



Photo: Jhpiego/MCSP

# Scale the Technology Now

Applying Engineering Principles to  
Promote Rapid Deployment of  
Mobile Digital Content Delivery Systems



# ACKNOWLEDGEMENTS

Edited by Lauren Reed and Carolyn Moore. The author thanks Alex Little, Lesley-Anne Long, Darian Bailey, Ali Habib, Dr. William Rouse, Miquel Sitjar, and Vijayan K. Pillai for providing comments on this paper and the participants of the Digital Health Collaborative in Sindh Province, Pakistan for their support. The author also thanks Qualcomm Wireless Reach for their sponsorship.

# CONTENTS

INTRODUCTION.....	3
THE CASE FOR IMMEDIATE SCALING OF MOBILE DIGITAL CONTENT DELIVERY SYSTEMS .....	4
Theory Reconsidered.....	4
Implications for Evaluation Methodologies .....	5
Limitations of Randomized Control Trials (RCTs) .....	6
Meta-Analyses .....	6
Procurement for Efficiencies and Cost-savings.....	9
Leveraging Market Trends for Scale.....	10
Implementing and Evaluating in a Health System Context.....	11
PUTTING THEORY INTO PRACTICE: IMPLEMENTING AN ENGINEERING APPROACH IN PAKISTAN.....	12
What Technology Independence Looks Like.....	14
Looking Forward .....	15
ENDNOTES .....	16



Photo: Jhpiego/MCSP

# INTRODUCTION

Existing approaches to the procurement, implementation and evaluation of mobile technology for use in the health systems of low and middle-income countries (LMICs) have yet to provide a repeatable process for bringing about wide-spread, nationally scaled, sustainable systems. This paper, based on recent primary and secondary research, looks at the problem from a new angle that balances the public health perspective with engineering principles.

Although mobile technology can play many roles in improving the health of a population - from improving the rate and accuracy of survey data collection and analysis to supporting the decision-making of health workers – this paper focuses on the distribution of content, or a delivery system, for the education and training of a frontline health workforce.

Delivery systems are designed to convey a product or service to a person or population. Universal iodization of salt may represent the most efficient delivery system for health ever to go to scale - preventing iodine deficiency in millions of people. Mobile technology can be a highly effective delivery system for national health systems, but has, so far, not been deployed as widely as technologists have anticipated. One characteristic of successful delivery systems is a separation of content (i.e. what is to be delivered) from the delivery system itself, but the present approach towards implementing mobile technology for health [mobile health in this paper] often fails to make that separation.

Our goal in this paper is two-fold: 1) reconsider existing approaches to the procurement, implementation and evaluation of mobile health, and 2) offer a cost-effective alternative approach using the implementation of a mobile digital content delivery system in Pakistan as an example.

# THE CASE FOR IMMEDIATE SCALING OF MOBILE DIGITAL CONTENT DELIVERY SYSTEMS

## *Theory Reconsidered*

Mobile phones, like televisions, mp3 and CD players and many other reliable digital content delivery systems, are already capable of delivering customized content at scale through a standardized engineering process. Standards surrounding how mobile phones connect to the network, or the conversion of content into digital audio, text or images are also well established. The other elements that make up a digital content delivery system (such as the application software, the server technology, etc.) have evolved to the point where informed implementers can select products and services that will reliably scale at a very low cost. Yet the technology is often incorrectly viewed as the common denominator when evaluating whether a mobile health intervention in an LMIC is successful.

Although we intuitively understand the concept of how the content (or message) can be viewed separately from the delivery system (or channel), the theoretical foundation for this view was not established until 1948, in Claude Shannon's paper "A Mathematical Theory of Communication." The paper provided the foundation for information theory, an entirely new branch of communication science. Information theory demonstrated that "any communication system could be separated into components, which can be treated independently as distinct mathematical models."<sup>1</sup>

Shannon's theory established that different modes of communication, such as text, telephone signals, images and film, could be encoded in bits. This digital representation of information provides the fundamental basis for separating content from delivery. This is precisely why we are able to use the same automated survey tool to collect soil fertility data from farmers and immunization coverage data from vaccinators.

