current neck support collars for motor neurone disease (MND) patients either don't allow sufficient movement – which is vital to slow down muscle wastage – or don't give an adequate level of support for the head. They are also uncomfortable, bulky and visually unappealing.

Working with partners and funded by the National Institute for Health Research through the i4i (Invention for Innovation) programme, we created a new product. The Sheffield Support Snood was supported by the Motor Neurone Disease Association, Devices for Dignity – Healthcare Technology Co-operative and Sheffield Institute for Translational Neuroscience as well as MND patients and carers.

We engaged clinical neurologists, MND nurse specialists, occupational therapists, physiotherapists and orthotists, as well as industrial designers, healthcare specialists and engineers from the University.

We assessed the comfort of existing MND collars and, using this insight, developed a snood neck support that is flexible and discreet enough to be worn under clothes. Support elements are designed to blend in with the snood material. The snood can be adapted to suit individual needs, manage symptom progression and to cope with different kinds of tasks – for example, travelling in a car might require greater support than usual. The wearer could add some extra support for the journey and then easily remove it when they arrive at their destination.

‘Among our 20 test patients, there was a massive upsurge in using the collar. Across the board, they reported wearing it for 2 hours a day, or 4, or 6 – and in one case 10 hours a day. This tells you what a difference the snood makes.’

Dr Joe Langley, project leader

Health and Social Care

Art and Design

Visionary student project transforms treatment for asthma

Asthma leads to an emergency hospital admission every seven minutes in the UK, yet 75% of these admissions are preventable. Many of these attacks are brought on by panic at not having any reliever drug or the thought of running out.

As part of an Industrial Design MA, one of our students, Mark Fisher, developed an idea for a new type of asthma inhaler that provides 'just enough' medication in a compact, discreet and easy to use package. We helped Mark to access a network of experts to take his idea further, and took him on as a member of staff following the completion of his MA.

The project team worked with a range of design partners, teenage patients living with asthma and a team of respiratory medical professionals from Sheffield Teaching Hospitals. These first-hand insights allowed us to develop a deeper understanding of how asthma medication needed to be redesigned to fit more realistically around people's lives.

The inhaler is breath-activated and simple to use, delivering a pre-metered dose of powdered medication. It contains five shots stored in the sealed unit and is automatically recharged after each use.

When combined with breath activation, this simplifies the process for the individual, resulting in a more effective inhaler that also reduces problems due to poor user technique.

The size of this new device is dramatically smaller than current inhalers on the market. The respiratory clinicians and teenagers with asthma we've surveyed support the new dry powder inhaler design. It has the potential to allow people with asthma more freedom and reassurance when going out and reduces any stigma associated with carrying a usual-sized inhaler. We are currently discussing the concept with manufacturers and negotiating a licensing deal to make the product a commercial reality.

'We're always telling people you must take your inhaler wherever you go. You've got something here that hasn't been done before. To be able to say to my patients "Do you know about this?" would be great.'

Clare Daniel, asthma nurse specialist, Northern General Hospital, Sheffield

Health and Social Care

Art and Design

Computing and Big Data

TacMap™ guides the way for visually impaired tourists

Sometimes visually impaired people can be dependent on sighted people for the information they need to navigate new cities, building and rooms. We set out to create an affordable and easy to use tactile system to enable these people to get around indoor spaces independently.

A team of our researchers and designers developed a novel tactile map system. The maps enable visually impaired people to acquire information about how a building, an individual floor or a room is laid out before visiting.

TacMap™ can represent a wide range of buildings and venues such as hotels, museums, theatres, universities, schools, bus and train stations, transport hubs, sports and leisure complexes or workplaces.

We created an iconic language using symbols to represent different indoor features and a key to explain the symbols to users. The system we developed also makes it possible to produce accessible information at a reasonable cost.

Once created on screen, the maps are produced on reactive paper. After printing, the paper is heat processed to produce the tactile surface.

One of the unique aspects of TacMap™ is that users can request a map from the venue they're planning to visit in advance, or from their local blind society. This means that visitors can familiarise themselves with the space before navigating it in real life. TacMap™ can also work alongside white canes and guide dogs.

We carried out substantial user trials in Sheffield's Winter Gardens and Millennium Galleries, with extremely positive outcomes. The trials were supported by Zychem Ltd, the Sheffield Royal Society for the Blind and Sheffield City Council.

TacMap™ has now been established as a dedicated company to meet the demand for tactile maps. The company have already supplied the London Olympic legacy project Queen Elizabeth Park with a map and undertaken an exciting project with East Midlands Trains.

