


Research Article

The role of digital innovation in improving healthcare quality in extreme adversity: an interpretative phenomenological analysis study

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Keywords: extreme adversity, digital health, healthcare quality, conflict settings

<https://doi.org/10.29392/001c.37241>

Journal of Global Health Reports

Vol. 6, 2022

Background

High quality is a necessary feature of healthcare delivery. Healthcare quality challenges are particularly present in conditions of extreme adversity, such as conflict settings or sustained humanitarian crises. Digital health technologies have recently emerged as an innovation to deliver care around the world in a variety of settings. However, there is little insight into how digital health technologies can be used to improve the quality of care where extreme adversity introduces unique challenges. This study aimed to identify how digital health technologies may be most impactful in improving the quality of care and evaluate opportunities for accelerated and meaningful digital innovation in adverse settings.

Methods

A phenomenological approach (Interpretative Phenomenological Approach [IPA]), using semi-structured interviews, was adopted. Six individuals were interviewed in person based on their expertise in global health, international care delivery, and the application of digital health technologies to improve the quality of care in extreme adversity settings. The interviews were informed by a semi-structured topic guide with open-ended questions. The transcripts were compiled verbatim and were systematically examined by two authors, using the framework analysis method to extract themes and subthemes.

Results

The participants identified several areas in which digital health technologies could be most impactful, which include engagement in care, continuity of care, workforce operations, and data collection. Opportunities for accelerated digital innovation include improving terminology, identity, ownership, and interoperability, identifying priority areas for digital innovation, developing tailored solutions, coordination and standardisation, and sustainability and resilience.

Conclusions

These results suggest that there are conditions that favour or challenge the application of digital health technologies, even in specific areas in which they could be useful. A better understanding of the drivers and barriers to digitally driven quality improvement in settings of extreme adversity could inform international policies and optimisation strategies for the future.

Quality in healthcare is not a static endpoint but a journey towards continuously improved health care.^{1,2} Over the past two decades, the conversation around quality has generated a nuanced understanding of how healthcare

providers can learn from best practices, share knowledge, invest in the necessary infrastructure, and build an organisational culture focused on quality and safety.³⁻⁵ Optimising quality requires clinical expertise, operational func-

tionality, and relational abilities to build a solution that addresses unmet needs.^{3,4,6} While the tenets of quality (including safety, effectiveness, and patient experience), remain relatively stable across the literature, contextual factors deeply influence their successful application.⁷ Quality care is now acknowledged as a necessity rather than a luxury,⁸ but it is often not prioritised in many settings around the world, particularly in extreme adversity settings where reactive care and limited resources pose important challenges.⁹

Extreme adversity is defined by Leatherman and colleagues as comprising (but not limited to) fragile states, conflict-affected areas, and sustained humanitarian crises.¹⁰ It captures the unrelenting nature of difficulty in these areas, which results in unstable institutions operating under dire challenges. Chaos and discoordination define situations of extreme adversity. Fragile, Conflict-affected and Vulnerable (FCV) settings¹¹ has also been used to describe settings of extreme adversity.¹²

Challenges like conflict, famine, extreme poverty, and national political fragility are often so insurmountable that prioritising quality in healthcare delivery becomes particularly difficult.¹⁰ A multicountry assessment of health workers' perceptions of priorities for care in settings of extreme adversity demonstrates that saving lives is the number one priority but this may neglect many other health implications, including mental health and preventive health.¹³ In these settings, healthcare quality is often synonymous with saving lives, contrary to more conventional definitions that include the importance of doing no harm.

Digital health technologies have emerged as a potential solution to improve healthcare quality. These digital health innovations have improved flexibility of care, remote monitoring, and chronic disease management and introduced the widespread use of electronic health records, genome sequencing, and the application of artificial intelligence to diagnostic decision making.^{14,15} Globally, the proliferation of mobile networks has increased access to health information and interpersonal communication between providers and patients. Even in areas of adversity, people have access to mobile phones. At present, 93% of refugees live in areas with 2G or 3G coverage and 75% of refugee families already own a mobile phone.¹⁶ It is estimated that by 2025, there will be 7.49 billion mobile phone users.¹⁷ By harnessing these technologies in healthcare, there is an opportunity to improve the quality of care and support a more integrated approach to health and social care delivery. In areas of extreme adversity, digital health technologies have increased the ability to move with personal health information, which can be critical for vulnerable populations, such as refugees.^{18,19} For example, the HERA mobile application has introduced preventive health access to refugee mothers and children, which offers continuity of care for moving populations.²⁰ The introduction of digital technologies has also demonstrated increased efficiency in providing care for vulnerable populations, as demonstrated by the implementation of the maternal and child health eRegistry in Palestine.²¹

