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RESEARCH AND DEVELOPMENT

Tackling incontinence and aiming to IMPRESS

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Abstract
Incontinence Management and PRevention through Engineering and ScienceS (IMPRESS) is a research project that aims to encourage more engineers and scientists to work on applying new technologies to manage incontinence in innovative ways. Many clinical challenges persist in the field of faecal and urinary incontinence, and therefore, IMPRESS has been developing a nationwide multidisciplinary network for incontinence research. Since 2014, it has run a series of technology-focused events devoted to understanding and showcasing the difficulties of dealing with this condition. Through this initiative, it is hoped that many new research collaborations will emerge, leading to an increase in cutting-edge engineering solutions that will ultimately improve the quality of life of people who live with incontinence. This article summarizes the work of IMPRESS, discusses its achievements so far, explains its plans for the future and highlights opportunities for collaboration.

Keywords: bladder, bowel, continence, pelvic floor, technology.

Introduction
In the UK, the number of people with some form of bladder problem is approximately 14 million; similarly, the figure is 6.5 million for bowel issues (Buckley & Lapitan 2009). Therefore, it is no surprise that incontinence places a massive burden on the National Health Service (NHS); it has been estimated that treatment for this condition uses up more than 2% of a national healthcare budget (RCP 1995). Incontinence has a powerful impact on the quality of life of thousands of people, leading to physical discomfort, emotional distress, stigmatization and social isolation (Norton *et al.* 2007; SBRI Healthcare & NHS England 2015). Incontinence is not a disease: its challenges originate from symptoms associated with a complex and varied set of clinical conditions that can be broadly categorized as faecal and urinary incontinence (FI and UI) (Norton 2016).

While many areas of medical engineering share a growth in the engagement of engineers and scientists to advance the exploitation of emerging technologies, incontinence receives relatively little attention, and many of the devices used to treat or manage incontinence have seen little innovation in decades (ICS 2015). Incontinence Management and PRevention through Engineering and ScienceS (IMPRESS), based at the School of Mechanical Engineering, University of Leeds, Leeds, UK, strives to attract the UK's wealth of engineering and science expertise. By working to develop a diverse network of academics, healthcare professionals, patients and industry representatives, IMPRESS offers an opportunity for a significant change in the attitude to research in the field of incontinence, and the real possibility that ground-breaking engineering solutions will emerge to overcome some of the long-held needs of people who endure daily life with this condition.

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Starting point
The inspiration for IMPRESS originates from long-standing collaborations in the field of healthcare and surgical technologies between the University of Leeds and the Leeds Teaching Hospitals NHS Trust. Through this ongoing relationship, it became clear that there was a distinct absence of research activity in the field of incontinence, a significant but neglected need