'This is wonderful. It illustrates so many things. The plans are really useful, and it is great to be able to go in a room such as the toilets and to know where the basins, the WC and the hand dryers are.'

Julie Smethurst, registered blind, Sheffield

Making space for innovation in abdominal keyhole surgery

Central Manchester University Hospitals NHS Foundation Trust (CMFT) wanted to investigate the potential for a space creation and organ retraction system for use in abdominal keyhole surgery. Business development manager Dr James Corden turned to us for our leading advanced materials expertise.

We have a strong track record in the design, simulation, fabrication and testing of auxetics. In technical terms, these materials have a negative Poisson's ratio, meaning that when they are stretched they increase in thickness, and decrease in thickness when put under pressure. Conversely, most materials become thinner as they are stretched, and bulge, or become thicker when pressure is applied.

This applied research opportunity seemed the perfect fit for a PhD studentship and doctoral student Dignesh Shah was appointed to deliver the project, supervised by one of our advanced materials experts, with an Engineering and Physical Sciences Research Council Industrial CASE studentship, match-funded by CMFT.

Current laparoscopic techniques (keyhole surgery) rely on a process called CO2 insufflation which inflates a patient's abdomen and can produce negative side effects. Laparoscopy also requires the intervention of a second surgeon whose job it is to move organs away from the surgical field, allowing the lead surgeon to operate.

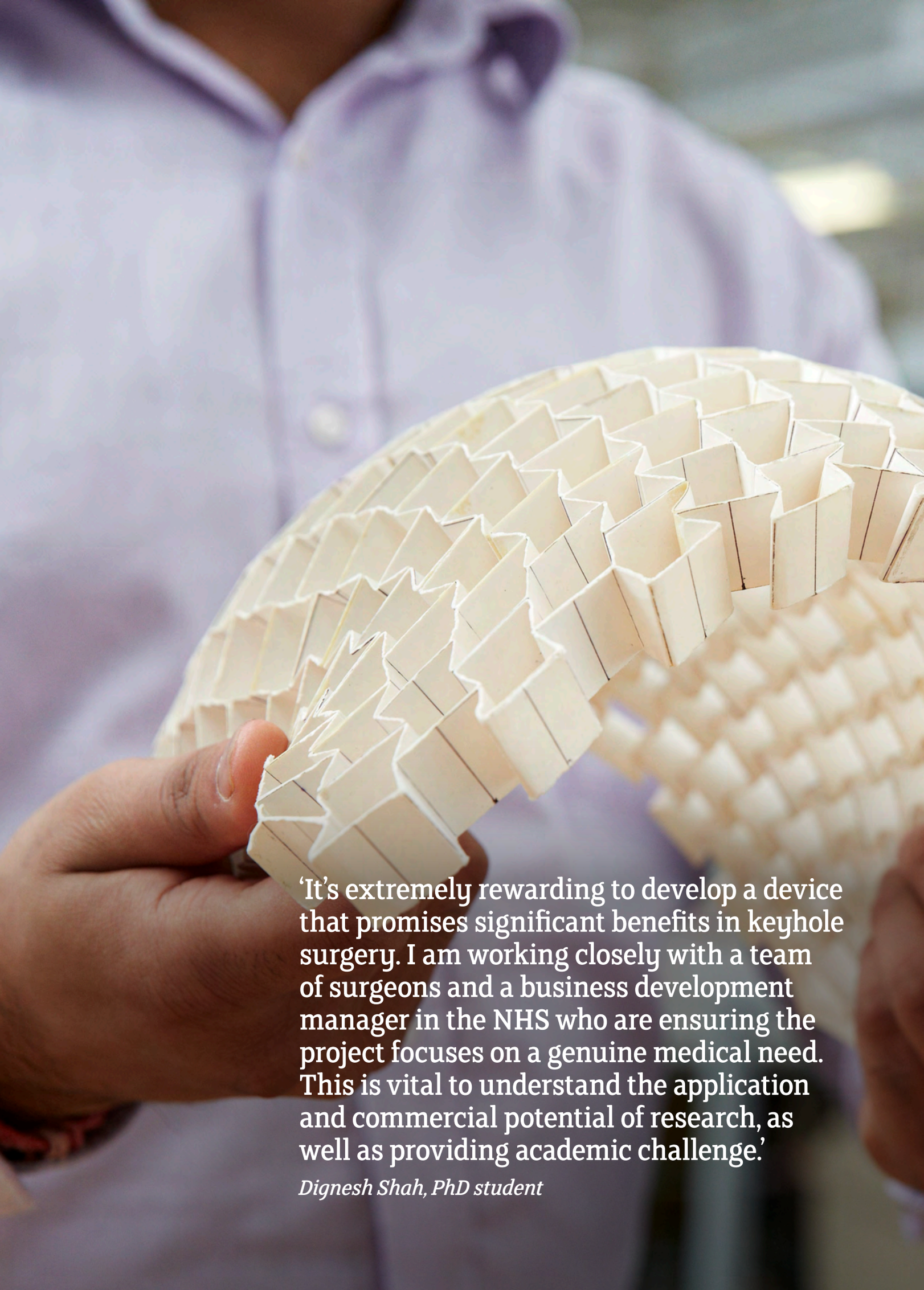
Working closely with a team of surgeons at CMFT, our researcher attended theatre to help measure surface pressures and retraction distances applied to organs during abdominal surgery. These measurements provided key inputs into the design requirements of the space creation and organ retraction device. CAD and 3D printing were used to design and produce viable models for simulation and testing during the development process.