Thus, information theory tells us it is possible to design and implement a delivery system that can collect, store, and transmit large amounts of information independent of the meaning associated with that content. There remain exceptions to this independence, but to date there has been little consideration of the implications this theory has on implementing mobile digital content delivery systems.<sup>2</sup>

## *Implications for Evaluation Methodologies*

Many evaluations of mobile technology, both for digital content delivery systems for health worker training and more generally, unnecessarily conflate the channel with the message, corrupting the assessment of both the technology and the content. This approach has impeded scale in many cases by influencing attitudes towards system design, implementation, cost, and especially evaluation methodology.

When providing aid for strengthening health systems in LMICs, empirical evidence demonstrating the viability of programs should inform decisions on resource allocation for additional or larger scale interventions. In the context of mobile technologies for health, the research community struggles to create an evidence base for decision makers to confidently expand digital health pilots to a provincial or national level. Although thousands of studies are published every year involving the use of mobile technology for health, few interventions lead to an evaluation that contributes directly to the decision-making process.<sup>3</sup>

***Evaluations of mobile technology, both for digital content delivery systems for health worker training and more generally, unnecessarily conflate the channel with the message, corrupting the assessment of both the technology and the content.***

Reviews of mobile health interventions suggest it is the heterogeneous nature of the body of research that prevents a meaningful comparison of results when examining outcomes such as increased usage, improved health, or increased knowledge.<sup>4,5</sup> Most articles acknowledge the lack of comparability of the research, yet recommend more research be conducted – albeit in a more rigorous fashion.<sup>6</sup>

Conflating the use of mobile technology with the intervention itself can lead to incorrect or irrelevant conclusions. The principle rationale for extrapolating results, for example, for Health Extension Workers in Ethiopia to Accredited Social Health Activists (ASHAs) in India, should not be simply the use of mobile technology. This fails to consider the wide range of implementation contexts, elements and desired outcomes across mobile health programs.

## ***Limitations of Randomized Control Trials (RCTs)***

Although Randomized Control Trials (RCTs) are viewed as the gold standard in experimental design for mobile health, and continue to be an important and necessary evaluation tool, the use of RCTs, as they are presently employed, may be inappropriate.

One of the main issues with many RCTs in mobile health interventions in LMICs to date is that small samples are the norm. Inadequate sample sizes are not representative enough to draw conclusions on the overall population or context, and lead to deeper statistical anomalies, introducing bias into statistical analysis.<sup>7</sup>

There has been a history of tension between researchers who promote more balanced designs in statistical experimentation and those promoting randomization.<sup>8</sup> Edward Deming maintained that random sampling and randomized experiments represent only the first steps towards a more scientific and useful approach. Complete randomization may make sense when the analyst does not understand the role a stratified population could play or if cost is not a factor.<sup>9</sup>

Whether using random or balanced designs, how does the research community overcome this inherent limitation of small sample sizes? The easiest way would be to expand the sample size—but studies that aim to examine the possibility of scale are, by nature, working with a small sample.

This situation could be characterized as a vicious cycle – where each of two conditions requires the other condition to be fulfilled first, which means that neither will ever be fulfilled. With the perpetuation of small-scale inconclusive pilot studies, it is not surprising that the community at large has been locked into a circular pattern of evaluations of limited value.

## ***Meta-Analyses***

Individual evaluations, even if successfully conducted, are usually not considered sufficient to inform decision-makers. The meta-analysis seeks to combine results from interventions to summarize findings and implications.<sup>10</sup>

A typical challenge to mounting a meta-analysis is that methodological flaws in the pool of available research dramatically reduce the number of eligible studies.<sup>11</sup> With these constraints, even though thousands are published, few mobile health studies qualify for inclusion from a methodological standpoint. The small pool of studies that do meet sufficient academic rigor tend to represent very disparate types of interventions—which can range from quality of care issues, to health behavior, to data collection.<sup>12</sup>

The rationale to go forward with these studies may be based, in part, on guidelines provided by the Cochrane Collaboration that accommodate a "...heterogeneous set of treatments if the purpose is to test applications of

a theory or principle that cuts across different interventions or fields of practice.”<sup>13</sup> The common denominator in mobile health meta-analyses is not a theory or principle but the use of mobile technology. It would be up to the researcher to rationalize the similarities of selected articles based solely on this factor. Yet, if we were to consider information theory when deciding whether to proceed with a meta-analysis, using mobile technology as the common point of reference, we would need to address whether the delivery system was sufficiently relevant to the outcomes of the studies selected. In many cases, if information theory is considered we would find that the delivery systems are not relevant to the outcomes.