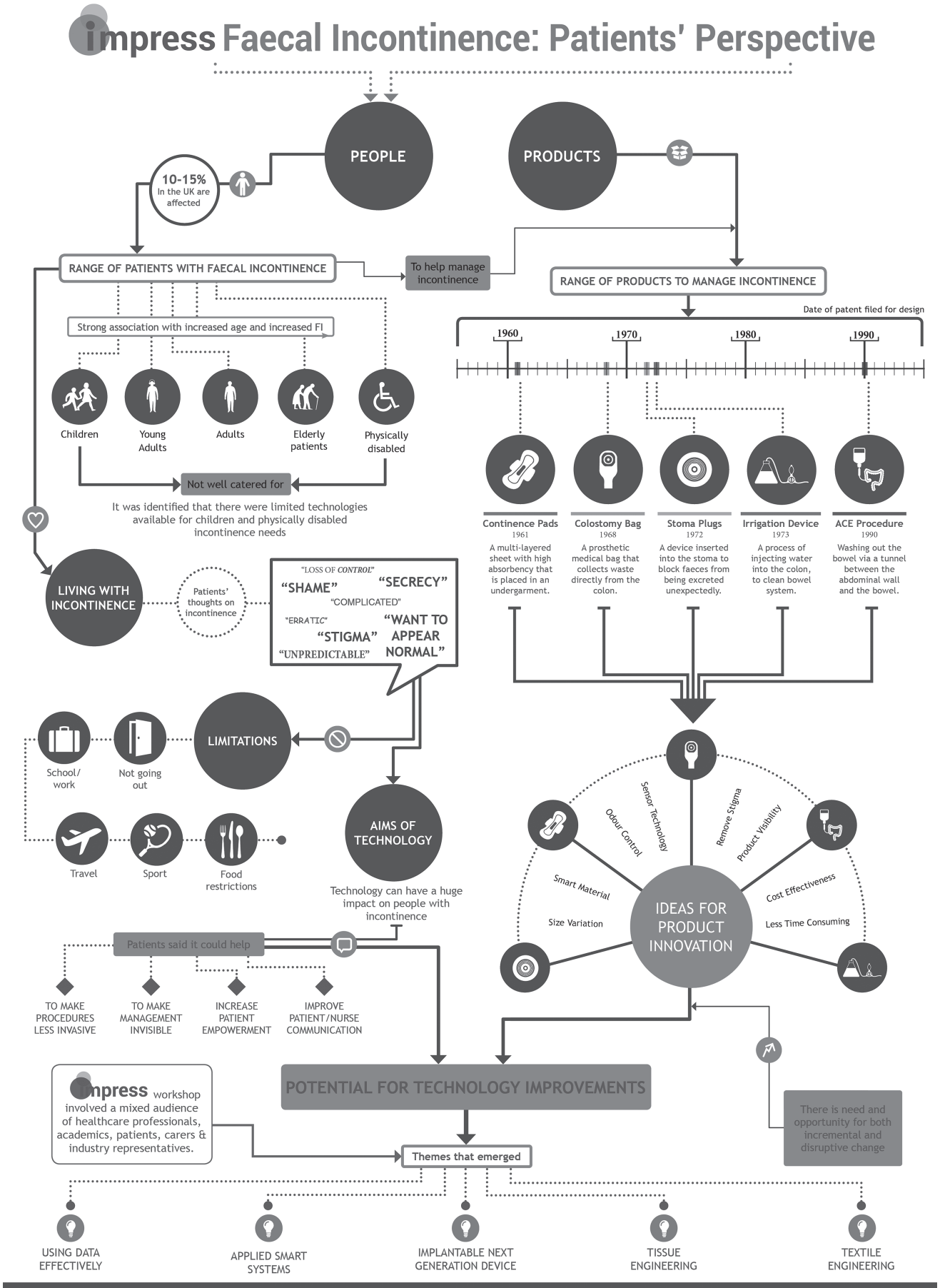

Figure 1. Faecal incontinence (FI) workshop infographic.

that inspired a successful bid for funding from the Engineering and Physical Sciences Research Council–National Institutes for Health Research (EPSRC-NIHR) Healthcare Technology Co-operatives (HTCs) Partnership Award to develop the IMPRESS network.

Building the network

Starting with a 3-day conference hosted by several clinicians who specialize in diagnosing, treating and managing incontinence, IMPRESS initiated a process for educating scientists and engineers about the clinical challenges that this condition brings, creating a forum for establishing a network of research relationships across these disciplines. It is from these small beginnings in 2014, and through a 2015 workshop to brainstorm new technological ideas for tackling incontinence, that the network began to expand.

Historically, UI has received more research attention than FI, which is less common, but conceivably more distressing. With this in mind, IMPRESS ran a workshop in 2016 that was specifically devoted to pinpointing the biggest issues from the perspective of those who live with this condition. IMPRESS now has over 200 members, and the output from that day (summarized in Fig. 1), has helped to shape the direction of future incontinence research facilitated by the network.

Pilot projects

Some fantastic research partnerships have emerged through the network, and some examples of the ongoing studies that have resulted are summarized in the pilot projects below. These investigations, which are all at a very early stage, have been catalysed through funding from IMPRESS. While a significant amount of further research, clinical trials and work on commercialization is needed before such innovations can become available, IMPRESS's support acts as a springboard, enabling each project to reach a point where obtaining future funding from other bodies becomes significantly more attainable.

Fat Chance

At the Institute of Biomedical Engineering at University College London (UCL), London, UK, a new technique using fat tissue in place of stitches is being developed to improve the success rate of surgery to repair the anal sphincter muscle. The Fat Chance study has shown that it is technically feasible to deliver fat cells in a preparation that can be retained between the overlapping sections of a reconstructed anal sphincter muscle to aid the healing process.

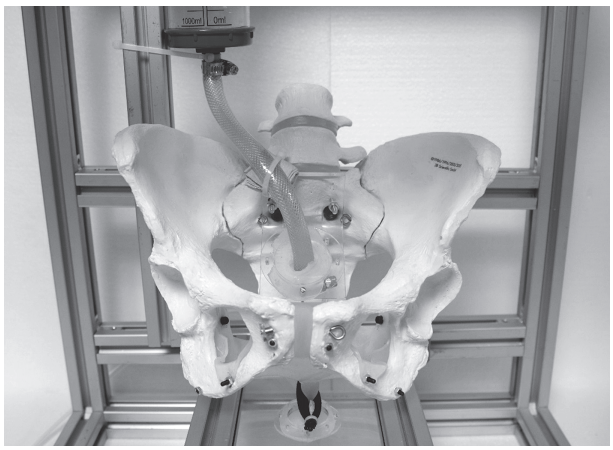

Figure 2. Pelvic anatomy test rig used to simulate defecation.

