**Information and Communication Technologies to Advance Child Health**

Smisha Agarwal & Alain B. Labrique

*Johns Hopkins University Global mHealth Initiative*

*Johns Hopkins Bloomberg School of Public Health, Department of International Health*

Table of Contents

[A. Global trends in advancing the health of children 2](#_Toc452934001)

[1. Interventions to advance child health 2](#_Toc452934002)

[B. Integrating Information and Communication Technologies (ICTs) with interventions that improve child health 5](#_Toc452934003)

[1. Major themes of ICT interventions for child survival 5](#_Toc452934004)

[Health systems constraints 5](#_Toc452934005)

[Health-systems continuum 6](#_Toc452934006)

[Integrating digital interventions across the health system and MCH continuum 9](#_Toc452934007)

[2. Evidence on ICT interventions for child survival 10](#_Toc452934008)

[Health-systems interventions 11](#_Toc452934009)

[Provider-level interventions 11](#_Toc452934010)

[Client-level interventions 12](#_Toc452934011)

[Integrated interventions 13](#_Toc452934012)

[3. Taking digital interventions to scale 14](#_Toc452934013)

# Global trends in advancing the health of children

The Millennium Development Goals (MDG) were established in 2000 with measurable objectives to be achieved by 2015. MDG 4 and 5 aimed at improving the health of mothers and children. The health of mothers and children are closely interlinked. The MDG 4, to reduce child mortality, specifically targeted the under-5 child mortality to be decreased by two-thirds between 1990 and 2015. The MDG 5, to improve maternal health, aimed specifically to reduce the maternal mortality ratio by three-fourths between 1990 and 2015 and to achieve universal access to reproductive health for all women by 2015. As of 2016, neither of these goals has been met completely, though significant improvements have been made in improving maternal and child survival.[1] Though 17,000 fewer than in 1990, in 2013, an estimated 6.3 million children under 5 died, largely of preventable causes.[2][3] Deaths during the first 28 days account for 45% of the deaths in children under 5, with the vast majority of these occurring in the first week of life. A large number of these deaths are preventable and result from preterm birth complications, pneumonia, intrapartum-related complications, diarrhea and malaria.[4]

With the transition to Sustainable Development Goals (SDG), maternal and child health specific priorities have been dispersed across the 17 SDGs and 169 targets. Specifically, SDG 3 aims to “ensure health lives and promote well-being for all at all ages”. It targets an end in the preventable deaths of newborns and children under age 5 years of age, a reduction in neonatal mortality to 12 per 1,000 live births, and in under-5 mortality to 25 per 1,000 live births.[3]

## Interventions to advance child health

Effective interventions to target preventable child deaths have been widely described across the continuum of maternal and child healthcare: preconception, antenatal, intrapartum, birth, newborn, under-five and adolescent health (Table 1).[5]–[9] Innovative, high impact, cost-effective, and evidence based interventions have been identified and clearly defined at each of these stages.[10] The most effective interventions to reduce child death include the effective management of labor and delivery, the care of preterm births, the treatment of serious infectious diseases, and the treatment of malnutrition [1]. These interventions are warranted across several life-stages of the ‘continuum of care’, from preconception through pregnancy and the intra/post-partum period. The continuum of care may, however, also be conceptualized as a patient-centered model across levels of the health system, with the community and home at the core, surrounded by the first level of outreach, typically minimum-capacity primary care facilities, then enveloped by the referral or district level. Successful interventions often benefit from being integrated across each of the three levels of care to optimize management and treatment. Recent innovative health strategies have integrated health activities across these three levels, with a focus on health promotion, health prevention, and the management of multiple childhood diseases where they manifest – in the community. Integrated child health strategies prioritize prevention, detection, and treatment of childhood illness while promoting healthy family and community behaviors [4].

Primary and secondary interventions: The essential interventions that have been shown to improve child health can be divided into those primarily for child health and those with child health as a secondary outcome [4], [11]. Interventions with the child as the primary health focus occur at delivery, immediately following birth during the first few hours, during the neonatal period, and interventions for children under five years. Interventions directed at the mother which impact under-five child health include pre-pregnancy and maternal antenatal care (ANC) interventions, infection management and prevention, chronic illness management and prevention, and intrapartum recognition and management of complications.

