Reverse Innovation in healthcare

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Standfirst – A Review of opportunities and challenges to learn from low- and middle-income countries

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Introduction

The notion of developed countries as the main producers of healthcare innovation is being increasingly challenged (1). Between 1985 and 2009, the annual growth rate of patent applications in developing countries was 19% and they more than doubled their share of global patent applications between 1985 and 2009 (2). This, together with the need for frugality in high-income country (HIC) health systems, means that increasingly low or middle-income countries (LMICs) are a source of innovations that HICs could learn from. Innovations that have been ideated, trialled, tested and initially adopted in LMICs, before spilling over into HICs, have become known as Reverse Innovations (RI) (2–4). In this Analysis, we review RI, the opportunities and challenges they present in healthcare, and provide examples of several potential RIs that would have significant benefit for the NHS.

Reverse Innovations – examples and opportunities

In 2009, when General Electric (GE) announced its $3bn investment to create low-cost healthcare innovations (3) one of those innovations was the GE Mac 400, a handheld, portable electrocardiogram (ECG) device that costs $1,000, a fraction of the cost GE normally charges for its regular ECG devices. The Mac 400 was initially developed for use in rural India, but was so successful, that GE then began selling it in the U.S. as well, where doctors in many isolated communities faced the same challenges as those in rural India (3). The frugality of the handheld device, coupled with its clinical efficacy, has made many wonder why they should pay the premium price for traditional ECG machines, when they can obtain one that is just as effective for a fraction of the cost (3).

This is an example of a RI, an innovation that was first developed in a LMIC before being adopted in a HIC. RI is not limited to technologies or products. Kangaroo care is a

practice that involves skin-to-skin contact between a preterm infant and their parent for 24h a day, as well as exclusive and frequent breastfeeding (5). This method was first introduced in Colombia nearly 25 years ago, used in lieu of expensive neonatal intensive care unit (NICU) (5). Its positive impact on infant mortality, infection and length of hospital stay as well as its impact on mother-infant bonding, breastfeeding and maternal satisfaction is well documented and has led to its routine use in maternity units throughout the developed world (5). The Ponseti Technique for treating Congenital Talpes Equino Varus (CTEV), commonly known as clubfoot, was scaled in LMICs such as Malawi (6) and Uganda (7), which are home to 91% of 174,000 children born with clubfoot each year (8,9) as an alternative to expensive surgical correction. Since then, multiple studies have been published on the efficacy of the treatment in these settings (6,10), and the technique is now the de facto gold-standard method of treating clubfoot in the U.K. as well (11). Finally, the Tree of Life approach to counselling originated in Zimbabwe and is used to support groups to overcome collective trauma they may have faced through a narrative technique based on Zimbabwean folklore (12). It can be used with both children and adults and has been adopted by several Mental Health Trusts across the U.K. demonstrating to have positive outcomes (12,13).

RIs, by virtue of their origin, development or scaling in LMICs, tend to be frugal innovations, doing more, with less for more people, driven by the necessity to use resources more efficiently (14,15). The resulting technologies, techniques or models tend to deliver care at a comparable level to best practice in high-income settings but at a fraction of the cost. The potential of RIs is being increasingly recognised. The Norwegian Government's international development department, Norec (formerly known as fk Norway), mandates that the international partnerships that they fund be mutually beneficial, through exchange of personnel and expertise with LMIC partners, to support the possibility of RI back into Norway. In the U.K., institutions such as the Tropical Health Education Trust (THET) through their Health Partnership schemes and Health Education England through their Earn, Learn and Return schemes and the Global Health Exchange, are increasingly looking to identify innovations from LMICs that would benefit the NHS, by supporting overseas professionals to work in the NHS or to identify innovations overseas and promote them back in the U.K. THET's *In Our Mutual Interest*, and the Chief Medical Officer's Annual Report (2019) both call for NHS organizations to genuinely learn from LMICs (16,17).