Modelling the Physiology of Faecal Incontinence

Little research has been done to develop a detailed understanding of the physiology that causes FI. This project used computer modelling to quantify the mechanism of defecation as a means of identifying how the anatomical components cooperate, and to what extent changes in these mechanisms may cause FI (Fig. 2).

Tactile Sensing Capsule for Treating Faecal Incontinence

A bio-inspired tactile sensing capsule (Fig. 3) recently developed at Bristol Robotics Laboratory, Bristol, UK (Winstone *et al.* 2015), has been used to characterize the muscular action in the rectum associated with FI in order to understand the severity of the condition and help advance current diagnostic practices. By creating a real-time software interface in collaboration with a specialist nurse, the study was able to show that the capsule is not only capable of detecting contractions in the rectum, but also of identifying the locations where these are not uniform.

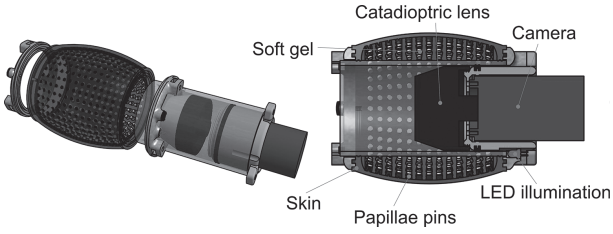

Figure 3. Tactile sensing capsule: (LED) light-emitting diode.

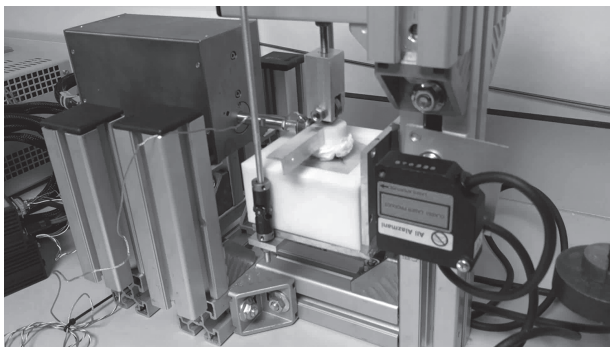

Figure 4. Skin friction test rig.

Bio-tribology of Incontinence Management Products

Within the microclimate of an incontinence pad, how does slip and contact contribute to the development of pressure ulcers on the skin in the presence of faecal or urinary matter, and emollients? Researchers at the University of Leeds used a porcine skin model to show that friction and shear are factors associated with the formation of pressure ulcers, and that these are exacerbated by the presence of urine and faeces (Fig. 4). The study also revealed that the use of skin- and wound-care treatments actually increased friction, and the addition of moisture only added to the friction effect. Conversely, hydrogel-based systems were found to be much more effective at controlling friction under both dry and wet conditions. The next stage for this study will be to focus on the nature of slipping on skin abrasion and susceptibility to the formation of pressure ulcers.

Pelvic nerve stimulation

Stimulation of the sacral nerve in the lower back is one of the current treatments for UI, but sadly, the success rate is only approximately 50% (Gupta *et al.* 2015). As an alternative to this method, researchers at the University of Bristol, Bristol, UK, investigated pelvic nerve stimulation. Their study explored the principle of an implantable device operated by the user that would temporarily block messages sent from the pelvic nerve at the onset of the urge sensation to allow extra time to reach a toilet. Using rat models, they identified that unilateral stimulation of either the right or left pelvic nerve within a specific frequency and intensity range successfully inhibited voiding for 1 min. Through further funding recently granted by IMPRESS, the research team will proceed to test the principle using *in vivo* porcine models in collaboration with the Aarhus University, Aarhus, Denmark, the long-term goal being to develop a fully implantable stimulating device and bladder pressure sensor capable of detecting imminent voids.

A new phase for IMPRESS

In 2016, IMPRESS was granted an extra £500 000 by the EPSRC-NIHR HTCs Partnership Award to continue encouraging and supporting more research into incontinence treatments, and to extend its sphere of influence internationally over the next 2 years. To begin with, the funding has allowed IMPRESS to appoint a dedicated medical technologies research fellow, who will apply biomaterials engineering expertise to some of the current and new research areas facilitated by the network.