In almost all cases of individual articles investigating interventions that use mobile technology, the performance of the technology itself (e.g. the performance of a smartphone, the storage and processing capacity of a server, the functional requirements of a pre-existing software application) is not tested, monitored or evaluated and only rarely discussed or described. In other words, the engineering problem is ‘solved’ long before the problem related to the health intervention is addressed. While even mature, proven technology (software or hardware) can fail, only rarely is it attributable to the content conveyed.

When considering the use of meta-analysis, articles selected for inclusion should be sufficiently homogeneous in terms of participants, intervention types and outcomes in order to provide a meaningful summary.<sup>14</sup> Inclusion criteria should be more narrowly defined in terms of types of interventions, health care field, and outcomes under investigation and target audiences. This may necessitate a more conservative view towards the definition of inclusion criteria established by the PICO framework widely used for this purpose in the Cochrane Collaboration.<sup>15</sup>

***When considering the use of meta-analysis, articles selected for inclusion should be sufficiently homogeneous in terms of participants, intervention types and outcomes in order to provide a meaningful summary.<sup>14</sup>***

The lack of a scientifically sound foundation for comparability of interventions is complicated further by the rapid pace of technological innovation, which will always outpace the deliberate process associated with academic research and evaluation. However, by adopting an engineering perspective that creates an environment where iteration on the technology and content can refine the solution over time, it may be possible to overcome these barriers.



Photo: Jhpiego/MCSP

## ***Procurement for Efficiencies and Cost-savings***

Procurement reform may be the most efficient fix to enable the scalability of technology provided to LMICs through donor organizations.<sup>16</sup> Technology procurement reform goes beyond the typical issues highlighted in donor reform initiatives. Although technology used in health delivery systems is often already designed to handle a large volume of information, it is often procured on the basis of single health issues and/or limited to specific geographic regions within countries. Procurement on this basis does not take advantage of the inherent scalability of the technology.

Procurement of technology is also conflated with content in a way that is damaging to the design, implementation and long-term success of the program. Procuring a solution that is limited to one area of health content or one type of data collection leads to long-term inefficiencies. For example, a request for a digital tool that supplies information on prenatal care for frontline health workers may lead to a design of an application where the content is hardcoded into the application itself, making updates unnecessarily difficult or expensive. In contrast, allowing for externally sourced content and data improves the chances of sharing content across different delivery systems and encourages local content development.

The close identification of specific health-related content with different forms of similar technology results in duplication of technology, content and effort as similar programs are deployed in an uncoordinated way across the same country. Conflating technology and content in procurement also results in investment in specific technologies as solutions rather than characterizing the solution in terms of an improved and stabilized workflow or process with specific entry points for technological support that can then accept evolutionary changes in technology over time.

### ***Global Mobile Device Trends***

***According to the GSMA, there are currently more than 7.8 billion mobile connections globally. This figure is expected to grow to 8.5 billion by the end of 2020, with significant growth in Africa and Asia.***

***In emerging markets, it is predicted that smartphones will be many users' only means of internet access.<sup>17</sup>***

## *Leveraging Market Trends for Scale*

Despite the paradoxical status of mobile health research in LMICs, the natural operation of the competitive market continues to optimize individual components of a mobile content delivery system.