In Table 1 we list several innovations that have been ideated, developed, trialled or scaled in low-income settings and which deserve further examination and consideration for

piloting in the U.K. NHS. Each innovation has different selling points, evidence bases and rationales for adoption in the U.K. For example, a modelling study examining the benefit to the U.K. of adopting the Brazilian Family Health Strategy (FHS) model of community health worker-based primary care suggests that if used in the U.K. at scale it could provide 753,592 additional cervical cancer screenings, 365,166 additional breast cancer screenings, and 482,924 additional bowel cancer screenings, as well as provide MMR1 vaccinations for an additional 16,398 children at 12 months and 24,716 MMR2 vaccinations at five years of age (18), all by identifying those individuals eligible for these services but that have not yet been reached. The Arbutus Medical Drill Cover System (AMDCS), a technology commercialised from a technique originating in Malawi, converts an ordinary hardware drill into a surgical-grade drill by inserting it into a reusable, sterile bag. Cost savings associated with the AMDCS could range between 85% and 94% compared to the existing technology used in the NHS and could save individual Trusts £250k each per annum (19). Mosquito net mesh used for hernia repair has been found to be vastly cheaper than commercial mesh (US$ 0.0043 compared to US$ 108; respectively) (20,21) and meta-analyses of head-to-head RCTs conducted in several LMICs (India, Uganda and Burkina Faso) have shown comparable effectiveness in terms of adverse events, relapse and infection rates (22). With 100,000 NHS bed days spent on open mesh hernia repair each year, the use of the mosquito net mesh would present a significant cost saving. Autotransfusion with the Hemafuse device is currently used in Ghana and Kenya. It takes approximately 10 minutes to use, and costs roughly US$ 60 per patient, compared to US$ 250 for a bag of donor blood (23) and could offer a viable solution to many of the shortages of donor blood faced in the NHS. Each of these examples present unique opportunities and challenges for piloting and then scaling but the potential for cost saving without jeopardising patient care is significant.

Challenges to Reverse Innovation – principles and practice

Innovations from LMICs are not, however, inherently beneficial to high-income health systems. For example, the potential market for Prepex, a non-surgical circumcision device used at scale in sub-Saharan Africa is likely to be quite small in the U.K. where circumcision is mostly for religious reasons and conducted shortly after birth, rather than as a strategy to prevent HIV transmission in adult life. Frequently, the innovations are neither patented nor owned by a particular enterprise and this presents challenges in terms of obtaining both regulatory approval and entry to new markets, as is the case with the mosquito net mesh. Furthermore, one of the features of frugal innovations is that they are often

repurposed technologies, and this is a challenge for example when it comes to obtaining CE marking, as is the case of the Arbutus drill. There are documented attempts to adopt innovations from low-income settings but that have not provided the intended benefits. Conditional cash transfer (CCT) programs, for example, have been used to provide incentives for students to attend school and perform well on exams (24,25), as well as to encourage patients to adhere to their medication regimes or to their weight loss programs (26,27). The Oportunidades program in Mexico has been among the most successful CCT programs (28) and led the New York City Mayor's Office to implement a similar CCT program for low-income families living in New York City, called Opportunity NYC – Family Rewards (29). The overall effects of the Family Rewards program were mixed. Though there was a decrease in poverty and material hardship during the course of the pilot (29), educational effects were most pronounced among academically prepared 9th graders, but not seen among their less-proficient peers (29). It resulted in a small increase in the rates of health coverage, but there was no observed increase in preventive doctor visits (29). The failure to demonstrate impact in one setting does not on its own undermine the potential or rationale for RI, but does suggest that tailoring to contexts, careful evaluation and a preparedness to adapt the intervention will be important.