Areas of extreme adversity, such as conflict settings, are particularly underrepresented in the literature and, therefore, are excluded from reaping the health benefits new digital solutions offer.²² However, there is a responsibility to leverage the features of these innovations that can improve access and deliver an appropriate level of quality care for patients in such settings. As the quality agenda extends to areas where it is needed most, it is necessary to develop the evidence base of how quality can be improved and what tools are available to support this. It is necessary to start to capture and collate areas of best practice where solutions like digital innovation have produced meaningful improvements to quality. As an evolving, complex field, this exercise requires the insight and testimony of experts working at the frontier of this area.

This qualitative study aims to 1) identify key areas in which digital technologies have the potential to improve the quality and safety of care in extreme adversity settings, and 2) to identify opportunities for accelerated and impactful innovation based on the perspectives of experts working in areas of extreme adversity.

METHODS

OVERVIEW OF THE METHODS USED

A phenomenological approach (Interpretative Phenomenological Approach [IPA]) was used. Phenomenology, developed by Edmond Husserl as an eidetic method, aims to identify the essential components of phenomena or experiences²³ and was, therefore, chosen to identify key areas and opportunities for using digital technologies in extreme cases adversity settings.

Semi-structured, in-depth, individual interviews were used for data collection. This approach is the most popular methodology used for data collection in IPA studies, because of its ability to elicit rich descriptive data about individual perceptions, attitudes, and behaviours.²³ In-depth interviews allow the interviewer to explore and examine a given topic or experience in detail and are, therefore, an effective method for interpretative inquiry.²⁴ The research team included health services researchers (OL, NO, LR, NK, AS, KF, AL, SL, AD, ALN), medical doctors (AL, ALN, SG, AD), and policy fellows (NO & AS) with previous experience conducting qualitative research.

RECRUITMENT

In line with the theoretical underpinning of IPA, purposive sampling was used.²³ Participants included individuals with ten or more years of experience developing innovative technological solutions in areas of extreme adversity. International, multidisciplinary interviewees with experience collaborating with local organisations in extreme adverse settings were prioritised. Samples in IPA studies are usually small, which enables a detailed and time-intensive case-by-case analysis. According to Turpin et al. (1997),²⁵ six to eight participants is an appropriate number for an IPA study, as this size sample gives an opportunity to examine similarities and differences between individuals.

Participants, including one female and five males, were recruited based on researchers' personal contact networks and knowledge of key field experts. All participants had experience developing healthcare solutions for areas of extreme adversity and were involved in executive-level leadership, epidemiology, health innovation, and healthcare quality. Participants were invited to participate in an interview study by email in October 2018, and consented by responding to the above-mentioned email, expressing their willingness to take part in a subsequent interview. Eight individuals were invited but did not respond to the invitation and one confirmed participant dropped out due to scheduling issues. There were no significant differences in terms of gender, setting, or expertise between the recruited participants and those who were invited and did not participate. All participants spoke English fluently and were able to consent themselves. No vulnerable persons were involved in the study.

DATA COLLECTION

Six in-depth, 60-minute, online interviews were conducted between November and December 2018 via Skype or in-person in the interviewees' workplaces. Interviews were facilitated by LR, KF, and NK with no others present beside the participants and researchers. A topic guide with open-ended questions was used to cover all the relevant topics during the online interviews (*Online Supplementary Document*). Notes from the interviews were transcribed verbatim. All interviews were conducted in English. Participants had a minimal knowledge of the characteristics of the interviewer and of the research team, thus minimising the potential for bias and assumptions. The interviewees' responses were not returned to the interviewee for review after the session. No repeat interviews were conducted.

DATA ANALYSIS

The Interpretative Phenomenological Analysis (IPA) was used to explore shared perspectives around digital innovation in extreme adversity, using a multi-perspective analysis. IPA aims to generate knowledge on the participants' journey to make sense of phenomena under investigation, while simultaneously documenting the researcher's sense making.²³ Analysis of the qualitative material usually include: 1) multiple reading and making notes; 2) transforming notes into emergent themes; 3) seeking relationships and clustering themes.²³ Two researchers (OL, NK) trained in qualitative analysis conducted independent thematic analyses using Excel. Emerging themes were supported by participants' quotations. The Consolidated Criteria for Reporting Qualitative Research were used to ensure the study met the recommended standards of qualitative data reporting (*Online Supplementary Document*).