The device is designed to be inserted through the keyhole during surgery. Once activated by compression or tension, it expands and changes shape from a cylinder to a cage. Following successful development and testing, the new system has the potential to deliver shorter hospital stays and rehabilitation times for patients, as well as reducing complications associated with current methods of space creation and/or organ retraction used in laparoscopic surgery.

Clinicians and the NHS will benefit from more efficient use of clinician time and better access to the surgical site, leading to improved laparoscopic surgical procedures, and healthcare cost savings due to fewer complications and accelerated patient recovery times.

The space creation system is a flagship project in the growth and development of our auxetic materials research and expertise. Opportunities to share our knowledge have ranged from a presentation at the House of Lords to showcase advanced materials technologies with commercial potential to a feature in a BBC2 programme.

The Central Manchester Hospitals Foundation Trust is actively seeking further funding to take the technology through clinical trials and on to market. There is real potential to develop the device for a range of other surgical applications in future.



‘It’s extremely rewarding to develop a device that promises significant benefits in keyhole surgery. I am working closely with a team of surgeons and a business development manager in the NHS who are ensuring the project focuses on a genuine medical need. This is vital to understand the application and commercial potential of research, as well as providing academic challenge.’

Dignesh Shah, PhD student

‘We will be able to use this tool to investigate the child more thoroughly. It narrows down the number of factors that could be responsible for a fracture. This technology will help us give a voice to those who don’t have one – the children too young to tell us what has happened to them.’

Dr Amaka Offiah, Sheffield Children’s Hospital

Health and Social Care

Materials and Engineering

Computing and Big Data

Improving bone mineral density measurement in the under-4s

Sheffield Children's Hospital approached us with a brief to develop new equipment to assess bone mineral density (BMD) of the under-4s. Assessing BMD has important health and social care benefits, as it can help identify bone disease as well as potential cases of child abuse. However, measuring it accurately is challenging, because the required normative data does not exist.

The University saw this as a challenge fit for the expertise of PhD student Hajar Razaghi, supervised by one of our computer engineering specialists. They received funding from the Children's Hospital Charity to take on the task of developing and evaluating a Bone Density Assessment System (BDAS) for her PhD study.

Dual energy x-ray absorptiometry (DXA) is the current gold standard for measuring bone density in children. However, DXA is difficult to use with children under four years of age and doesn't predict fracture risk accurately at any age.

The BDAS system Hajar is developing automatically analyses bone physical characteristics, meaning it's easier to use and could enable a clearer and more accurate method of monitoring patients. It's safe and non-invasive: vital for its target patient group of young children. There are potential economic gains, as the system's maintenance requirements are much more straightforward compared to existing methods for densitometry (measuring density), like DXA.

Hajar explains, 'While existing densitometry methods have their own individual limitations for assessing BMD in infants, BDAS is potentially a novel, non-invasive, cost-effective, accurate and rapid assessment system to screen BMD and predict bone fracture risk in young children.'

Initial findings suggest that BDAS has the potential to be more reliable and cost effective than existing methods to measure BMD in young children. The system is currently being evaluated at Sheffield Children's Hospital with older children to establish how it compares with DXA.

There is considerable potential for the system's development and application in NHS settings in the UK and internationally. Most importantly, BDAS could have a powerful impact on improving outcomes for very young and vulnerable patients both in terms of safeguarding and bone disease diagnosis.