All these are specific challenges related to the specific innovations, their features and the contexts where they are adopted. However, there are general challenges that are also worth considering. There is an obvious tension in the use of the term 'Reverse Innovation' in that it undermines the very paradigm shift in knowledge translation that it seeks to promote. The notion that innovation flows from HIC to LMICs in 'normal' circumstances and that adopting innovations from LMICs into HICs is a reversal of that process can be construed as perpetuating a hegemonic view of knowledge production as a whole (30). Related to this is when to document an innovation as a RI? Zedtwitz et al present a typology of RI that considers the geography of the ideation, development and scaling of the innovation (2). They propose therefore that there are several types of RIs ranging from those that are stronger types that have been ideated, developed and scaled in LMICs before spilling over to HICs (2). And there are weaker types, those that may have been ideated first in HICs, before being tested, and scaled in LMICs, where the barriers to entry and regulatory barriers might be less, and then re-entering HIC markets once proof-of-concept has been established (2). The Ponseti technique is a good example of this. Although it was scaled in LMICs, it was in fact first developed by the orthopaedic surgeon Dr Ingnacio Ponseti Vives at the University of

Iowa in the 1950s (9). Narrating the trajectory and spread of RIs is challenging, not least because there are very few documented examples of this type of knowledge flow (9). It is rare for attempts to adopt innovations from LMICs, whether successful or failed, to be published or even documented. Equally, it is challenging to identify high-value, low-cost frugal innovations from LMICs in the first place. These types of innovations, oftentimes work-arounds or quick fixes to intractable local health service delivery issues, are not patented, not evaluated and not documented. Some notable databases are available such as the Centre for Health Market Innovations, the WHO Compendium for Technologies for Global Health, but many remain under-the-radar. The U.K. NHS's extensive commitment to overseas volunteering and partnership is an opportunity to identify innovative practice for the NHS and if well documented could become a repository for innovative solutions.

Finally, whilst much progress is being made to level the playing field in global health innovation, there remains extreme inequity in terms of the production, publication and consumption of healthcare research and innovation, favouring the Global North (31–33). It is well documented in the marketing and consumer research literatures that the country-of-origin (COO) of a product serves as a cue for quality, reliability and safety (34,35) and it is well-known that products from LICs are discounted early on because of this extrinsic cue. COO effects are therefore likely to play a particularly vital role in the adoption and diffusion of innovations which have been ideated, developed, and primarily marketed in LMICs (2,36,37). There is a need to challenge the biases that continue to favour the dominant, often North American and Eurocentric narrative around global innovation diffusion. By considering the value of adopting LMIC innovations in HICs, as well as through recognising the contributions to science of countries from which they originate, we can create an innovation landscape that is more equitable. The related decolonization movement, which challenges us to see entrenched power structures, is a useful impetus to make us aware of the unconscious biases that undermine social and cognitive justice (38,39).

Conclusion

Despite the growing literature surrounding RI, only a select few have been successfully implemented in the healthcare field. There are many specific and general challenges to the adoption and diffusion of RI in the U.K. However, considering the need for frugality and cost-savings in the NHS, and the wide variety of low-cost, high-value innovation originating in LMICs, there is a health service need for a concerted effort to

identify potential RIs, stimulate the demand for them in the NHS and to pump-prime their pilot-testing in local contexts.