ETHICS

This study has received ethics approval from Imperial College Research Ethics Committee (ICREC) (Reference 211C6785).

RESULTS

PARTICIPANT CHARACTERISTICS

Six interviewees were selected based on their expertise in global health, care delivery, and the application of digital technologies to improve the quality of care in conflict and extreme adversity settings. The six experts interviewed have been involved in digital innovation in circumstances of extreme adversity around the world and, therefore, can provide anecdotal evidence to share with broader audiences to facilitate the spread of emerging best practices.

AREAS IN WHICH DIGITAL TECHNOLOGIES HAVE THE POTENTIAL TO IMPROVE THE QUALITY AND SAFETY OF CARE IN EXTREME ADVERSITY SETTINGS

Four major themes emerged as areas in which digital technologies have the potential to improve the quality and safety of care in extreme adversity settings, including engagement in care, continuity of care, workforce operations, and data collection (*Table 1*). The themes presented are listed in no particular order, and in line with the qualitative approach, no one theme is presented as more important than the other.

1. ENGAGEMENT IN CARE

Patient engagement is a key pillar for safe care but in extreme adversity settings, this engagement is often compromised by lack of continuity due to conflict, lack of accessible information that can be used to evaluate high quality care providers, and stigma, particularly around mental health. Participants noted that digital technologies could offer an avenue in which patients are better able to advocate for themselves and could operate as a vehicle to raise awareness, share information, and audit professional quality and safety behaviours.

2. CONTINUITY OF CARE

Participants described the lack of care continuity, particularly for refugee populations, as a driver of poor health outcomes and a feature in many extreme adversity settings. Technologies that safeguard patient information, enhance portability of information, protect patient identity, and retain previous medical history with the anticipation that the individual may relocate to another area or country were described as potentially impactful to improve the quality of care.

3. WORKFORCE OPERATIONS

Participants identified areas in which digital technologies could enhance workforce operations, specifically in training, simulation, and distance learning and in the protection of workers. Because of the limited learning and development activities in extreme adversity settings, digital technologies may offer improvement in quality and safety through more readily accessible educational opportunities. Participants emphasised that digital technologies could

also mitigate several current challenges around workforce protection, including tracking of workers taken as hostage, mitigating workers' direct contact with infectious diseases through virtual care, and evaluating the efficacy of new vaccines.

4. DATA COLLECTION

Use of data for improving healthcare quality is contingent on robust mechanisms for data collection. Participants identified data capture and interoperability as areas in need of improvement in extreme adversity settings, specifically for improved disease surveillance and supply chain forecasting. Currently, the processes for data collection are largely manual and do not allow for the sharing of information in times of crisis.

OPPORTUNITIES FOR ACCELERATED AND IMPACTFUL DIGITAL INNOVATION IN ADVERSE SETTINGS

Six major themes emerged as opportunities for improvement in the context of using digital technologies in extreme adversity settings, including improving terminology, identity, ownership, and interoperability, identifying priority areas for digital innovation, developing tailored solutions, coordination and standardisation, and sustainability and resilience ([Box 1](#)).

1. IMPROVING TERMINOLOGY

Multiple participants cited the current lack of consensus regarding the terms used in this research area. Terms such as “digital health”, “adversity” and “conflict” were specifically cited by interviewees as concepts requiring clarity in research and in practice.

The importance of term clarity for robust, evidence-based action planning cannot be understated. Because conflict-ridden areas differ greatly from stable but poorly resourced areas, the application of one digital health solution may not have the same impact in another area due to the various influences of contextual factors. Some participants offered examples to illustrate the variation in settings captured under the umbrella of “extreme adversity”. Despite the variation in terminology used even within the study sample, the concept of uncertainty underscored nearly all responses as a key characteristic of extreme adversity.

2. IDENTITY, OWNERSHIP & INTEROPERABILITY

Certain interview themes, around topics such as patient control of digital health information, mobility of information, system interoperability, digital identity, and shared commonalities for a larger theme around data tracking and protection.

There was a nearly universal call for digital health innovations to assess the technologies that already exist in the target region and understand the strictures that could prevent a new innovation's scalable success, particularly in the realm of data interoperability. Interviewees emphasised

the importance of first assessing similar technologies before adding new digital health innovations to the market.