The price for low-end smartphones in India is about US \$30 – about the same as a high-end feature phone.<sup>18</sup> Estimates of a five or even three-year timeline before smartphone ownership outnumbers other phone ownership now seem conservative, as the US \$30 smartphone has already arrived in many markets. Factors that make this price possible include:

- Moore’s Law, where computer processing power doubles roughly every 18 to 24 months due to advances of silicon transistors. This means the cost of a processor reduces by half over the same time period. After 50 years of accurately predicting processing power, Moore’s Law has begun to slow, but alternative ways to improve computing power and telecommunications still exist, which will continue to drive down cost and increase adoption.<sup>19</sup>
- Improvements in chip design, where multiple chips that provide different functions are integrated into a single chip (known as “system on a chip”), providing more room for everything else. For example, Qualcomm® designs custom ‘technology blocks’ into its Snapdragon™ processors that include its own display engine, sensor engine, and other dedicated processing engines that drive the hardware.<sup>20</sup>
- New smartphone manufacturers, such as Xiaomi, have been willing to accept about half the margins of existing manufacturers on device sales. This explains, in part, the rise of Xiaomi as the third largest global supplier.<sup>21</sup>
- Large device makers are expanding sales into low-end markets by using revenues from high-end smartphones to subsidize their initial investment into the low-end in order to beat out competition and appeal to the next generation of smartphone users.<sup>22</sup>

While technologies based on second generation or basic phones may provide immediate support for voice and text applications in the health system, these will be rapidly supplanted by systems that deploy smart devices with powerful features such as touch screens, advanced audiovisual capabilities, and Internet connectivity. Content provided or collected on these devices can be easily accessed offline or via wireless connections with zero or low connectivity fees. Knowing this, decision-makers should begin planning for the market transition to digital and mobile-centric systems in the health sector.

## *Implementing and Evaluating in a Health System Context*

There are four levels of a national health system that can have an impact on the success of a large-scale mobile health intervention. Each can create potential barriers to achieving a cost-effective, sustainable implementation of mobile health technologies:

1. The ecosystem level, where societal and institutional barriers relating to ownership, rights, policies and legal issues exist.
2. The organizational level, where issues related to cost, resources, coordination and collaboration between private, non-profit and public institutions are addressed.
3. The process level, where the focus is on service delivery and technology used in the intervention.
4. The people level, where user needs related to content, access, privacy and data confidentiality are paramount.<sup>23</sup>

Levels one, two and four are very context or country dependent. A successful intervention in one country is highly unlikely to be as successful in another, unless the program is adapted to accommodate the context in which these three levels of the health system operate.

For decision-makers to invest in scaling a solution, they need evidence that success is likely on all four levels. To generate this evidence, proven technologies should be deployed as rapidly as possible on a sufficient scale – provincial or national - to iterate, refine and ultimately validate the content over all four levels of the health system. This would make possible rapid, stratified and iterative evaluations of the content, in turn generating learning opportunities for decision-makers on what content and indicators are effective. At scale, subsequent iterative adaptation of content and indicators becomes a normal part of the content delivery system management process.

Scaling proven mobile and digital technologies to create a centralized content delivery and data collection system would result in immediate savings simply through the elimination of duplicate systems. Intuitively, we understand that implementation of country-specific, centralized systems would lead to other long-term cost savings through a large-scale deployment, including:

- Surveillance and accountability costs of health worker attendance and performance based on application usage statistics
- Cost of face-to-face refresher trainings can be reduced or eliminated
- Cost of printing manuals reduced or eliminated
- Cost-savings of pre-loaded training content, data collection and content review, primarily conducted offline or through low-cost Wi-Fi networks

By transitioning to digital-based delivery and collection systems, these and other cost savings become possible. Although cost figures for some activities (e.g. printing costs) are available now from a variety of sources, hard evidence of cost savings within the context of a country's health system is only possible with diligent cost monitoring and reporting of a full-scale implementation.

# PUTTING THEORY INTO PRACTICE: IMPLEMENTING AN ENGINEERING APPROACH IN PAKISTAN

Pakistan is one country that recognizes the evolution of digital and mobile technologies and the power for them to drastically improve efficiencies in the delivery of critical government services. The Ministry of Information Technology and Telecommunications (MoIT&T) supports the exploration of the ideas outlined in this paper - an engineering approach to implementing mobile content delivery systems. In the fall of 2016, a collaborative workshop for digital management brought together public and private sector representatives in Pakistan to examine the possibility of a shared interoperable platform to distribute digital training content across Sindh province.

The MoIT&T endorsed this collaboration with the understanding that this strategy will aim to not only implement a mobile content delivery system for health workforce training, but will expand the platform's functionality to include other sectors, such as agriculture and education. By doing so, Pakistan can realize the cost savings and service optimization that leveraging a single system can provide.