Health and Social Care

Art and Design

Using design to make a difference to spinal cord injuries

Spinal cord injury is a life-changing event for most patients. While there have been significant advances in how spinal cord injury is managed medically, psychological approaches lag behind.

Working with the spinal cord injury unit at the Northern General Hospital in Sheffield, our art and design researchers devised a programme of workshops to explore the value of 'design thinking' as a wellbeing tool for spinal cord injury (SCI) patients. In collaboration with the Royal Society of Arts and funded by the Silvia Adams Trust, the project offered students the chance to facilitate the workshops and apply their design skills to a real-life scenario and work directly with users, as well as widening their perceptions of the career paths a design degree can lead to.

MA/MDes Design students delivered the series of workshops with SCI patients under the direction of academics from the research team. The workshops provided a forum for students to help patients and carers to see challenges from a different perspective, and use design thinking to generate solutions – ultimately giving them a greater say in their own rehabilitation.

Patients and their needs varied from week to week – some attendees used wheelchairs or oxygen, while others didn't have use of their hands – meaning the team had to be resourceful and adaptable at all times. Sessions engaged participants in a range of activities, from design challenges to mini-projects.

Feedback from the patients on the sessions was positive and pointed to the potential benefits from taking a design-led approach to SCI. The project team were awarded funding from the Health Foundation's Shine programme to work with the hospital's service improvement team to update the workshop into a format that could be included in rehabilitation schedules.

Rebecca Partridge, one of the students, maintained her links with University researchers and received expert mentorship for her final degree project. Following graduation, she was offered a job as a full-time researcher at the University. She has since won a GTA PhD scholarship to undertake research into 'design thinking' as a self-management tool for children with long-term health conditions, working closely with Sheffield Children's Hospital. Rebecca credits her undergraduate research project with spinal injury patients as the driver for her current research.

‘Working on the spinal injury project opened up a whole new area that I didn’t know existed, as I was uncertain about where I would fit in the design world after my degree. I can say with confidence that my degree result was influenced by a renewed enthusiasm for my subject that I gained from applying design thinking in a real-world, spinal cord injury context.’

Rebecca Partridge, PhD student

Health and Social Care

Computing and Big Data

Materials and Engineering

Embracing a new air ambulance service for Yorkshire

Based at Sheffield Children's Hospital, Embrace transfers young patients between hospitals in Yorkshire and the Humber. Patient transfer times can be critical and can impact on patient outcomes and survival rates. With this challenge in mind, Embrace asked us to assess the benefits of a dedicated air medical response for infant and child patients across the region.

One of our senior lecturers teamed up with a PhD student to create an advanced simulation model to conduct the research. We assessed the difference between using dedicated helicopters and the current road ambulance service, and whether a dedicated helicopter could reduce transfer times for patients.

The experiments demonstrated that of the 47 opportunities for patients to be transferred by helicopter, on 29 occasions a helicopter would not have been available to perform the transfer. This meant that 62% of patients had to go without the aeromedical response where a helicopter could have reduced the amount of time it took for them to reach specialist emergency medical treatment.

We also established that 93% of potential journeys could be accessed by a dedicated helicopter service where road transfers would take more than 90 minutes.

As a result of our findings, Embrace established an improved air transfer service which directly benefits one of the NHS's most vulnerable patient groups: babies and children. The new service began in May 2013 and is delivered by the Children's Air Ambulance. Patient journey and waiting times have been reduced and the new service is bringing about a higher level of clinical care for patients region-wide.

Our findings were also presented at a conference, highlighting the benefits to a wider audience. The model we developed could be rolled out for other UK regions, meaning that our work will have even more impact in the future.

'Working with the research institute was a very positive experience for us. Their advanced simulation modelling provided us with an understanding of our activity which we could not have achieved independently. The data they analysed also provided us with a valuable perspective within the project. We look forward to further opportunities to work with the team at the University.'

Ian Braithwaite,
senior transport nurse, Embrace

Art and Design

Health and Social Care

A sense of home: designing for people with dementia and memory loss

Part of the unique learning experience we offer is to involve students in projects that have real-life application and impact. In one example students are encouraged to immerse themselves in healthcare environments and talk to clinicians and patients, finding out what issues and challenges they experience day-to-day and then developing ideas and solutions.

Building on our reputation for design innovation in health and social care, Sheffield Teaching Hospitals approached us to set their own design challenge.

Claire Jepson, senior occupational therapist at the trust, set a group of our postgraduate students the task of developing a product that would help people with dementia to retain memories and navigate technology.