Though the importance of data interoperability is multifaceted and significant around the world, interoperability becomes even more important for refugee populations in settings of extreme adversity, as the ability to move across borders with health information offers a source of continuity.

3. IDENTIFYING PRIORITY AREAS FOR DIGITAL INNOVATION

Interviewees cited priority areas for digital innovation based on common needs identified across various contexts of extreme adversity. Many have recognised the importance of digital innovations for infection control and prevention and used previous experiences to reflect on future research and implementation areas. Mental health was cited as a priority area for digital innovation due to conflict, where psychosocial vulnerabilities are increased, as a common feature in settings of extreme adversity, where the mental health treatment gap is particularly high.²⁶ Areas of extreme adversity are often characterised by risk and uncertainty, factors which must be considered in the deployment of human or digital resources. Interviewees suggested that many of the successful digital innovations have minimised the risk for external personnel, particularly around infection control and prevention.

Multiple participants cited previous experiences using digital technologies, such as tablets, to deliver education and training to health workers in remote, poorly resourced areas.

Regardless of the practice area for digital health innovation, interviewees placed significant priority on building digital innovation solutions for sustainability from the beginning. See “Sustainability and Resilience” section for more information.

4. DEVELOPING TAILORED SOLUTIONS

As with the interviewees' emphasis on defining terms, a similar priority was placed on tailoring digital solutions to the setting, particularly by first defining the features of the extreme adversity experienced by the group.

All responses captured within this theme overtly or covertly underscored the importance of including the target population in building the digital health solution to ensure end-user buy-in, address relevant needs of the group, and enhance the likelihood of sustainability. Even for seasoned health researchers and practitioners who have experienced barriers to digital health innovation, consideration of the context sheds light on the innovations that will be most impactful. Involvement of those living and working within the context from the beginning is imperative.

It was explicitly clear that the success of the digital health innovation, in the short term and in the long term, was dependent on customising the solution to the context after a thorough review of the area's current state and assessment of stakeholder needs.

Table 1. Areas in which digital technologies have the potential to improve quality and safety of care in extreme adversity settings

Area / System factor	Purpose	Description
Engagement in care	Patient engagement in their safety	<ul style="list-style-type: none"> • “Digitalisation can be very good for auditing provider behaviour for quality improvement and this digitalisation can be used by patient groups to assay whether or not they’re getting patient care from providers.” [ID 5] • “If you go to Khana health centre, most people will be women in a war zone and usually with babies and often old. The older women say that people don’t see them, and they’re forgotten. Making it so that the option for accountability and assurance that your interests [as a patient] are going to be served is increased as a result of having some sort of device, even being able to send text messages, would make a huge difference.” [ID 5]
	Raising awareness	<ul style="list-style-type: none"> • “With more expertise in digital technology, we could have done more on this side, particularly using social media to raise awareness and to monitor rumours associated with Ebola.” [ID 3] • “Mental health is a huge issue which is going to be recognised, particularly in conflict zones, as you have PTSD seen now as fairly important aspect of overall health. There’s a lot that can and needs to be done on mental health, because people of different levels of training can be helpful in that context, community health workers can be leveraged to recognise symptoms. [There is an] alarmingly high incidence of PTSD in conflict zones.” [ID 1]
Continuity of care	Patient information	<ul style="list-style-type: none"> • “What really matters is making certain that as much as possible of the chronicle of a person’s disease and therapeutic approach is in the hands of the person rather than in the hands of the provider. If there’s a case of patient retained medical records, it’s in settings of adversity.” [ID 5] • “For the mobile populations, digital identity is key for importance of protection. [It is important to] make sure people can have access to service. I have seen in the Syrian crisis where having such information is important [because] people [are] crossing the border without documentation. There should be a way of [using] digital tools to enable refugees to access services including employment.” [ID 2] • “It would be helpful to have a way of records being retained by the person in a form they can access, but also on behalf of that person, on a cloud that others can access that is still somehow controllable for the patient...The ideal is [to have] records with the patient, accessed by the patient, that they can read and understand. This means there’s capacity for reasonable continuity.” [ID 5] • “In India, the Aadhaar ID system is a fundamentally helpful way of tracking medical records.” [ID 1] • “Mobile [phones] can also be seen as a health passport, which is a digital thing, not a physical thing. You could develop it to monitor stuff in blood, in saliva, in areas that might be infected, to check whether you’re fertile, etc.” [ID 5]
	Digital identity	<ul style="list-style-type: none"> • “The challenge is identity, whether person has one. In India, they have digital identity based on I think fingerprint, but [they] may start introducing based on retina.” [ID 5] • “Technologies to identify individuals can help to develop centralised missing persons board.” [ID 6]
Workforce operations	Training, simulation and distance learning	<ul style="list-style-type: none"> • “In terms of health workers training and quality service, in many areas, especially sub-Saharan Africa, health workers don’t have good training. There are few learning opportunities. Small investments like tablet-based learning weekly in a clinic, would have huge impact, but there’s not much available.” [ID 2] • “[We] tried distance learning for health workers in a refugee camp through a partnership with a university in Geneva that developed online learning platform so that when refugees go back to Somalia, they have transferrable European credit. [This can be] used to gain employment when they go back...The uptake is quite good.” [ID 2]
	Protection of workers	<ul style="list-style-type: none"> • “How do we track our own staff, in areas subject to hostage taking in the past? [We] implemented Scan app, GPS system with live dashboard.” [ID 3] • “[In the case of] Ebola, it was difficult to get healthcare experts into country because of security. [We] don’t want to put more people at immediate risk, [so there was a] conundrum of trying to get many people with expertise... [Through an] online support system via video conference, experts [were] able to support physicians on site. Extremely interesting and done in real time.” [ID 3] • “Using the Ebola experimental vaccine, 44,000 people were vaccinated as part of research trial. [Using a] cloud-based system to monitor for adverse events, with all information sent to the cloud, people across world [were] analysing data in real time.” [ID 3]
Data collection	Data capture	<ul style="list-style-type: none"> • “[There are] issues around the way we capture data related to outbreaks in infectious diseases. The surveillance system captures data from around the world, [with] around 7,000 signals of public health threats every month, whittled down to 600 more serious threats, then using ma-