The platform would be managed through the MoIT&T so Sindh Province would not assume the entire cost of maintaining the technology. In this way, the government of Pakistan can provide these services to other provinces, defraying costs further and allowing each province to contribute their own understanding and ideas.

More importantly, evaluations of the content used for health worker or other sector training can be conducted in an iterative manner over much shorter time periods. Take the case of health: by concentrating health worker training within a single delivery system it allows content and user interface design to be frequently tested and improved across the entire health worker community. Through A/B testing, also known as split testing, two different approaches to a training on a particular health topic could be rolled out to two different user groups. Automated usage statistics make it possible to track which group performs best in nearly real-time, identifying which training was the most effective. With a user base consisting of an entire health workforce, evaluations of health workers' usage of the platform can be stratified by demographic characteristics, experience, education and other relevant co-variates to better understand how those characteristics may affect a user's learning.<sup>24</sup>

# *The technology and content conflation problem can be resolved through the integration of a digital content sharing library with a mobile-enabled delivery system.*

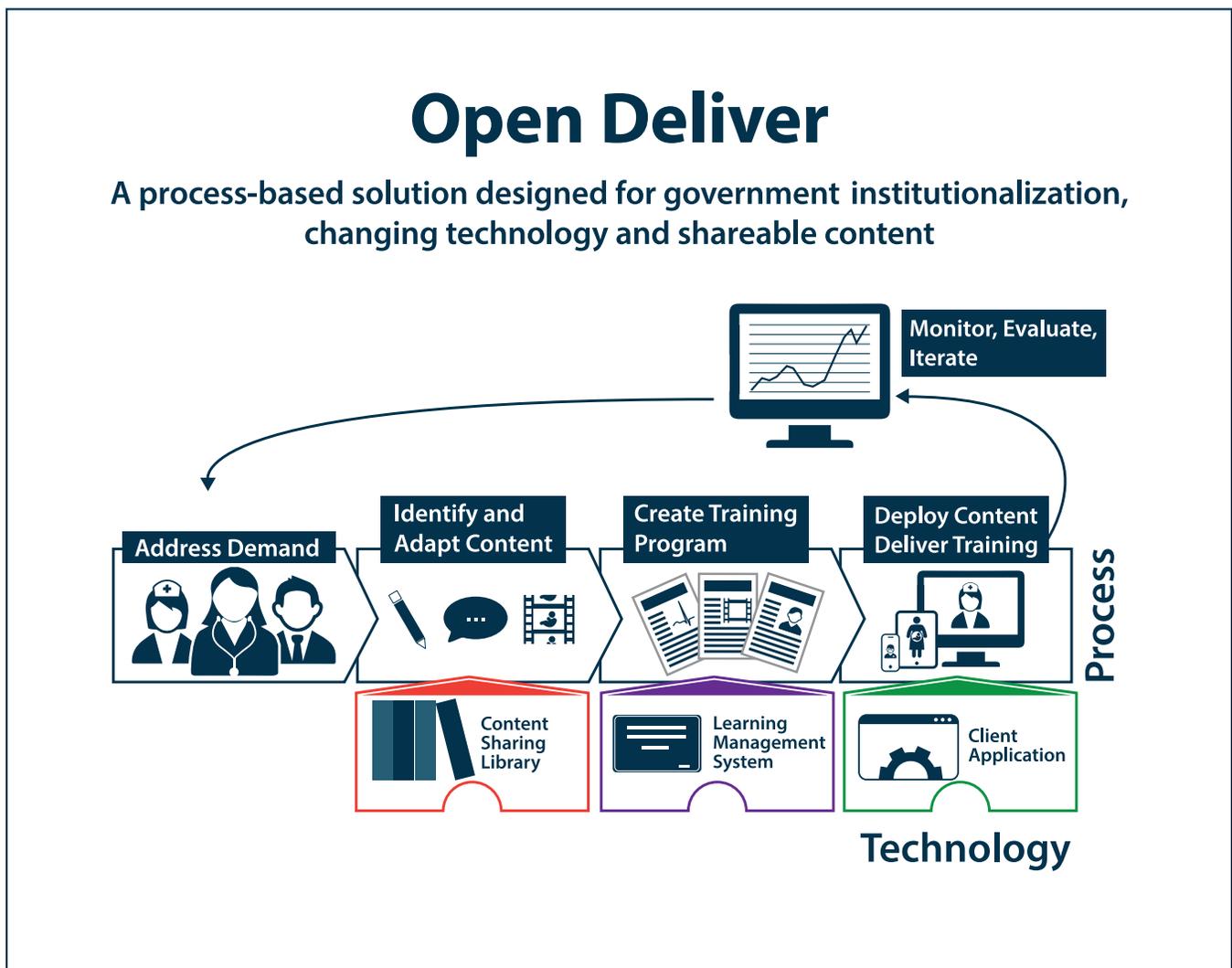
The technology and content conflation problem can be resolved through the integration of a digital content sharing library with a mobile-enabled delivery system. This library separates the content from the delivery system, allowing local and international organizations to contribute validated health content that meets the training curricula needs of a health workforce.