Innovation	Country of origin	Unique selling point	Evidence base	Rationale for adoption	Probable challenges
Brazilian Family Health Strategy (FHS)	Brazil, inspiring similar models in South Africa and Angola	FHS teams comprising a physician, a nurse, a nurse assistant and 4-6 full-time community health workers (CHWs) serve populations of up to 1,000 households with no overlap or gap between catchment areas. FHS is rapidly scalable growing from 2,000 teams with 60,000 CHWs serving 7 million people in 1998 to 39,000 teams with more than 265,000 CHWs serving 120 million people in 2014 (40).	Cross-sectional comparison of FHS enrolees to non-enrolees and those on private health plans found that FHS enrolees were more likely to have usual source of care, to have visited a doctors or dentist within the past year, to have access to their required medications and to find the care they received satisfactory, compared to non-enrolees and those on private plans (41). Two longitudinal analyses found that due to FHP coverage unnecessary hospitalisation for ambulatory-care sensitive chronic diseases (stroke, CVD, and asthma) declined at a statistically significant rate (42), and that FHP coverage was negatively associated with mortality rates from cerebrovascular and heart diseases (43).	A U.K. modelling study found that if CHWs were to successfully engage with just 20% of all eligible but unscreened and unimmunised individuals, they could provide 753,592 additional cervical cancer screenings, 365,166 additional breast cancer screenings, and 482,924 additional bowel cancer screenings, as well as provide MMR1 vaccinations for an additional 16,398 children at 12 months and 24,716 MMR2 vaccinations at five years of age, all at a cost of £2,22bn annually (18). Employing CHWs in the U.K. in a systematic fashion could potentially reduce unnecessary workload on GPs by identifying problems early and supporting chronic disease monitoring (18).	Task-shifting the NHS to a CHW-based system would require a fundamental restructuring of the system. As there are other fundamental differences between the Brazilian and U.K. health systems (such as differences in baseline health provision, health needs and health inequalities), there is no guarantee that employing CHWs in the NHS would have the same measurable effects as in Brazil. Further, situating the newly-trained CHWs in the highly specialized primary care workforce of the NHS could prove difficult.
Arbutus Medical Drill Cover System (AMDCS)	Canada, commercialised from techniques developed in Malawi, in use by Canadian military in several LMICs	The AMDCS converts a regular hardware drill into a surgical-grade drill by creating a sterile barrier around the device (44). Following surgery, this pouch can be autoclaved and subsequently reused, precluding the need for purchasing often expensive, sterilisable surgical drills (44).	User feedback from surgeons who have used the device has been positive. The AMDCS has been used in 30,000 patients in 50 hospitals across 15 LMICs with no difference in clinical outcomes identified to date (19) although formal evaluation is pending.	Musculoskeletal disease accounts for greater than 25% of surgical interventions in the NHS and has the third largest budget at £10bn (45). Nearly all orthopaedic interventions require the use of either a surgical drill or saw. A modelling study found that cost savings associated with the AMDCS in the NHS could range between 85% and 94% and could lead to significant cost savings for Trusts if used at scale (19).	The drill system is FDA approved but lacks CE marking. Distributors prefer to sell fewer 'big-ticket' items to improve their margins, rather than repeatedly selling low-cost items such as the AMDCS. competition with other low-cost manufacturers in LMICs, as well as with large, well-established firms in the medical device industry in HICs will be high. Clinicians must use the device as instructed, as there have been reports of bags being used beyond their life span (19).
Mosquito net mesh for hernia	Burkina Faso, Cameroon,	In many low-resource settings, surgeons have resorted to using mosquito nets as a raw material from which to cut	Prospective trials with a limited number of participants established that using sterilised mesh was both safe and	Roughly 70,000 surgeries were performed to repair inguinal hernias in England in 2001/02, comprising	Asking surgeons to change their practice and use an unfamiliar material may prove challenging. Additional effort involved in