Area / System factor	Purpose	Description
		<p>chine learning and AI techniques to reduce down to 300. Then, humans cut that down to 30 that we will investigate. Most commonly, it's infectious disease outbreaks like Ebola or other pathogenic outbreaks. It would be helpful to improve these systems using AI, [because] it's heavily reliant on manual expertise at the moment." [ID 3]</p> <ul style="list-style-type: none"> • "Adoption of standards for information sharing is key where the use of standards allows you to share information in a crisis." [ID 6]
	Supply chain forecasting	<ul style="list-style-type: none"> • "Another area where I see biggest need is supply chain in conflict settings. Health facilities [are] dependent on humanitarian funding, with no capacity for planning tools/forecasting. We cannot plan for when we will run out of medicine, and it can take some time to deliver. A tool for forecasting and planning would be very valuable for being able to track stock movements." [ID 2]

5. CO-ORDINATION & STANDARDISATION

The unity theme captures interviewee sentiments around the centralisation of information, auditing of practice, and standards for digital health technologies. Many interviewees cited the lack of a centralised mechanism for clinical practice at all, let alone standards for digital innovation in areas of extreme adversity. Currently, technologies are developed without shared guiding principles and this lack of coordination among developers of new technologies continues to exacerbate fragmentation and poor uptake of the technology after its initial launch.

6. SUSTAINABILITY & RESILIENCE

All interviewees cited the importance of sustainability, the current lack of scalability in many digital health innovations, and various elements that could contribute to a sustainable digital health initiative. However, there are few examples to emulate for the sustainability of future digital health innovations as many initiatives do not move beyond pilot trials. The implementation and sustainment of the digital health technology itself relies first on the human expertise and a robust supply chain to provide necessary equipment and resources. Both dictate the feasibility of the digital innovation beyond the pilot launch in areas of extreme adversity.

The pattern of funding itself contributes to the often-piecemeal digital health technology improvements that are not able to be sustained. Because international aid and non-governmental organisational work is often perceived as fragmented transactions, a relationship built on trust and understanding of the relevant contextual factors is critical.

Finally, interviewees highlighted the importance of local stakeholder engagement to ensure that the hand-off of the digital innovation from the pilot phase is met with contextual buy-in.

DISCUSSION

SUMMARY OF KEY FINDINGS

In this study, interviewees identified four top priorities for digital health innovation in areas of extreme adversity,

which include engagement in care, continuity of care, workforce operations, and data collection. Iterative thematic analyses revealed several opportunities for impactful digital innovation in adverse settings, including improving terminology, identity, ownership, and interoperability, identifying priority areas for digital innovation, developing tailored solutions, coordination and standardisation, and sustainability and resilience.