Content can then be rapidly adopted and distributed to the health workforce using a learning management system and a mobile application that are already integrated into the platform, or by adopting other technology that meets the criteria for long-term sustainability. The platform can also ensure that all health data collection requirements are addressed through the integration of point-of-care mobile registries and population survey templates.



## What Technology Independence Looks Like

The application of this approach is represented by the Open Deliver process for digital content management and delivery. Open Deliver is a process-based solution designed to provide educational content to workforces in low-resource settings and can be maintained through integrating new technologies as they emerge. By ensuring that a training infrastructure and data collection system are in place, Open Deliver achieves two goals that would also incentivize private sector investment: introducing governments to centralized, platform-based solutions for their health workforce and moving governments closer to a fully trained workforce. The centralized platform provides a means for private and public sector actors to invest in the integration of their own standards-based software, hardware and content products while providing assurances of a workforce that is better equipped to manage increasingly more sophisticated digital solutions.



### *Case in Point: Evaluating Open Deliver in Ondo State, Nigeria*

A program in Ondo State, Nigeria, aimed to improve FLHWs' knowledge and skills in the delivery of maternal health care using video-based training.<sup>25</sup> The training package leveraged a mobile-optimized platform to provide high quality, mobile-enabled training on antenatal care, basic obstetric care and essential newborn care. This training was rolled out to FLHWs in 18 selected Primary Health Care Centres in Ondo State.

Health workers who completed the training showed an improvement in knowledge on material in all three areas (average post-test scores increased to 77% from 44% on the pre-test).<sup>26</sup> Health workers' feedback on the training experience was largely positive, and they reported that the video platform was easy to use and navigate. This program helped provide access to ongoing learning for health workers in Ondo State, demonstrating the potential of mobile content delivery systems in Nigeria and more broadly.

### *Looking Forward*

Technology deployments involving a government's health workforce should be designed for rapid transition to government ownership and institutionalization. Working from a common digital platform will help ensure that services and functions are implemented in accordance with international standards, and will allow contributions from validated content creators. This paper lays out the argument that the benefits to immediate scaling of collaborative mobile content delivery systems outweigh the costs. As the proposed approach is put into practice, decision-makers will be able to compare the costs of implementation with historical costs of training programs for further evidence of economic benefits.

Conflating technology and content in mobile health can lead to fragmented implementations, inconclusive evaluations, stalled scaling processes and impediments to content sharing and collaboration. By considering the engineering principles upon which the technology is designed, we discover opportunities to accelerate, strengthen and institutionalize systems that leverage mobile technology for health.

# ENDNOTES

<sup>1</sup> O. Aftab, P. Cheung, A. Kim, S. Thakkar and N. Yeddanapudi, "Information Theory and the Digital Age," 6.933—Final Paper, The Structure of Engineering Revolutions, Massachusetts Institute of Technology, Cambridge, 2001. <http://web.mit.edu/6.933/www/Fall2001/Shannon2.pdf> Accessed October 1, 2016.