**Table 1: Effective interventions to advance child health along the continuum of care**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Essential Interventions | | | | |
| Pre-pregnancy | Family planning: Reduce unintended pregnancies, delay age at first pregnancy, contraception services, safe abortion | Maternal interventions to improve psychosocial health and substance abuse: Antenatal assessment and interventions for anxiety, antenatal and postnatal psychosis, and depression. Prevention of smoking, alcohol use, and illicit drug use. | Maternal immunisation: Tetanus, pneumococcal, Haemophilus influenzae type b, influenza | Address chronic diseases and pregnancy-induced disorders: Pregnancy-induced hypertension, pre-eclampsia, eclampsia, gestational diabetes, diabetes, hypertension |
| Antenatal | Maternal infection prevention, screening and management: Malaria (IPTp, ITN), syphilis, lower genital tract infections, group B streptococcus, bacterial vaginosis, urinary tract infection, chlamydia, gonorrhoea, HIV, toxoplasmosis | Maternal nutrition enrichment: Iron, folate, calcium, multiple micronutrient, balanced protein energy | Prevention of Rhesus disease | Detection and management of significant IUGR: Doppler velocimetry for early antenatal detection of IUGR and appropriate treatment and timely delivery |
| Intra partum (birth) | Management of term breech and post-term pregnancies: Induction of labour after 41 weeks of pregnancy | Management of preterm labour & preterm premature reupture of membranes | Emergency obstetric care: Basic and comprehensive planned caesarean section if indicated | Skilled birth attendance with hygienic care at birth: Use of clean birth kits, hand washing with soap and, if appropriate, chlorhexidine |
| Post natal (neonate immediately following birth) | Cord care and clamping: Delayed cord clamping and cord cleansing with antiseptics | Interventions to prevent hypothermia: Drying, head covering, skin-to-skin care, and delayed bathing for every newborn baby | Nutrition in neonates: Early initiation and exclusive breastfeeding | Comprehensive care of children infected with or exposed to HIV infection |
| Resuscitation of neonate for perinatal depression and care for babies with neonatal encephalopathy | Care for small (preterm and/or small for gestational age) infants: Extra thermal care including plastic wraps for transfer, kangaroo mother care, topical emollient therapy, secondary level care, tertiary level care, management of respiratory distress syndrome | Recognition and management of neonatal infections: Antibiotics for neonatal pneumonia/sepsis/meningitis. Facility-based supportive care with intravenous fluids and intensive care | Hyperbilirubinaemia prevention and management: Phototherapy to prevent complications |
| Infancy & Childhood | Exclusive breastfeeding for 6 months; Continued breastfeeding and complementary feeding from 6 months. | Prevention and case management of childhood malnutrition, pneumonia, diarrhea, mengitis, malaria | Vitamin A supplementation from 6 months of age | Routine immunization plus *H.influenzae*, meningococcal, pneumococcal and rotavirus vaccines |

Adapted from Bhutta et al.[4], Agarwal et al. [17]

Integrated Management of Childhood illnesses*:* Several integrated strategies to advance the health of children have been described and implemented in low and middle-income countries [4]. These strategies provide a framework to link interventions across levels of care. The integrated management of childhood illness (IMCI) strategy prioritizes management of child health interventions across the home, clinic, and district level of care to improve outcomes with a prioritization on immunization, oral rehydration therapy, management of acute respiratory infections and improved infant feeding [10]. The IMCI strategy was developed as a way to address the most significant causes of child death through multiple interventions integrated for the prevention and treatment of childhood illness. The strategy includes direct interventions as well as improvement of case management of health care workers, strengthening of health care systems, and improved practices in the home and community [10]. As IMCI strategies are introduced in a region, local health systems may treat IMCI as a “wide umbrella, relevant to both developing and developed countries, with each country choosing the components from the available options depending upon its national child health priorities.”[12] Regions are able to add initiatives or supplemental IMCI programs using IMCI health system framework to address child growth, child psychosocial development, child abuse and neglect, HIV/AIDS and PMTCT, vitamin A supplementation, and immunization programs [10].

# B. Integrating Information and Communication Technologies (ICTs) with interventions that improve child health

The last decade has seen an unprecedented increase in the availability and use of mobile and other digital technologies, especially in low and middle-income countries. A large number of healthcare projects around the world have leveraged ICTs to alleviate constraints faced in scaling up cost-effective, evidence-based interventions through the antenatal, intrapartum and post-partum periods, with direct or indirect impact on child survival. Despite an ample library of evidence-based interventions for child survival, programs struggle to reach effective population coverage with these high-impact interventions. Gaps persist at local and national levels in the coverage of proven effective family planning, newborn survival strategies, and case management of childhood illness.[13] Additionally, there is considerable variability in the quality of services provided within countries due to bottlenecks in workforce, financing, and service delivery.[14] Digital health has been proposed as a means to leapfrog some of these barriers experienced in service delivery, by impacting the coverage and quality of these child health interventions that are known to be efficacious.[[1]](#endnote-1)

For example, a range of interventions during the antenatal period are proven to impact downstream child health. The importance of immunization during pregnancy, intermittent preventive treatment of malaria, use of bed nets, diagnosis and timely treatment of syphilis and hypertensive disease, etc. has been well-established. However, the achievement of coverage and quality is a barrier, especially in areas where infrastructure and skilled healthcare workforce is in short supply.[7] Bhutta et al. recommend some effective community-based and outpatient mechanisms to advance coverage. To improve quality, they propose strengthening governance, investing in health workforce training, promoting interpersonal care and social support, audits, information systems, pay for performance and mHealth as strategies. This would suggest that ‘mHealth’ is a intervention strategy, which could be the case when mobile devices are used to deliver information directly to clients or their families.[15] However, mHealth solutions are less often considered as monolithic stand-along strategies, but rather, as catalysts for established interventions. For example, providing better digital accountability to strengthen supervisory monitoring and thus, governance mechanisms, or extending access to training materials or expert advice through mobile and digital devices, on demand, can contribute to improving the quality of the frontline health workforce, etc. With this in mind, the next section will broadly present the major themes in the application of ICTs to advance child health, with specific examples from existing projects.