FINDINGS AS COMPARED WITH PREVIOUS STUDIES

Interviewees highlighted the significant potential for digital solutions to improve health outcomes for individuals living in circumstances of extreme adversity. A number of themes extracted from the interviews, particularly the need to develop processes for sustainability as early as possible, were aligned with previous literature. It has been suggested that the scalability of digital technology relies on the program or technology addressing an unmet need from the end user perspective.^{27,28} Assumptions about contextual barriers to and need for digital health technology will lead to the development and implementation of solutions that are not sustainable or do not address the population's needs.

Similarly, an analysis of previous studies reveals that although there is strong potential for digital technologies for health improvement, these interventions are often characterised by pilot projects that end once the initial funding has been used.¹⁴ Indeed, literature shows that initiatives for digital health solutions in areas of extreme adversity are largely initiated on an *ad hoc* basis, without a structured process for sustained delivery.²² More specifically, it has been suggested that contextual pressures, such as immediate needs in unstable conflict conditions, drive providers and organisations to deliver *ad hoc*, unregulated services.²² Certain elements are required for a successful scale-up of digital health initiatives.¹⁴ These include the ability to plan for sustainability upon initial launch, identify the real needs of the target audience, collaborate with other similar organisations to avoid duplication, engage end users in the development to support uptake, align programs with existing priorities, and maintain flexibility to adapt to changing needs.¹⁴

The interviewees' suggestions for "adoption of standards for information sharing" is supported significantly by re-

Box 1. Opportunities for accelerated and impactful digital innovation in adverse settings

Theme 1: Improving terminology

- “There’s a big push for digital health, which means different things to different people.”
- “Conflict is very different from very poor but stable areas.” [ID 1]
- “[Depending] on how you define extreme adversity, [whether] a refugee camp in Palestine or resource-restricted area of Kenya.” [ID 4]
- “The various extreme adversity conditions could be resource -tight conditions, settings with extreme political pressure, areas with horrific diseases, little environmental resources for indigenous people, areas with no trained professionals, etc.” [ID 4]
- “[Extreme adversity includes] whether or not you can access a care provider. Any preventive interventions are often uneven, irregular, or badly recorded. For example, it is easy to get multiple vaccinations in settings of adversity.” [ID 5]
- “When you’re ill, it’s a potluck as to whether you’ll get help.” [ID 5]
- “Key thing about extreme adversity is unpredictability. You can’t predict anything.” [ID 5]

Theme 2: Identity, ownership & interoperability

- “It is important for platforms to be as few as possible so they can be solid and well architected.” [ID 1]
- “Having information and being able to move with it [helps] people crossing the borders without documentation.” [ID 2]
- “What really matters is making certain that as much as possible of the chronicle of a person’s disease and therapeutic approach is in the hands of the person rather than in the hands of the provider. If there’s ever a case for patient-retained medical records, it’s in settings of extreme adversity.” [ID 5]
- “The ideal record is with the patient, accessible by the patient so that they can read and understand.” [ID 5]

Theme 3: Identifying priority areas for digital innovation

- “Mental health is a huge issue which is going to be recognised, particularly in conflict zones. There’s a lot that can and needs to be done on mental health... Alarmingly high incidence of PTSD in conflict zones.” [ID 1]
- “In terms of health workers, especially in sub-Saharan Africa, health workers don’t have good training and have few training opportunities. Small investments, like tablet-based weekly learning activities in a clinic, would have huge importance but not much is available.” [ID 2]
- “[We’ve] tried distance learning for health workers in refugee camps [through] a partnership with a university in Geneva. They developed an online learning platform so that when refugees go back to Somalia, they have transferrable European credit and can use it to gain employment when they go back.” [ID 2]
- “For Ebola, it is difficult to get healthcare experts into the country because of the security. We don’t want to put more people at immediate risk, so there’s a conundrum of trying to get many people with expertise...Online support system via video conference [allow] paediatric experts to support physicians on site.” [ID 3]

Theme 4: Developing tailored solutions

- “It’s important to tailor the system to the needs and the means of the particular context.” [ID 1]
- “Indigenous health professionals kept asking for notepads that are waterproof or damp proof [because] their records got mouldy...from the heat and humidity.” [ID 4]
- “[It is] important to recognise that the barriers in India are very different from the barriers in Congo, Sierra Leone, and Liberia.” [ID 1]
- “Anyone can write software, but the modification should be as local as possible so it’s most relevant... You won’t need multiple platforms, as long as you can customise and adapt locally.” [ID 1]