repair	Ghana, India, Ivory Coast, Uganda	appropriately-sized pieces of mesh to use in hernia surgery (46). After pieces have been cut to size, they are sterilised and subsequently implanted (46).	effective (47,48). Randomized controlled trials (RCTs) were undertaken establishing no significant difference in short-term clinical outcomes (20,49). Mosquito net mesh has been found to be vastly cheaper than commercial mesh (US$ 0.0043 compared to US$ 108; respectively) (20,21).	0.14% of the population and accounting for 100,000 NHS bed-days of hospital resources (50). Open mesh repair is the preferred surgical technique to remedy inguinal hernias, performed by 96% of U.K. surgeons (51). No cost-effectiveness analyses have been performed in a high-income context, but there is potential for significant cost savings to the NHS.	cutting large nets down to size and sterilising them before surgery, present another barrier. There is no long-term data to support the efficacy of mosquito net mesh for hernia repair, as most trials only monitored up to 12 months post-surgery. There is a theoretical risk of mesh material distortion at U.K. standard autoclave temperatures (52) leading to concerns of prion disease transmission if sterilised at lower temperatures. This requires substantiation in order to ensure that double standards in clinical practice between HIC and LMIC contexts are avoided.
Friendship Bench	Zimbabwe	The Friendship Bench (FB) is a community-based intervention focused on delivering brief psychological interventions for common mental health disorders, such as anxiety and depression with the assistance of lay health workers (53). Patients are referred to the benches by clinicians, where they receive up to six 45-minute counselling sessions and may be referred to other health or social services (53).	An RCT from 2016 investigating the effectiveness of the intervention found that in the group of individuals who received the intervention, had lower symptom scores of anxiety and depression after 6 months as compared to those who received the usual standard of care (54). Cost-effectiveness analyses of a similar programs in Chile and India found that a stepped-care approach to mental health, and the use of lay health workers was more effective and only marginally more expensive than treatment in primary care (55) and had a sustained effect on depression outcomes over a 12-month period while maintaining cost-effectiveness (56).	Around 1 million people received some form of psychological therapy for a common mental disorder in the U.K. in 2016/17, and 1 in 6 people experience a bout of depression or anxiety each week (57). Additionally, people living in deprived areas are less likely than average to recover from their condition after psychological therapy (57). Eight CCGs are expected to miss their required mental health investment standard for the second year in a row (57). Task-shifting mental health care to a multicomponent stepped-care program, could provide much-needed relief to the NHS' mental health facilities.	Shifting the NHS' mental health facilities from a primary-care-focus to a community-based model will require a significant investment in terms of time and effort. Training lay health workers in both mental health and cultural competencies, so that they may have productive conversations with potential patients may entail a significant up-front investment.
Sayeba's method	Bangladesh	An improvised intrauterine tamponade consisting of a condom secured to a sterile rubber catheter using a piece of string (58). The catheter is inserted into the uterus and subsequently inflated using saline solution to control postpartum haemorrhage (PPH)	A prospective study of 23 women conducted in Bangladesh, found that in all 23 patients, bleeding stopped within one hour of the intervention, patients did not go into irreversible shock and there was no infection detected (59). A	PPH is the second leading cause of direct maternal deaths in the U.K. (62). A 2019 report by MBRRACE-UK identified the need to 'Improve care for women with haemorrhage' (63). There is also an increased emphasis	Sayeba's method is unlikely to replace other frontline treatment for PPH in a hospital setting in HICs, where different catheters may be more readily available than condoms. Further, medicinal management is likely to remain the