## Major themes of ICT interventions for child survival

The ways in which ICTs have been tested to optimize child health interventions are numerous and widespread. Previous reviews have described strategies and opportunities for intervention to impact neonatal survival [17]. From innovations focused on point-of-care, patient-focused sensors and devices to decision-support tools for health workers, to system-strengthening innovations which reduce stockouts of essential commodities, many different ideas have been tested at varying degrees of rigor and scale. One way in which to characterize these strategies in a systematic way is by classifying them according to the problems, or the health system constraints, which are being targeted for resolution.

The following constraints framework is drawn from a comprehensive taxonomic classification developed by the members of the WHO Technical and Evidence Review Group (mTERG). In the next section, we describe the interventions targeted at improving child health- either as a primary or secondary outcome, categorized by the health systems constraints they seek to address (Table 3). At each step of the maternal and child health continuum (pre-pregnancy, antenatal, intrapartum, and postnatal), digital health interventions may address various barriers (i.e. constraints) to improving the health of children. These constraints, also reflected in the classic 1978 health systems cascade by Tanahashi[[2]](#endnote-2), include [16]-

1. Information: The lack of availability of relevant health information either to the client or provider.

2. Availability: Having appropriate care available by skilled providers at facilities which are geographically convenient.

3. Cost: Includes the direct and indirect (e.g. lost wages) cost of either providing or seeking treatment, and barriers incurred due to inaffordability.

4. Efficiency: The provision of and access to appropriate health services in a timely manner with minimal costs.

5. Quality: The adherence of care delivered to established best practices or guidelines, and thus positively impact health.

6. Acceptability: The alignment of the health services with the client’s social and cultural norms (constraints may include cultural superstitions, stigmas associated with diseases and use or provision of certain services, and other factors that negatively affect the provider’s ability to provide service to specific groups of people).

7. Utilization: Is defined as a constraint that limits an individual’s or group’s use of a particular service or treatment. Factors such as low demand for services, poor transportation, poor understanding of the disease can affect the utilization of services.

It is important to note that often the barriers/constraints at each point in the continuum of care are similar, and therefore the digital approach to address it may also be similar. For example, limited access to health information or quality of provider care is a similar barrier experienced in the antenatal and post-partum stages. A similar digital intervention to improve access to health knowledge or improve provider quality may be applied to address these barriers in the antenatal and postpartum stages. To further elaborate, if sending informational text messages to mothers during the antenatal stage has a proven positive effect on improving antenatal health behaviors, this same approach might be applicable to improve postnatal health behaviors.

Health-systems continuum: An additional dimension in addressing these constraints is the level of the health system where these interventions are targeted. Digital interventions may focus on the overarching “pipelines” of the health system; the provider; or the client/patient.[16] At the macroscopic health systems level, common mHealth applications used include tracking of vital events, routine data collection, electronic health records, supply-chain management to improve availability of essential drugs, mobile-based financial incentives, and facilitating improved communication across components of the health system. Provision of patient-side decision support tools and mobile-based longitudinal clinician training may improve health care practitioners’ knowledge and adherence to treatment protocols. Assistance with provider’s workflow management and record keeping may improve regularity of client follow-up, and efficiency in responding to client needs. Lastly, patient-level strategies include preventive or curative education and behavior change communication through messaging to patient’s phones, and although still an emergent part of the landscape, point-of-care diagnostics.[17]

Table 3 below provides a summary of sample constraints at each level of the health system with specific examples of how existing projects are addressing them. Program documents with further details are cited as footnotes for the ease of referencing by the reader.