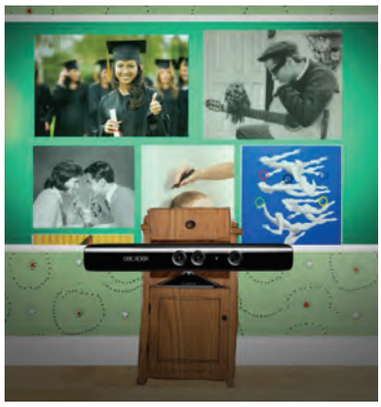
The postgraduate students applied their design knowledge and created innovative solutions to the unmet needs of dementia patients, with the potential to deliver real benefit to the patients. Two students – Josephine Gomersall and Paddy Beirne – shared their idea of an interactive memory cabinet for people experiencing memory loss and were selected to develop a more detailed proposal.

The memory cabinet was conceived to meet the needs of people living in hospital or care, away from home. The cabinet connects personal memories with display devices, offering an interactive and responsive way to help users remember what home means.

The students have since shared their ideas in a number of settings within the trust and have gone on to present their work at industry conferences.

'I am thrilled that all Sheffield Hallam students are now receiving some education on dementia and how it impacts our society. Thanks to the two students who went on to develop their ideas by designing an interactive Memory Cabinet for people living in 24-hour care. This design proposal was recently presented to a group of occupational therapy colleagues who found it very inspiring.'

Claire Jepson, senior occupational therapist, Sheffield Hospital Trust



'I've learned what an important role empathy plays in the design process. How to design through emotion and a human connection, how to walk in another person's shoes and identify their problems and solve those problems in a way that suits that person.'

Paddy Beirne, student

Health and Social Care

Art and Design

Materials and Engineering

New contactless monitor to transform measurement of respiratory rates

We are proud of the strong research partnership we have forged with Sheffield Children's Hospital. This pioneering hospital regularly poses clinical challenges to our engineering design experts who collaborate across disciplines to offer cutting-edge solutions.

Hospital medical director Derek Burke approached our digital signal processing expert with an urgent technological challenge: the need for a hand-held and accurate respiration monitor in paediatric care. Measuring a sick child's respiration rate is a key indicator in the early warning system which includes pulse, temperature, blood pressure and oxygen saturation rate. Respiration rate is measured in acute wards and ICU using in-mask sensors and chest bands, while in accident and emergency, triage or general wards clinicians count breaths or measure the chest rising and falling by eye. There is no device on the market which is contactless, automatic and gives a rapid and accurate measurement of a patient's respiration rate.

Thanks to development funding provided by the University, a team of experts from Sheffield Hallam, the Universities of Sheffield and Leeds and Sheffield Children's Hospital began work to investigate possible solutions to this unmet need. Progress was made but many of the first methods were discounted on the grounds of noise, patient contact and cost.

A prototype emerged that used a simple electronic technique, based on the capture of exhaled air. The partnership attracted funding to further develop and test this prototype resulting in a patent application. We now have a series of working prototypes that we're testing in Sheffield Children's Hospital and results tell us that the device is accurate and reliable.

The prototype is used to monitor breathing among patients who have a higher medical risk. Its wireless, non-invasive approach combined with its accuracy in monitoring respiration makes it a perfect replacement for the existing methods, and is especially suitable for long-term monitoring. The device would enable clinicians to diagnose conditions more quickly and accurately, particularly in A&E and triage settings. In turn this can lead to improved patient outcomes owing to faster diagnosis in critical cases and long-term patient comfort during respiration monitoring.

The next step is to secure funding to produce a final product. Bringing the monitor to market will herald a real medical breakthrough for measuring respiration rates in children.

‘Knowing the respiratory rate in children is very important because if it’s not normal, the nurse looking after the child knows that he or she may be seriously ill. Currently there is no simple electronic device which can measure respiratory rate automatically. That’s why our device could transform the patient experience during the measurement of respiratory rates.’

Heather Elphick, consultant, Sheffield Children’s Hospital

‘It was totally immersive. Once I’d got used to the headset, opening and closing the virtual hand was exactly the same as using my prosthetic hand. The electrodes used the same muscle mass as my Bebionic hand, so I can see how it would be great training for amputees learning to use one of these prosthetics.’

Kevin Everson, patient at the Northern General Hospital

Health and Social Care

Art and Design

Computing and Big Data

Gaming technology enables amputees to learn to touch again

Modern electric prosthetic limbs are very expensive – up to £30,000 each. Patients are given hours of training before they get them, but it can be difficult to take to a prosthetic and many go unused.