<sup>2</sup> Stephens, Keri K., Ashley K. Barrett, and Michael J. Mahometa. "Organizational communication in emergencies: Using multiple channels and sources to combat noise and capture attention." *Human Communication Research* 39.2 (2013): 230-251. We should not take this theoretical perspective to an extreme, as there are exceptions to this separation where the delivery system can impact the meaning of a message. For example, in the case of emergency communication presented by the authors, "if the message is delivered over a familiar channel (e.g. an SMS-based emergency notification system), the transmission of which may impart a sense of urgency to the receiver simply through repeated delivery". A strict Information Theory perspective would reject any role the delivery system would have on the receiver of such a message but "in this case a new model might encompass aspects of Information Theory but also social presence theory (specifically the focus on channel immediacy) and source credibility as well".

<sup>3</sup> Sondaal, Stephanie Felicie Victoria, et al. "Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in Low-and Middle-Income Countries: A Systematic Review." *PloS one* 11.5 (2016): e0154664. For example, one systematic review focusing only on the effect of mHealth interventions that support pregnant women during antenatal, birth and postnatal periods in LMICs found 3,777 articles from June 2014–April 2015, accompanied by a grey literature search using pre-defined search terms linked to pregnant women in LMIC and mHealth.

<sup>4</sup> Higgins, Julian PT, and Sally Green, eds.. *Analysing data and undertaking meta-analyses in Cochrane handbook for systematic reviews of interventions*. Vol. 5. Chichester: Wiley-Blackwell, 2008. [http://handbook.cochrane.org/chapter\\_9/9\\_5\\_1\\_what\\_is\\_heterogeneity.htm](http://handbook.cochrane.org/chapter_9/9_5_1_what_is_heterogeneity.htm). Accessed October 30, 2016. "Variability in the intervention effects being evaluated in the different studies is known as statistical heterogeneity, and is a consequence of clinical or methodological diversity, or both, among the studies. Statistical heterogeneity manifests itself in the observed intervention effects being more different from each other than one would expect due to random error (chance) alone. We will follow convention and refer to statistical heterogeneity simply as heterogeneity".

<sup>5</sup> Sondaal, Stephanie Felicie Victoria, et al. "Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in Low-and Middle-Income Countries: A Systematic Review." *PloS one* 11.5 (2016): e0154664. In this sample study 3214 articles were found, of which only 29 met the eligibility requirements. Of these 29 studies more than half were characterized as descriptive studies and of the remaining studies none were comparable in terms of location or context. Because of the heterogeneous nature of the studies, results could not be pooled to conduct a meta-analysis causing the authors to resort to a "narrative synthesis of qualitative information ... with an analysis of the strengths, weaknesses, opportunities, and threats (SWOT)" which is an insufficient basis upon which to make decisions regarding future implementations.

<sup>6</sup> For example: Agarwal, Smisha, et al. "Guidelines for reporting of health interventions using mobile phones: mobile health (mHealth) evidence reporting and assessment (mERA) checklist." *bmj* 352 (2016): i1174.

<sup>7</sup> See Ziliak, Stephen T., and Edward R. Teather-Posadas. "The Unprincipled Randomization Principle in Economics and Medicine." *The Oxford Handbook of Professional Economic Ethics* (2016): 423. For example, Ziliak posed a series of questions to determine if RCTs met basic requirements including: "...whether these studies are in a position to handle questions of balance for sample strata and covariates? Allocation imbalance can be related to design failure. Does the study test the favored model on subpopulations or strata and/or test for robustness of estimates across different periods of time? Another internal problem with the process can lead to Simpson's Paradox. This is a common defect of statistical studies and especially of randomized controlled trials. In summary, if the experiment is not prudently stratified to eliminate heterogeneity bias, the randomized trial can mislead investigators".

<sup>8</sup> Ziliak et al. 437.

<sup>9</sup> Deming, W. Edwards. "Sample surveys: the field." *The International Encyclopedia of Statistics* 2 (1978): 867-885. Edwards writes: "The primary aim of stratified sampling is to increase the amount of information per unit of cost. A further aim may be to obtain adequate information about certain strata of special interest.... The goal should be to make each stratum as homogeneous as possible, within limitations of time and cost." 879.

<sup>10</sup>Matthews, John NS. Introduction to randomized controlled clinical trials. CRC Press, 2006. 212.

<sup>11</sup>Mathews, 222.