**Table 3: Systemic constraints to advancing child health and possible digital health solutions. Initials (S, C, P) are used to denote whether the innovations are targeting constraints at the system infrastructure, client or provider level of the health system.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Constraints to improving child health example | Possible digital health solution |
| Information | **S** | Enumeration of new births or neonatal deaths | The Millennium Villages Project in Ghana initiated a vital registration and verbal autopsy system where CHWs report deaths using an SMS message. This is followed by a detailed verbal autopsy using Open Data Kit-support mobile forms. The forms are uploaded on the electronic medical record system called OpenMRS, which uses the verbal autopsy data to generate reports.[[3]](#footnote-1) |
| **C** | Access to health information (e.g. about breastfeeding, home-care for diarrhea etc.) | Tahir et al. tested the effect of unidirectional telephone counselling to provide education on breast- and infant feeding practices, in order to encourage exclusive breastfeeding.[[4]](#footnote-2) |
| Availability | **S** | Supply of drugs to treat pneumonia, malaria and other childhood illnesses | cStock in Malawi allow health surveillance assistants to report community-level stock-out of drugs for IMCI using an SMS message. District Product Availability Teams ensure that the drugs are available for pick up at the health facility.[[5]](#footnote-3) |
| **P** | Lack of availability or access to diagnostic kits/centers or skills to use them | To reduce the time between blood sampling for detection of infant HIV and notification of the test results to the health facility, Project Mwana in Zambia uses an SMS message using RapidSMS to deliver the results to the facility ahead of paper records. Delays resulting from lack of local availability of skilled diagnosticians and labs are thus addressed.[[6]](#footnote-4) This is now scaling-up as a national program. |
| **C** | Poor availability of transport services to seek emergency obstetric care | In Zanzibar, D-tree International D-tree uses a mobile algorithm to help trained birth attendants (TBA) identify high-risk pregnancies. For births that need health facility referrals, TBAs partner with local transport services, and are able to pay promptly for transport using mobile money. D-tree partnered with with Zantel, the largest mobile phone operator in Zanzibar, and Etisalat, another telecom operator, to incorporate an SMS-mobile money payment system into the program.[[7]](#footnote-5) This project, too, is in close collaboration with the Ministry of Health, aiming for district-level scale. |
| Cost | **S** | Expenses association with the production and supply of commodities | As a low cost option to addressing supply-chain issues, mVacciNation in Mozambique digitized information on vaccine demand, stocks and storage. The health facilities offering vaccination services receive a warning text message to alert them if their vaccine stock is running low.[[8]](#footnote-6) Other programs, such as Novartis and Malaria No More’s program SMS for Life also demonstrated marked success in sharply reducing stock-outs through scheduled, text-message reporting of stock levels.[[9]](#footnote-7) |
| **C** | Expenses of seeking care at a health facility | The Wired Mothers intervention combined unidirectional text messaging and direct two-way communication in a free call voucher system to provide education on pregnancy, reminders for antenatal care visits and an emergency medical response system.[[10]](#footnote-8) |
| Efficiency | **S** | Timeliness of data collection, entry and use about high risk pregnancies | mSakhi is a mobile-based multimedia job-aid used by CHWs in two districts in Uttar Pradesh, India. Using a open-source android platform, CHWs can register pregnant women and newborns. The data is then used for real-time tracking of the pregnancies and reduces delays in responding to any birth-related complications.[[11]](#footnote-9) |
| **P** | Timely provision of postnatal care | The data collected as part of the mSakhi project is used to generate a work planning schedule for CHWs and sends them reminders to visit mothers and newborns as per the nationally recommended postpartum visitation schedule. 6 |
| **C** | Timely diagnosis and start of treatment for childhood illnesses | mSakhi alerts CHWs to visit newborns, They can then use the multimedia content, decision support, diagnosis and assessment tools available on their mSakhi smartphone to identify newborn and childhood illnesses, and make timely referrals to the health facility. 6 |
| Quality | **S** | Counterfeit drugs for treatment of childhood illnesses | In Nigeria, mPedigree allows consumers to send text messages with item-unique codes on medicine packaging to verify their authenticity.[[12]](#footnote-10) |
| **P** | Poor knowledge of healthcare providers | Mobile Academy launched nationwide in India, designed by BBC Media, provides audio (using interactive voice response) training courses to CHWs to strengthen their knowledge of preventive maternal and child healthcare behaviors. The course comprises of 36 chapters and 9 quizzes and CHW receive a certificate of completion.[[13]](#footnote-11) This is currently slated for national scale-up over the next 2 years in India. |
| Acceptability | **C** | Acceptability of post abortion contraception use | The Mobile Technology for Improved Family Planning (MOTIF) intervention addressed negative perception and fear of side-effects of the use of contraceptives in clients seeking care for abortion services. Clients willing to participate in the intervention receive post-abortion family planning counselling at the clinic followed by 6 automated interactive voice messages on the advantages of contraceptive use and availability of choices.[[14]](#footnote-12) |
| Utilization | **P** | Poor health worker accountability and absenteeism | mTrac in Uganda allows community members to send reports on any health service delivery issue such as drug stock-outs, provider absenteeism, or mistreatment, to the district health teams using an anonymous SMS hotline. The SMS hotline is advertised at all health facilities, on posters and through radio and print advertisements.[[15]](#footnote-13) |
| **C** | Low demand for services such as facility-based births or poor care-seeking for childhood illnesses | BBC Media Action’s program Kilkari, set for national scale in India, delivers time-appropriate recorded voice messages to families with pregnant women and children, starting from the sixth month of pregnancy until the baby is one-year-old. Families who are subscribed receive information and reminders to encourage appropriate health behaviors and care-seeking based on the individual’s stage of pregnancy and motherhood.[[16]](#footnote-14) |

S: System-level constraint; P: Provider-level constraint; C: Client-level constraint

Integrating digital interventions across the health system and MCH continuum: In recent years, the emergence of interventions which target more than one level of the health system has been noted. This transition from single purpose, single function digital interventions (e.g. sending SMS messages to pregnant women to advance knowledge of pregnancy-related care) to more comprehensive complex interventions reflects efforts to integrate within complex, multi-faceted health systems (e.g. system that allows health workers to gather pregnancy-related information, sends gestation-appropriate messages to women, integrates with district health facilities to identify high-risk pregnancies, and works with local emergency services to facilitate transfer to the health facility for advanced obstetric care). mSakhi, presented above under the “efficiency” constraint in Table 3 provides one such example of how an intervention works across all levels of the health system, as well as across the prenatal, birth and post-partum stages to address various barriers to improve maternal and child health outcomes. The case study on D-tree International’s project, presented below, in Zanzibar is another such example.