One of our games developers had been working with a piece of virtual reality hardware called Oculus Rift. After talking to other experts at a conference about how virtual reality could be used with prosthetics, they realised that virtual reality offered patients an opportunity to 'see' the limb and adjust to using it prior to getting the real thing.

A project team was created to take the idea forwards, including a physiotherapist, health psychologist, games designer, materials engineer, industrial designer, analytical scientist and a 3D artist.

The team combined the Oculus Rift virtual reality with a Myo armband, which is worn on the end of the amputated limb. Using the same sensors for electrical activity as much of the wearable technology available on the market, the Myo can read the muscle activity of a user's arm. It translates these messages into the virtual arm shown on the Oculus Rift headset. It means the patient wearing the headset can see a virtual arm and move it around, grabbing things with the hand and generally practising how to move their muscles to control a prosthetic arm.

After spending time developing the technology, the team tested their design with amputees by joining up with patients at the Northern General hospital in Sheffield. The project was a revelation. One patient picked up an apple with a prosthetic limb for the first time as he was able to use the muscle movements in his upper arm to control it. After taking part he wanted to change his cosmetic prosthetic limb for a Myo-electric one.

This research could change the way amputees train for their prosthetics, bringing a range of benefits both for the patient and for the NHS. As well as making the training for prosthetics more effective, it could speed the process up.

Health and Social Care

Art and Design

Making foot orthoses fit for modern patients

Trulife UK invited us to work with them on a redesign of their carbon fibre ankle foot orthoses (AFO) product range. AFOs help to control the position and motion of the ankle, provide support to compensate for weakness, and correct the function of the ankle. The company's vision was to put in place a flexible and efficient production platform for new and existing AFO designs.

Our designers started the project by combining anthropometric (measurement of the size and proportions of the human body) research data and Trulife's in depth knowledge of the market. From this dataset, we could create a sophisticated CAD framework that was easy to adapt to create a wide range of mould forms.

To develop the forms we used our in-house prototyping facilities to create a set of moulds for testing and evaluation. Trulife verified these through a series of trials with end users.

The new design process is now operating at Trulife's factory and fulfils the brief and the vision they originally approached us with. Our collaboration provided a flexible production platform, capable of producing over 270% of the output compared with the previous techniques and has significantly reduced energy consumption.

The foot mouldings Trulife now produce are of higher quality and more accurately reflect the human form, which means a more effective product for patients. It also keeps our partner's business at the cutting edge of technology.

Health and Social Care

Art and Design

Materials and Engineering

Improving life for women with breast cancer

Breast cancer is the most common type of cancer in the UK, and rates are increasing. Around 50,000 women are diagnosed every year.

The majority of patients require radiotherapy to the breast. There are a lot of women going through radiotherapy for breast cancer, and this makes up a large part of the workload of NHS radiotherapy departments.

Our health technology experts have been working on projects that will improve the treatment of women with breast cancer, relieve the pressure on clinicians' time, and potentially make huge cost savings for the NHS.

Making radiotherapy more comfortable and effective

Researcher Dr Heidi Probst has been working on a support device to make breast cancer patients' radiotherapy more comfortable, more dignified – and more effective.

'Since I first trained as a radiographer, technology has moved on immensely,' she explains. 'But how we position the patient hasn't kept pace with the developments in radiotherapy technology.'

At the moment, women lie naked from the waist upwards and the radiographer positions them manually for their radiotherapy treatment.

Heidi says, 'A patient has at least 15 treatments across three weeks, and you have to make sure the position of the breast is the same each time so that the radiation distributed across the breast is the same each time the patient attends.

'This is important to make sure the patient has a good cosmetic outcome following treatment, and also to minimise side effects to the lungs and heart (in women treated for a left breast cancer) later in life.'

Previous attempts to meet this challenge have proven undignified at best, and ineffective at worst.