		resistant to medicinal treatment (58)	systematic review of different uterine balloon tamponade methods found that Sayeba's method was the most commonly used device in resource-poor settings (60). Sayeba's method was successful in 186 of 193 cases (60). Prices to create uterine balloon tamponades vary from US$ 225 oesophageal catheters to US$ 0.19 for condom catheters (61), suggesting a high potential for cost-effectiveness.	on the availability of births at home or in midwife-led contexts (62). Using Sayeba's method to control PPH could address both points. Other advantages, include the availability of the materials used, rapid insertion requiring no anaesthesia, and ease of the procedure, which can be performed by relatively inexperienced personnel (61).	preferred method of treatment in the hospital setting. Changing these guidelines would require robust evidence, as well as the endorsement from professional associations such as the Royal College of Obstetricians and Gynaecologists, as well as MBRRACE-UK.
Zipline – Drone-based delivery for medical supplies	U.S.A., marketed and scaled in Rwanda	Zipline was established in 2014 to improve access to medical supplies for people living in remote locations (64). The first healthcare delivery service was started in Rwanda in 2016 (65). Drones – called 'Zips' – can carry up to 1.8kgs of medical supplies (66). Blood transfusions make up the majority of Zipline's deliveries (67). Medical practitioners request a delivery via a text message or the Zipline App and are notified one minute prior to delivery to 'walk outside and receive [their] delivery.' Boxes with supplies are dropped from the Zip using a paper parachute (66). By relying on drones, Zipline not only ensures fast delivery of medical supplies, but they are also able to lower costs compared to land-based delivery by up to 50% (66,68).	70% of the population in Rwanda live in rural areas, indicating that healthcare is likely not easily accessible for most of the rural population (68). Zipline partnered with the Rwandan government to enable delivery of over 50 different medical products to serve those communities living in remote areas of the country. For instance, since Zipline's establishment in Rwanda, many mothers who give birth in remote areas no longer need to be transported to centrally-located hospitals in the event of PPH, as blood transfusions can be delivered directly to them on-demand (69). Zipline's success is beginning to spill over into other LMICs. A second distribution centre was opened in Ghana in 2019, with plans to open more over the course of the next four years (70). Zipline also seeks to expand to Indonesia in the future (66).	Underserved communities without regular access to medical care are not unique to LMICs. Zipline has recognised this and has started to implement plans to bring medical supplies to communities in several U.S. states, such as Maryland, Nevada, and Washington, as well as to Native American communities. As the telemedicine market continues to grow in the U.K. (71), Zipline could provide a complementary service to the increasing telemedicine offerings.	Regulatory hurdles are likely to be the biggest barrier to implementing Zipline in HICs. As was seen in the U.S., there are several guidelines laid out by the Federal Aviation Agency (FAA) that could severely restrict the ability of Zipline to function effectively. For instance, in the U.S., Zipline is not allowed to deliver goods at night, and their drones are not allowed to fly over people (72). A thorough understanding of the regulatory landscape facing drones in the U.K. is necessary before Zipline's services can be offered.
Peek Vision	United Kingdom, marketed and scaled in Botswana,	Peek Vision's innovative approach to eye health system strengthening is centred around a smartphone-based vision screening app, as well as real-time data reporting and eye health service analytics (73)	Nonclinical photographers using the smartphone-based adapter for optic disc imaging were as effective at acquiring optic nerve images as ophthalmic assistants using desktop retinal cameras (74). A cluster RCT	The number of people living with sight loss in the U.K. is set to increase steadily, reaching 4 million by 2050 (77). The indirect costs due to partial sight and blindness were estimated at more than £4mn in 2008 (77). At least	Though Peek Vision's smartphone-based technologies could be easily used in the U.K., their holistic approach to strengthening the eye health system would likely not find traction in the NHS. Peek specifies that, 'We work with our partners