**D-tree International project to improve maternal and child health outcomes in Zanzibar**

D-tree International’s decision-support mobile job aid was initially piloted to improve provider adherence to protocols in the integrated management of childhood illnesses (IMCI). These ‘eIMCI’ electronic protocols reportedly increased clinical adherence to protocol from 60% to 84%.[42] In 2011, through a Bill and Melinda Gates Foundation Award, D-tree expanded its program activities to include a more comprehensive system that supports community health workers to deliver services to women and children from the antenatal period across to the postpartum period. A decision support algorithm, similar to the eIMCI, was used by traditional birth attendants (TBAs) to deliver community-level antenatal care, and identify at-risk women who should be referred to the health facilities. TBA’s also used the reminders provided by the algorithm to follow-up on the pregnant women, and accompany them to the health facilities, and provide post-partum care for the mother and child, as needed. A mobile money payment system incentivized timely and appropriate referrals. In partnership with local mobile phone operators, and local community drivers, D-tree tested a system in which TBAs could initiate mobile money transfers to the drivers to transport at-risk pregnant women to the nearest health facility. Transfers are made from the TBAs; mobile money accounts to the drivers’ accounts at pre-negotiated prices, at on average, US$ 30 per referral. After such a referral, D-tree pays each TBA US$6 directly through mobile money. Based on the results from the pilot intervention, a modified form of this intervention is currently being implemented at scale across the island of Zanzibar.

## Evidence on ICT interventions for child survival

Though the evidence on digital health strategies with direct impact on child health outcomes is limited; a growing body of evidence exists on how digital health interventions can support intermediate outcomes such as coverage of antenatal care, and skilled birth attendance, with known impact on child survival. It should be noted that there is a great deal of discordance between the digital approaches for which robust evidence exists and the approaches described in the previous section that are being scaled up. As has been repeatedly reported by mHealth researchers, the pace of digital health intervention adoption outpaces the generation of evidence on its efficacy.[18] [19]

Digital health studies consistently report positive usability and acceptability of digital health components; from software to assist in managing clinic patients, or monitoring stock levels, to voicemails providing health information to mothers, to SMS messages with routine health or emergency obstetric information-on-demand.[20] Multiple qualitative studies describe the empowerment of participants, especially healthcare workers, reported due to an increased ability to communicate though digital platforms. When comparing digital communication with paper formats, or standard of care, the digital platforms were preferred even when no improvements were measured in maternal or birth outcomes.[21][22]–[24] In the following section, we describe the evidence on the use of digital approaches to address barriers to service delivery for improved child health, at the health-systems level, provider-level and client-level.

Health-systems interventions: Using digital technologies to prevent drug stock-outs has been one of the more widely evaluated health systems interventions, with likely child survival consequences. SMS for Life allowed facility-based health workers to report stock-levels of malaria rapid diagnostic tests (RDT), and artemether-lumefantrine (AL), using an SMS message. Each health worker received a small monetary incentive (50 Kenyan shilling or 0.5 USD) for timely reporting. These reports were automatically aggregated on a web-based reporting tool at the district level and needed stocks were channeled to the health facilities. The program resulted in a significant reduction of stock-outs of AL and RDT.[25] cStock in Malawi further expanded on this concept through the incorporation of management teams for increased accountability of reporting. cStock, which is currently being scaled in Malawi, aims to reduce stock-outs of life saving medicines for treating childhood illnesses (malaria, pneumonia, diarrhea). cStock was introduced as an integral component of two strategies- Enhanced Management (EM), and Efficient Product Transport (EPT). The program reports that EM was significantly more effective than EPT in reducing stock-outs, and had a mean drug resupply duration of 12.8 days compared to 26.4 days for EPT. These findings suggest that the implementation of a mobile-based intervention to reduce stock-outs is more effective with an accountable management structure.[26]

In order to avoid the delay in diagnosis and treatment of infant infection with human immunodeficiency virus (HIV) in Zambia, an automated SMS message system was developed so that regional laboratories could promptly and confidentially send the diagnostic report to the point-of-care health facility via a SMS message. The study to evaluate this intervention reported that the turnaround time for result notification to the health facility fell from 44.2 days pre-implementation to 26.7 days post-implementation. This has potential implications for early initiation of infant HIV treatment.[27] Given its success as a project, Mwanaa is now being implemented at scale as a Project by the Zambian Ministry of Health.

Provider-level interventions: A number of studies have shown that mobile decision support algorithms and treatment information sent to healthcare providers can improve their practices. In one of the earliest studies on the use of a digital intervention on improving provider adherence to treatment regimens, Zurovac et al. reported that health workers who received motivational and informational messages about management of malaria in children, had demonstrated improvements in correct management by 24% compared to those who did not receive similar messages.[28] D-tree International’s pre-post study on the impact of using a mobile decision support algorithm on provider adherence to IMCI protocols also reported a significant improvement in protocol adherence.[29] Pathfinder International implemented a pre-post study to assess the effect of using a decision support system for ANC provision by Community health Extension Workers (CHEWs) on quality of ANC, in Abuja, Nigeria. 150 CHEWs were trained in the use of the application, and 266 clients were counselled using it. Quality was assessed based on 25 indicators covering technical and counselling elements of ANC. The study reports that the quality score improved from 13.3 at baseline to 17.2 at endline, a statistically significant increase.[30]

Some digital interventions have been targeted at improving the practices of information healthcare providers. To encourage the use of oral rehydration solution (ORS) and zinc by licensed chemical providers (LCPs) in Ghana, Friedman et al. tested the effect of sending LCPs information messages and interactive quizzes via SMS messages over an 8-week period.