Heidi is working with colleagues from Sheffield Hallam University and Sheffield Teaching Hospitals on a new support device that will

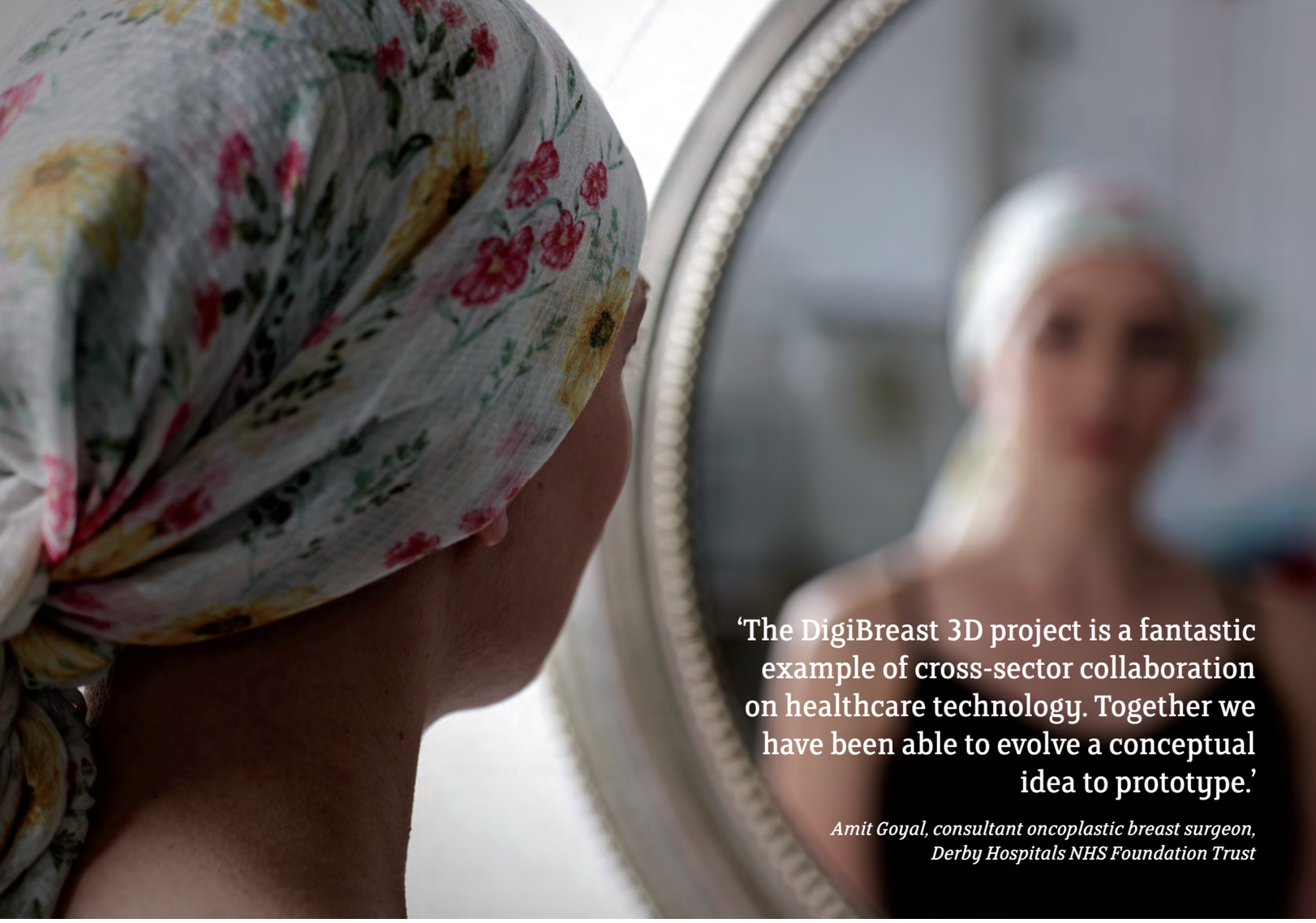
- provide accuracy and reproducibility in breast position
- reduce the radiation dose received by normal tissue such as the lungs and heart
- preserves the patient's dignity and modesty

The team includes product designers, engineers, clinicians and an industrial partner. They have held focus groups with patients, interviewed oncologists and sought views from radiographers. Medipex has conducted a market analysis that showed there was a definite need for a product in this area.

Now they are testing their designs on specially created breast phantoms, realistic models which can be imaged the same way as normal breast tissue. They are also using surface scanning with healthy women to test the product is able to immobilise the breast tissue and reproduce breast positioning on repeated instances.

'The support device is on its third prototype, and following a series of further safety tests it will be tested on a small sample of patients,' says Heidi. 'After that, we hope if the product works well to manufacture the device and see it adopted as standard throughout the NHS.'

This project is funded by the National Institute for Health Research (NIHR) Invention for Innovation fund (project code II-LA-0214-20001).



‘The DigiBreast 3D project is a fantastic example of cross-sector collaboration on healthcare technology. Together we have been able to evolve a conceptual idea to prototype.’