IMPRESS introduced this new phase with a symposium entitled "Next Generation Technologies for Incontinence" that was held in Leeds on 20 June 2016. This covered a broad range of topics that demonstrated how technologies from many different disciplines can be and are being applied to the challenge of incontinence. Delegates heard about new developments in the Netherlands and Switzerland, and from several groups across the UK. Researchers from the Swiss Federal Institute of Technology in Zurich (ETH Zurich) presented their latest work: a stretchable, silicone material that can transmit electronic signals and could be patched onto the bladder in order to sense its fullness. A Dutch start-up company, Novuqare BV, demonstrated MAPLe, their first multi-sensing high-definition device for the diagnosis and treatment of pelvic floor dysfunction (Novuqare 2016). Available in the Belgian market, MAPLe can accurately stimulate individual muscles in the pelvic floor, allowing more-precise treatment and more-accurate biofeedback. British presentations from the University of York and Queen's University Belfast included re-engineered bladder tissue and smart coatings for catheters (BBC News 2015).

In June 2016, World Continence Week saw the launch of the network's IMPRESSplus Funding call (IMPRESS 2016). With up to £50 000 each available for up to three projects that seek to apply new science or engineering to a clinical need in the area of incontinence, it serves as a much-needed opportunity to support research work that goes beyond the initial concept stage.

Constantly keen to expand its network, IMPRESS is always interested to hear of new ideas from healthcare professionals and engineers/

scientists alike, and invite this journal's readership to participate through the @IMPRESSleeds Twitter account, our website (http://www.impress-network.com) or IMPRESS events.

More information about the IMPRESS network can be found on our website.

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References

BBC News (2015) *Queen's Scientists Develop Catheter Coating*. [WWW document.] URL http://www.bbc.co.uk/news/uk-northern-ireland-31737679

Buckley B. S. & Lapitan M. C. M. (2009) Prevalence of urinary and faecal incontinence and nocturnal enuresis and attitudes to treatment and help-seeking amongst a community-based representative sample of adults in the United Kingdom. *International Journal of Clinical Practice* **63** (4), 568–573.

Gupta P., Ehlert M. J., Sirls L. T. & Peters K. M. (2015) Percutaneous tibial nerve stimulation and sacral neuromodulation: an update. *Current Urology Reports* **16** (2): 4. DOI: 10.1007/s11934-014-0479-1.

IMPRESS (2016) *IMPRESSplus Funding Call 2016.* [WWW document.] URL http://www.impress-network.com/our-work/funding

International Continence Society (ICS) *Is It Time for Catheters to Be Redesigned? Mandy Fader Talks to BBC.* [WWW document.] URL http://www.ics.org/news/442

Norton C., Thomas L. & Hill J. (2007) Management of faecal incontinence in adults: summary of NICE guidance. *BMJ* **334** (7608), 1370–1371.

Norton N. J. (2016) *Impact of Fecal and Urinary Incontinence on Health Consumers – Barriers on Diagnosis and Treatment – a Patient Perspective.* [WWW document.] URL http://www.aboutincontinence.org/barriers-on-diagnosis-and-treatment.html

Novuqare (2016) *MAPLe.* [WWW document.] URL http://www.novuqare.com/maple-3/

Royal College of Physicians (RCP) (1995) *Incontinence: Causes, Management and Provision of Services*. Royal College of Physicians, London.

Small Business Research Initiative for Healthcare (SBRI Healthcare) & National Health Service (NHS) England (2015) *Faecal and Urinary Incontinence in Frail Elderly People.* [WWW document.] URL http://sbrihealthcare.co.uk/wp-content/uploads/2015/06/SBRI_9_Faecal-and-Urinary-Incontinence_Multimorbidities_Brief_FINAL.pdf

Winstone B., Griffiths G., Pipe T., Melhuish C. & Rossiter J. (2015) TACTIP – tactile fingertip device, texture analysis through optical tracking of skin features. In: *Biomimetic and Biohybrid Systems: Second International Conference, Living Machines 2013, London, UK, July 29 – August 2, 2013. Proceedings* (eds N. F. Lepora, A. Mura, H. G. Krapp, P. F. M. J. Verschure & T. J. Prescott), pp. 323–334. Springer-Verlag, Berlin.

Sarah King is an experienced project manager who moved into the academic research sector in 2011. She gained her managerial skills during a 15-year career as an architect, leading the design and construction of large commercial developments. Sarah joined the IMPRESS team in 2014.