- “There’s no universal technology. It’s very contextual. One researcher was leading a large trial in Congo and Vietnam using mobile-based technology and sending [health-related] texts to people as reminders. People opened the messages and it worked in the Congo. The same technology in Vietnam didn’t work because the Vietnamese people are so used to spam on their mobiles that people don’t open their phones. But in the Congo, mobiles are often used and people respond quickly to messages...One size does not fit all.” [ID 4]
- “So many tools have been developed with people on the move in mind, and the challenge is we try to fit that to a different setting, instead of developing it with a population in mind, that’s the thing that’s missing.” [ID 2]
- “Only Kenyans will solve Kenya’s problems.” [ID 1]

Theme 5: Co-ordination & standardisation

- “There are different agencies with a mandate, each one taking a leadership role for different clusters.” [ID 2]
- “[Digital technologies] can be used by patient groups to assay whether or not they are getting high quality care from providers. Providers get quite scared at the notion that digital information can be used to judge them, so there needs to be some principles written through it. If we are using digital information for provider checking, there needs to be a certified community... There are very good and valid reasons for doing provider checking. The problem in adversity is that these checks do not occur because the systems are broken.” [ID 5]
- “People [develop] technologies that serve their own way of thinking, that suit their own settings. Coordination between groups is missing.” [ID 2]

Theme 6: Sustainability & resilience

- “Many [technologies] fail to scale.” [ID 2]
- “All the geographies I talk of are emerging now, weren’t five years back, so it is hard to say if they’re being sustainable.” [ID 1]
- “It’s all about having a predictable source of revenue coming in.” [ID 1]
- “On the donor side, there’s not much investment in this area. Most funding is short term, like six months, usually project based, and not necessarily developing systems. There are crises, like epidemics, that we must control but usually happen on a short timeline. However, many disasters are protracted in a sense that trying to serve long-term needs with a short-term humanitarian mindset is not helpful. We need to think long-term, which means the solution must be long-term.” [ID 2]
- “Another area [where I see the biggest need in terms of conflict settings] is the supply chain. Health facilities are dependent on humanitarian funding, there’s no capacity for planning tools or forecasting, can’t plan for when we’ll run out of medicine, and this can take some time to deliver. A tool for forecasting and planning would be very valuable.” [ID 2]
- “The digital side can be helpful, but if you don’t have a good clinician to take care of devices, it doesn’t help.” [ID 1]
- “If you don’t put measures in place to maintain that person in the community, the solution is gone. Establishing the contact took so long in that community. [It’s all about] establishing trust in the people.” [ID 4]
- “[Aid is often] a come and go transaction” [ID 4]

search calling for minimum standards as a necessity for digital health expansion in conflict-ridden areas.²² Researchers have called for the development of guidelines to align the goals of health policies with the supply of digital innovation to meet the demand of health systems.²⁹ Additionally, there is a need for central oversight from governments, funders, and industry to set standards for innovation in digital health.³⁰ Digital technologies intrinsically require standards for their safe use and, in recognising their ability to drive safety in healthcare, require standards for their safe use at the interface of the technology, users,

and the healthcare setting.³¹ Recently, the WHO has spearheaded numerous initiatives on establishing and adopting global standards for the transaction of health information during the pandemic to facilitate cross-border harmonisation of immunisation data.³²

Finally, appropriate identification of the population need was seen as crucial to inform the development of the digital health solution for the end user. The importance of engagement with the stakeholders was cited by interviewees and upheld by previous research, in addition to being one of the foundational principles for digital develop-

ment, supported widely by the digital health community. For example, in Syria, due to the severe shortage of psychiatrists and a considerable number of individuals suffering from post-traumatic stress disorder (PTSD) because of ongoing conflict, telepsychiatry was identified as a priority need in that area, with the digital feature purposefully included to expand access to treatment.²² Previous literature and the interviewee responses both uphold the perspective that rigorous and continuous examination of the cultural dimensions that influence the delivery of care is a necessity in a variety of contexts where digital solutions are considered.²²