Some differences in the prescription of antimicrobials were observed between the intervention and comparison groups, based on self-reported practices; however, no differences were observed in actual practices based on mystery client surveys.[31]

Client-level interventions: The Wired Mothers study in Zanzibar perhaps provides some of the most concrete evidence on the effect of digital interventions targeted directly at the client. The Wired Mothers intervention in Zanzibar aims to link pregnant women to their healthcare provider throughout the antenatal, childbirth and postpartum periods. It comprises of 2 components- A unidirectional text messaging system to provide gestational- and post-partum-stage specific information to women; and a mobile phone voucher system that helps pay for two-way communication between the mother and their provider, in case of emergencies. A cluster randomized controlled trial of this intervention across 24 primary healthcare facilities, with 2550 pregnant women in the intervention group, and 1311 women in the control group, reported a significant reduction in perinatal mortality (odd ratio: 0.50; 95% CI 0.27-0.93).[32] Additionally, the intervention resulted in a marginally significant increase in the coverage of 4 or more antenatal visits (OR: 2.39; 95% CI: 1.03-5.55), [33] and a significant increase in the coverage of skilled birth attendance (OR:5.73; 95% CI: 1.51-21.81).[34]

A number of large scale interventions aim to improve the knowledge of mothers about care for themselves and their infants from the antenatal period to a year or more post-partum through information text messages sent to their mobile phones. The effect of such interventions, like MAMA in Bangladesh, and MomConnect in South Africa, on healthcare outcomes, care-seeking, or long-term knowledge gains have not been reported yet in the peer-reviewed literature, although robust evaluations are ongoing. A number of small-scale studies that have adopted a similar approach of sending unidirectional informational text messages to pregnant and post-partum women have reported no significant knowledge or behavioral gains.[21], [22] These study results should be interpreted keeping in mind that the studies were underpowered, and had large client drop-out rates. Additionally, the intervention approach, though similar is seldom the same. The content of such informational messages, the level and ease of engagement, the incorporation of appropriate behavior change communication theories and the frequency of engagement, all contribute to defining “what” the intervention is and its potential benefits. The Chipatala Cha Pa Foni (CCPF) project implemented in the Balaka district in rural Malawi provided families of pregnant women and children with a toll-free case management hotline, to connect families with healthcare providers. The program also sent SMS or voice messages to women and caretakers of children with gestational/post-partum stage-appropriate health information. A pre-post study conducted using cross-sectional surveys in the intervention group at baseline and two years of follow-up, reported no aggregate effect on the MNCH knowledge of clients. However, a 25 percentage point increase was observed in the use of bed nets by mother and children, and a 15 percentage points increase was observed in initiation of breastfeeding within one hour of birth. A 45 percentage point decline in the use of facility-based services for children was observed.[37], [38] Note that none of these outcomes control for confounding variables which may have impacted selected uptake of CCPF services to begin with.

Two recent studies looked at the effect of digital interventions to improve breastfeeding practices. In the intervention in China, mothers in the intervention group received weekly SMS messages about infant feeding, starting from the third trimester to 12 months post-partum. The study, published in JAMA Pediatrics, reported that the intervention group had a significantly longer duration of exclusive breastfeeding at 6 months (adjusted OR: 2.67; 95% CI: 1.45-4.91), and a much lower rate of introduction of solid foods before 4 months (Adjusted OR: 0.27; 95% CI:0.80-0.94).[35] Another intervention in Malaysia, used twice-monthly telephone counselling on breast- and infant feeding practices over 6 month post-partum, in order to encourage exclusive breastfeeding. The study found that 84.3% of the women in the intervention group breastfed exclusively one month postpartum, compared to 74.7% in the control group with a significant odds ratio of 1.83. However, when adjusted for significant factors relating to exclusive breastfeeding, the effect was no longer significant (OR:1.63; 95% CI:0.82 to 3.22).[36]

Integrated interventions

Maternity care and birth outcomes: A recent impact evaluation of the Information and Communication Technology (ICT) Continuum of Care Services (CCS) intervention in Bihar, compared the effectiveness of a mobile phone based intervention added onto an existing maternal and child health program. The ICT-CCS is one of the most comprehensive digital maternal and child health program that targets all the critical MCH outcomes starting from early pregnancy to the postpartum stages. The Ananya program in Bihar aims to improve maternal and infant health outcomes through a series of interventions at the community level. The ICT-CCS provided CHWs with mobile phones to aid with pregnancy registration, schedule home visits, and use guided audiovisual job-aids for counselling clients. Auxiliary midwives (ANMs) and lady supervisors (LSs) were provided ICT-enabled phones to improve oversight and supervision of CHWs. Though technical and logistical challenges were reported by the project, a significant 2-year impact on several coverage indicators was observed. The intervention significantly improved the frequency of CHW- client interactions especially during the final trimester. 50% of the women in the ICT-CCS group had at least 3 antenatal care visits, compared to 29% women in the comparison group. No significant effect was found of the program on most recommended behaviors in the delivery and newborn care domain, including facility delivery. A significant effect was found on immediate breastfeeding (76 percent in the intervention group versus 62 percent in the control group); skin-to-skin care (65 percent in the intervention group versus 58 percent in the control group); timely introduction of complementary feeding (41 percent for the treatment group versus 32 percent for the control group).[40]