<sup>12</sup>Lee, Siew Hwa, et al. "Effectiveness of mHealth interventions for maternal, newborn and child health in low-and middle-income countries: Systematic review and meta-analysis." *Journal of Global Health* 6.1 (2016). This has not been the central problem with the systematic reviews and meta-analysis conducted so far, as the authors admit that from the pool of several thousand studies that may fall under the heading 'mHealth' there are many methodological flaws and the criteria for inclusion usually weeds these out. Introductions to meta-analysis typically begin with a statement like the following drawn from the cited study: "Most studies of mHealth for MNCH in LMICs are of poor methodological quality and few have evaluated impacts on patient outcomes."

<sup>13</sup>Higgins, et al.

<sup>14</sup>Higgins, et al.

<sup>15</sup>Littell, Julia H., Jacqueline Corcoran, and Vijayan Pillai. *Systematic reviews and meta-analysis*. Oxford University Press, 2008. Page 10-11 PICO stands for populations, interventions, comparisons, and outcomes, which are four topics that should be addressed in detail in developing study eligibility criteria.

<sup>16</sup>USAID, one of the largest donor organizations, has recognized this need since initiating USAID Forward; a program designed to reform the way the organization administers assistance. See USAID Has Increased Funding to Partner-Country Organizations but Could Better Track Progress GAO-14-355: Published: Apr 16, 2014. Publicly Released: Apr 16, 2014.

<sup>17</sup>GSMA. *Global Mobile Trends*. October 2016.

<sup>18</sup>Mirani, Leo. Smartphones are Here and They Are Getting Better Every Day. Quartz. <http://qz.com/314285/30-smartphones-are-here-and-theyre-getting-better-every-day/>.

<sup>19</sup>Simonite, Tom. Moore's Law Is Dead. Now What? MIT Technology Review. May 13, 2016 <https://www.technologyreview.com/s/601441/moores-law-is-dead-now-what/>

<sup>20</sup>ARM and Qualcomm: Enabling the Next Mobile Computing Revolution with Highly Integrated ARMv8-A based SoCs. Joint White Paper from ARM and Qualcomm Technologies, 2014.

<sup>21</sup>Mirani.

<sup>22</sup>Mirani.

<sup>23</sup>Rouse, W. B. (2009). Engineering perspectives on healthcare delivery: Can we afford technological innovation in healthcare? *Journal of Systems Research and Behavioral Science*, 26, 573 – 582.

<sup>24</sup>These are common practices among private and non-profit companies such as Khan Academy and Duolingo that deploy digital solutions for distance education. See <https://apptimize.com/blog/2014/07/how-khan-academy-uses-ab-testing-to-improve-student-learning/> for Khan Academy and [http://duolingo.wikia.com/wiki/Experimental\\_feature](http://duolingo.wikia.com/wiki/Experimental_feature) for Duolingo. Both accessed on November 1, 2016.

<sup>25</sup> This program was implemented by InStrat Global Health Solutions, Ondo State Primary Health Management Board, mPowering Frontline Health Workers, Medical Aid Films, and Digital Campus, with funding from USAID.

<sup>26</sup> Research was performed by Anadach Consulting. Assessment report pending publication.

Sponsored by  
Qualcomm® Wireless Reach™

Authored by  
**Michael Bailey**  
*Senior Country Advisor*  
mPowering Frontline Health Workers

**mPOWERING**  
FRONTLINE HEALTH WORKERS

[mpoweringhealth.org](http://mpoweringhealth.org)

**We encourage you to download and share the PDF version of this document by visiting  
<https://goo.gl/PvZ2nx>**

Qualcomm, Wireless Reach and Snapdragon, are trademarks of Qualcomm Incorporated, registered in the United States and other countries. Qualcomm Snapdragon is a product of Qualcomm Technologies, Inc.

Other product and brand names may be trademarks or registered trademarks of their respective owners.

Opinions expressed in the content here are the personal opinions of the original authors, and do not necessarily reflect those of Qualcomm Incorporated or its subsidiaries (“Qualcomm”). The content is provided for informational purposes only and is not meant to be an endorsement or representation by Qualcomm or any other party.



<https://creativecommons.org/licenses/by-nc-sa/4.0/>