STRENGTHS AND LIMITATIONS

There were several strengths to this study. The interviewees have experienced the challenges associated with the implementation of digital health technology in settings of extreme adversity first-hand and have led and participated in efforts toward their sustainment. Additionally, because the meanings of experiences are often debated, the interpretative phenomenological analysis allowed researchers to understand the complexities of the multiple perspectives that came to fruition based on similar lived experiences.³³ Another limitation includes the subjectivity inherent in the definition of 'extreme adversity', as extreme adversity will be defined differently based on the individual human experience. Therefore, findings may not be directly comparable across settings, contexts, and populations. Future researchers should consider narrowing the definition of extreme adversity and carefully select the interview participants to capture actionable insights that may be more generalisable. However, the application of the interpretative phenomenological analysis within the small sample size allowed the researchers to gain insights and reflections based on the interviewees' ability to richly illustrate their understandings of the topic through narrative.³³ Although improvements in health technologies in settings of extreme adversity would be beneficial, it is important to recognise the limited capacity of these settings. Therefore, the plethora of priorities identified in this study may not be realistic to translate into practice. Future research should focus on prioritising the interventions that are likely to be the most impactful. Finally, most of the interviews were conducted in person, and this could have led to bias in the sample, as many of those with potentially relevant expertise (e.g., frontline experts living in working in extreme adversity) may have been excluded based on their inability to travel or lack of access to online video conferencing platforms when the interviews were offered virtually. This speculation is fortified upon examining the recruitment method and results of recruitment. Nearly half of the participants invited did not respond when invited via email. Therefore, email-based recruitment may have introduced a barrier to diverse recruitment, though there were no significant differences between the participants recruited and the individuals invited who did not participate. Future researchers should ensure fairness and equity in recruitment methods, particularly for research on extreme adversity.

IMPLICATIONS FOR RESEARCH AND POLICY

This study emphasises the imperative role of digital technologies on the journey to improving the quality of healthcare delivery at the micro and macro levels. Future work should focus on how digital technologies can be utilised to improve the quality of care in these settings to both address the unmet needs of the target population and ensure any solution is sustainable, particularly within these limited resource contexts. Because digital interventions in settings of extreme adversity are often delivered on an ad hoc basis, coordination between humanitarian, research, non-governmental organisations (NGOs), and government planning is critical to ensure sustained improvements. Potential for context-specific impact and promise of sustainability are factors that should be considered in planning the allocation of resources to support digital health technologies. While digital technologies may have the potential to impact specific areas, interventions that have the potential to be scaled up and widely used should be prioritised.

There is a need to provide evidence for policy makers and health systems to promote the uptake of digital technologies in the pursuit of high-quality care. Research investigating the benefits of the use of digital health technologies is needed, but it is important to consider the potential disadvantages, such as overreliance in unsustainable and ever-changing environments, to ensure they are fully evaluated in these contexts. An increasing number of persons living in extreme adversity have access to mobile phones, which presents an opportunity to understand how digital technologies can be optimised to empower patients to play an active role in their care and increase their access to high-quality care. Research and policy development should focus on strategies to give patients ownership of their health data and to transcend interoperability challenges and geographical movement. Seeking the insights of those in need of, receiving, and delivering healthcare in these settings is crucial, and research partnerships between institutions both inside and outside these contexts have the potential to solicit context-specific insights, without which, the promise of digital health technologies to improve the quality of care could be compromised.

Finally, digital technologies also have the potential to enhance partnerships between healthcare professionals, patients, and organisations to enable knowledge sharing. These connections should be leveraged to enhance access to training, support, and advice in resource-limited contexts. This offers the possibility of collective growth through mitigation of siloes across entities.

CONCLUSIONS

Healthcare quality is imperative in the delivery of healthcare globally. Although digital technologies have recently emerged to mitigate many barriers to safe healthcare delivery, little is known about how these technologies should be adapted to extreme adversity settings. This study enhances existing literature by providing insights from a variety of professionals to better understand areas in which digital technologies have the potential to improve quality

and safety of care, as well as identifies specific opportunities for accelerated and impactful digital innovation in extreme adversity settings. Though further research is needed, these insights provide clearer guidelines for future research and policy development.

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ACKNOWLEDGEMENTS

The authors wish to acknowledge the Institute for Global Health Innovation for pioneering digital health globally and wish to thank the participants for their time and dedication to their respective fields.

FUNDING

None.

AUTHORSHIP CONTRIBUTIONS

All authors contributed to the study and manuscript.

COMPETING INTERESTS

The authors completed the Unified Competing Interest form at <https://www.icmje.org/disclosure-of-interest/> (available upon request from the corresponding author), and declare no conflicts of interest.

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Submitted: May 30, 2022 GMT, Accepted: June 16, 2022 GMT



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SUPPLEMENTARY MATERIALS

Online Supplementary Document

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