TulaSalud in Guatemala trained 125 community facilitators (CFs) to use mobile phones to consult with medical staff, call for emergency transfer of pregnant women with intrapartum complications, capture data on pregnant and post-partum women in real-time, and receive continuous training on promotional and prevention activities through teleconferences. The study reported that over the 5-year implementation period, the CFs conducted 116,275 medical consultations, monitored 6,783 pregnant women, and coordinated 2,014 emergency transfers. The project claims a significant decline on maternal and infant mortality attributable to the intervention, however the study methods do not substantiate these claims well. [39]

Immunization: A number of interventions have targeted improvements in the coverage of childhood immunizations using different combinations of interventions such as real-time data collection to generate immunization schedules for healthcare providers, and reminder messages about upcoming immunization due dates sent directly to the child’s parent/caretaker, and/or the CHW responsible for that community. Using a retrospective cohort, Kaewkungwal et al. showed that a combination of schedules sent to health care workers and reminders sent to the child’s caretakers resulted in higher on-time rates of extended programme on immunization (EPI) (OR: 1.48; 95%CI 1.09-2.03).[41]

## Taking digital interventions to scale

Digital interventions have benefited from the enthusiastic, and often unquestioning support of implementing and governmental agencies, corporates, and donors. As presented in the previous section, the evidence in for most intervention approaches, if exists, comes from fairly small scale studies. However, we note that when supporting a specific digital intervention approach, in addition to the evidence in support of the intervention, one should also take into account the level of evidence that may be *needed* to justify investments in the intervention, given the possible costs or negative consequences of implementation. Some interventions have a more tangible observable benefit. Our recommendations for innovations that should be scaled is determined not just based on the evidence in support of the intervention, but also the feasibility of scaling the intervention and the potential value of the intervention.

Some digital interventions at the health systems-level seem to have a more easily discernible value, even in the absence of extensive evidence. Interventions such as cStock which combine SMS reporting of community drug stock-levels, improved data aggregation and visibility at the district level, and robust management mechanisms to hold all the key health care personnel accountable show immense promise for scale. In areas where timely treatment of childhood illnesses is limited due to poor availability of drugs, such an intervention would be relevant. Assessing the feasibility of such an intervention at the start would be important. Improving drug availability only becomes relevant if some basic healthcare infrastructure is present, and trained healthcare workers are available to diagnose and prescribe the drugs.

There is also a growing body of evidence and value in arming healthcare providers with job-aids to support on-the-job training and assistance. Mobile job-aids, such as those implemented by D-tree International, to support diagnosis and treatment of childhood illnesses are promising and are currently being tested in several other countries, for a variety of health services. One factor that limits our enthusiasm for scaling such interventions is the lack of cost-effectiveness studies that compare these digital job-aids with paper job-aids. Yet, a digital job aid can provide additional benefits in terms of collection of real-time service delivery data, and aggregation and use of the data for quality control. Comparative cost-effectiveness studies should account for these secondary benefits resulting from the digitization of health records.

A majority of current digital health interventions have some component that directly engages with the client to share health information or encourage recommended health behaviours. Though single function interventions such as those that only share unidirectional informational messages with clients in the form of SMS messages, seem to have scaled in many countries; there is little to no evidence to suggest that they impact client knowledge or practices. Health programs may view access to health information as a basic right; but sending individually-targeted SMS messages is a rather expensive way to make information accessible. It also limits access to information to the sub-group of literate populations that are mobile-phone owners. Since so much investment has been made into such programs, there needs to be greater support to study their impact. A growing number of interventions have combined such demand side interventions (such as direct messaging to clients) with supply side interventions. Supply side interventions may include, but are not limited to, linking the client to the health facility/provider (as in the case of Wired Mothers), improving community outreach by arming health workers with job-aids and other decision support tools (as in the case of ICT-CCS), improving real-time data collection and visibility to improve health system response to client needs (as in the case of ICT-CCS), and using incentives such as mobile money to improve health worker accountability or reduce barriers to accessing health facilities (as in the case of D-tree international’s project in Zanzibar). Such integrated interventions, though complex, and a lot more challenging to scale, appear to have important benefits beyond impacting immediate health outcomes to strengthening the basic health infrastructure for long-term improvements in service delivery.

**References**

[1] R. E. Black, C. Levin, N. Walker, D. Chou, L. Liu, and M. Temmerman, “Reproductive, maternal, newborn, and child health: Key messages from Disease Control Priorities 3rd Edition,” *Lancet*, vol. i, no. 16, pp. 1–15, 2016.

[2] unicef; World Health Organisation; The world Bank; United Nations, “Levels & Trends in Child Mortality Report 2015,” pp. 8–9, 2015.

[3] United Nations, “Sustainable Development Goals: 17 goals to transform our world.” [Online]. Available: http://www.un.org/sustainabledevelopment/health/. [Accessed: 30-May-2016].

[4] Z. A. Bhutta, J. K. Das, R. Bahl, J. E. Lawn, R. A. Salam, V. K. Paul, M. J. Sankar, H. Blencowe, A. Rizvi, V. B. Chou, and N. Walker, “Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost?,” *Lancet*, vol. 384, no. 9940, pp. 347–370, 2014.

[5] G. Jones, R. W. Steketee, R. E. Black, Z. A. Bhutta, and S. S. Morris, “How many child deaths can we prevent this year?,” *Lancet*, vol. 362, no. 9377, pp. 65–71, 2003.