Amit Goyal, consultant oncoplastic breast surgeon, Derby Hospitals NHS Foundation Trust

Improving post-surgery breast reconstruction

Meanwhile, another group of Sheffield Hallam researchers are tackling a problem faced by many women after they have had a tumour successfully removed from their breast.

When deciding which implants to use for reconstructing breasts after surgery, currently surgeons have to use their visual judgement. This is an unreliable and inexact method which results in 1 in 6 reconstruction patients requiring additional surgery.

The implications of this are clear. Having undergone a stressful programme of chemotherapy, plus surgery to reconstruct their breast, these women then have to undergo more upheaval and discomfort.

‘If you could measure the volume of the breast accurately and work out what size implant is required, you could get it right first time and reduce the need for additional surgery,’ says Dr Jon Wheat, a biomechanics researcher in the Centre for Sports Engineering Research.

‘This would improve the quality of life for the patient, give surgeons more time to concentrate on surgery, and save the NHS money.’

Working with consultant surgeon Amit Goyal, Jon and his colleague Dr Simon Choppin have developed the DigiBreast3D system.

DigiBreast 3D uses Microsoft Kinect – a depth camera used more commonly with Xbox games to track players’ movements – to allow simple, inexpensive 3D surface imaging of the breast region.

It can be used across the NHS to plan operations, evaluate them, and compare different breast reconstruction surgical techniques. The scans can be taken by anyone with basic computer training, speeding up the breast reconstruction process and giving surgeons more time to concentrate on surgery.

Above all, it will lead to better care – and a better quality of life for women who have had breast cancer.

These projects could only have come about by bringing researchers together with clinicians and businesses to work on projects collaboratively.

Sheffield Hallam University is uniquely placed to do this, thanks to our world-leading expertise in design, healthcare and materials engineering, combined with strong links with the NHS and the healthcare technology industry.

Health and Social Care

Bioscience

Injectable hydrogels for regenerative medical applications

Hydrogels are three-dimensional cross-linked polymers that contain significant amounts of water. They have numerous applications including wound management dressings, contact lenses and as scaffolds for cellular growth – because they mimic the microenvironment of the living body they are able to contain stem cells to help repair diseased or damaged tissue.

One of the challenges in manufacturing hydrogels is that the cross-linking process, which is designed to make the materials more robust, renders them impossible to inject, meaning that to use them would necessitate a major surgical procedure. Researchers have looked at various strategies to overcome this problem, including two-part *in situ* reaction systems, with limited success. A multidisciplinary team including polymer scientists and molecular cell biologists has developed a method of preparing fully cross-linked and fully biocompatible hydrogels that are highly processable and therefore fully injectable.

One of the unique features of our hydrogel is the ability to target specific tissue regeneration applications including cartilage, intervertebral disc (IVD) or bone. Treating lower back pain is an application the new hydrogel could help with. Lower back pain affects approximately 80 per cent of the population at some point in their lives, incurring a cost of billions to the UK economy. Around 40 per cent of cases are caused by degradation of the intervertebral discs.

The group has developed a potential cure for chronic back pain using hydrogel injections that can regenerate damaged discs. Partly funded by the Engineering and Physical Sciences Research Council (EPSRC), they are developing a minimally invasive injection which could contain stem cells, growth factors and inhibitors in a single injection which would be injected directly into the intervertebral discs of patients. The team are developing ways to encapsulate and protect fragile protein-based inhibitor molecules so they can be slowly released and offer protection over a period of months after injection.

Early tests have shown that the unique combination found in the hydrogel system can stimulate matrix deposition and cell types similar to those of the IVD using adult stem cells. This could potentially be used clinically using the patient's own stem cells.

Dr Christine le Maitre, one of the University's molecular cell biologists, says, 'One of the main causes of lower back pain is the close proximity of the nerve root to moveable structures. When you move, you bend, you flex; all of that is made possible because through your spine you have these intervertebral discs, which basically act as shock absorbers allowing all the stresses and strains to be dissipated. Our novel therapy holds the potential to restore these discs, returning their function and removing the pain.'

The team are exploring additional applications for the new hydrogel and are looking for commercial partners to develop these further.

‘Our laboratory studies have been encouraging, showing that hydrogel injections could potentially repair and restore damaged discs. Although the work is still in its infancy, it has enormous potential. If our product comes to the open market, it could prove to be a blockbuster with a market value of tens of millions.’

Dr Christine Le Maitre, molecular cell biologist

Contact us

Email business@shu.ac.uk
Phone 0114 225 5000
Visit **shu.ac.uk/healthtech**