	Zimbabwe and Pakistan		found that the Peek school eye health system showed increased adherence to hospital referral for visual impairment among school children compared with the standard approach (75). Peek Vision has expanded to Botswana, Zimbabwe and Pakistan (76).	half of all sight loss is avoidable (77). The simple and effective screening provided by Peek Vision, which has also shown increased adherence to follow-up visits (75) could significantly impact the burden of disease in the U.K.	to assess unmet needs for eye health services,' (78). This unmet need would likely not be identified in the U.K., where the NHS provides 13 million eye tests per year (79).
Sproxil	U.S.A., marketed and scaled in Nigeria, Kenya and Ghana	Sproxil's suite of products (called Sproxil Solutions) empower consumers to play an active role in detecting and combatting counterfeit drugs. Sproxil Defender is a point-of-sale product code, also known as Mobile Product Authentication (MPA) which allows consumers to authenticate the medication they have purchased (80)	Sproxil's MPA codes have been used over 8.5 million times by consumers to verify a range of different products, from pharmaceuticals to automotive parts and electric cables. Law enforcement is able to use cell-phone tracking data to identify hot-spots for counterfeit medication (80). Sproxil launched in Nigeria, but has since expanded to Kenya, Ghana and India (80).	The global incidence of counterfeiting has increased by 51% between 2011 and 2015 (81). 11 cases of falsified or counterfeit medicines were detected in the U.K. between 2001 and 2011 (81). In 2013, £12m worth of counterfeit medicines were seized in the U.K. as part of a week-long international operation (82). In the event of a no-deal Brexit, the U.K. will be left out of an E.U.-wide system to combat counterfeit drugs (83). A 2016 study testing the efficacy of medication authentication technology in the U.K. found that the technical detection rate was at 100%, though because of low compliance with scanning at the start of the study, only 31% of counterfeit medicines were detected (81). A user-friendly, easily scalable system such as Sproxil could prove beneficial in the U.K.	The U.K. has collaborated heavily with the E.U. on the E.U.'s Falsified Medicines Directive (FMD), which offers protections against counterfeit drugs should the U.K. remain in the E.U. in some capacity (83), making a system such as Sproxil obsolete. In the absence of such regulatory frameworks, compliance may be the biggest hurdle, as evidence by Naughton's 2016 investigation (81). Ensuring buy-in and participation, which will require contributions from manufacturers, pharmacists and consumers could prove challenging.
Prepex	Israel, marketed and scaled thoughout sub-Saharan Africa	Prepex is an elastic ring-controlled radial compression device that is designed to offer non-surgical male circumcision (84). Its primary use has been to rapidly scale up voluntary medical male circumcision (VMMC) in Sub-Saharan Africa in order to prevent the transmission of new HIV infections (84).	Multiple trials have confirmed the safety and effectiveness of the Prepex device for VMMC (84–86). The procedure can be performed by relatively inexperienced personnel, in non-sterile settings in approximately 4.5 minutes, without anaesthesia or sutures (87). The device is in use in 13 countries in Sub-Saharan Africa with high HIV prevalence (87). Cost-effectiveness analyses have been	New HIV cases in the U.K. continue to decline (90). The Prepex device is unlikely to be used for the prevention of new HIV infection as it is in Sub-Saharan Africa. Prepex could offer a significantly cheaper, quicker and less painful alternative to men who require circumcisions for medical or other reasons. Current procedures are carried out on a day-patient basis, require general anaesthesia, sutures	The number of circumcised men is declining in the U.K. (92). In communities where circumcisions are performed for religious reasons, it is unlikely that the Prepex device would be used, as it may not be in accordance with cultural traditions. In light of the low frequency with which the procedure is performed, expending effort to convince practitioners to switch from surgical to non-surgical circumcision may not be seen as a high priority.

			conducted in several African countries (86,88,89), concluding that Prepex can be cost-effective if human resources are employed effectively.	as well as the prescription of pain-killing medication (91). These expenses could be avoided by using Prepex.	
Hemafuse	U.S.A., marketed and scaled in Kenya and Ghana	The Hemafuse is a manually operated autotransfusion device that can be used to collect a patient's blood during an internal haemorrhage. It is subsequently re-transfused back to the patient, thereby addressing the lack of donor blood available in many emergency and resource-constrained settings (93).	The process of autotransfusion has been proven to be clinically safe and effective (93). Autotransfusion devices used in many parts of the Global North, however, are expensive and rely on a power source, whereas the Hemafuse device can be operated manually by a single individual (23). The autotransfusion process using the device takes approximately 10 minutes, and costs roughly US$ 60 per patient, compared to US$ 250 for a bag of donor blood (23). The device is currently being sold in Kenya and Ghana (94), and the company will soon be expanding to India (95).	Over the past five years, the number of men giving blood in the U.K. has fallen by roughly 25% (96). The NHS has identified a shortage of donors in three areas with majority black African and black Caribbean populations (97). Further, it is estimated that although about 8% of people have O negative blood, O negative constitutes 13% of requests from hospitals (98). Autotransfusion could offer a viable solution to many of the shortages of donor blood faced in the NHS. Especially for hospitals unable to afford expensive autotransfusion devices, the Hemafuse could be a cost-effective alternative.	In areas where enough donor blood is available, it is unlikely that autotransfusion will become the new standard of care. Additionally, Hemafuse cited 'friendly regulatory environments' as a reason for seeking approval in Kenya and Ghana (94), implying that the process of obtaining regulatory approval for their device may be significantly more difficult in places like the U.K.

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