[6] G. L. Darmstadt, Z. A. Bhutta, S. Cousens, T. Adam, N. Walker, L. De Bernis, L. Neonatal, and S. Steering, “Neonatal Survival 2 Evidence-based , cost-effective interventions : how many newborn babies can we save ?,” no. panel 1, pp. 19–30, 2005.

[7] Z. A. Bhutta, T. Ahmed, R. E. Black, S. Cousens, K. Dewey, E. Giugliani, B. A. Haider, B. Kirkwood, S. S. Morris, H. Sachdev, and M. Shekar, “What works? Interventions for maternal and child undernutrition and survival,” *Lancet*, vol. 371, no. 9610, pp. 417–440, 2008.

[8] Z. A. Bhutta, M. Y. Yakoob, J. E. Lawn, A. Rizvi, I. K. Friberg, E. Weissman, E. Buchmann, and R. L. Goldenberg, “Stillbirths: What difference can we make and at what cost?,” *Lancet*, vol. 377, no. 9776, pp. 1523–1538, 2011.

[9] Z. A. Bhutta, J. K. Das, A. Rizvi, M. F. Gaffey, N. Walker, S. Horton, P. Webb, A. Lartey, and R. E. Black, “Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost?,” *Lancet*, vol. 382, no. 9890, pp. 452–477, 2013.

[10] A. K. Shetty, “Global Maternal, Newborn, and Child Health: Successes, Challenges, and Opportunities.,” *Pediatr. Clin. North Am.*, vol. 63, no. 1, pp. 1–18, 2016.

[11] S. Agarwal and A. Labrique, “Newborn health on the line: The potential mhealth applications,” *JAMA*, vol. 312, no. 3, pp. 229–230, 2014.

[12] a K. Patwari and N. Raina, “Integrated Management of Childhood Illness (IMCI): a robust strategy.,” *Indian J. Pediatr.*, vol. 69, no. 1, pp. 41–48, 2002.

[13] Requejo, “Countdown to 2015 and beyond: fulfilling the health agenda for women and children,” *Lancet*, vol. 385, pp. 466–476, 2015.

[14] K. E. Dickson, A. Simen-Kapeu, M. V. Kinney, L. Huicho, L. Vesel, E. Lackritz, J. De Graft Johnson, S. Von Xylander, N. Rafique, M. Sylla, C. Mwansambo, B. Daelmans, and J. E. Lawn, “Every Newborn: Health-systems bottlenecks and strategies to accelerate scale-up in countries,” *Lancet*, vol. 384, no. 9941, pp. 438–454, 2014.

[15] Z. a Bhutta, M. Chopra, H. Axelson, P. Berman, T. Boerma, J. Bryce, F. Bustreo, E. Cavagnero, G. Cometto, B. Daelmans, A. De Francisco, H. Fogstad, N. Gupta, L. Laski, J. Lawn, B. Maliqi, E. Mason, C. Pitt, J. Requejo, A. Starrs, C. G. Victora, T. Wardlaw, and B. K. Moon, “Countdown to 2015 decade report (2000-2010): taking stock of maternal, newborn, and child survival,” *Lancet*, vol. 375, pp. 2032–44, 2015.

[16] L. Marsch, S. Lord, and J. Dallery, *Behavioral Healthcare and Technology: Using Science-Based Innovations to Transform Practice*, vol. 10. Oxford University Press, 2014.

[17] S. Agarwal and A. Labrique, “Newborn Health on the Line The Potential mHealth Applications,” *JAMA*, vol. 312, no. 3, pp. 229–230, 2014.

[18] S. Agarwal and H. Perry, “Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review,” *Trop. Med. …*, 2015.

[19] A. Labrique, L. Vasudevan, L. W. Chang, and G. Mehl, “H\_pe for mHealth: More ‘y’ or ‘o’ on the horizon?,” *Int. J. Med. Inform.*, vol. 82, no. 5, pp. 467–469, 2013.

[20] S. F. V. Sondaal, J. L. Browne, M. Amoakoh-Coleman, A. Borgstein, A. S. Miltenburg, M. Verwijs, and K. Klipstein-Grobusch, “Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in Low- and Middle-Income Countries: A Systematic Review.,” *PLoS One*, vol. 11, no. 5, p. e0154664, 2016.

[21] R. Jareethum, V. Titapant, T. Chantra, V. Sommai, P. Chuenwattana, and C. Jirawan, “Satisfaction of healthy pregnant women receiving short message service via mobile phone for prenatal support: A randomized controlled trial,” *J Med Assoc Thai*, vol. 91, no. 4, pp. 458–63.

[22] Y. K. Lau, T. Cassidy, D. Hacking, K. Brittain, H. J. Haricharan, and M. Heap, “Antenatal health promotion via short message service at a Midwife Obstetrics Unit in South Africa: a mixed methods study.,” *BMC Pregnancy Childbirth*, vol. 14, no. 1, p. 284, 2014.

[23] S. S. Datta, P. Ranganathan, and K. S. Sivakumar, “A study to assess the feasibility of text messaging service in delivering maternal and child healthcare messages in a rural area of Tamil nadu, India,” *Australas. Med. J.*, vol. 7, no. 4, pp. 175–180, 2014.

[24] S. O. Oyeyemi and R. Wynn, “Giving cell phones to pregnant women and improving services may increase primary health facility utilization: a case-control study of a Nigerian project.,” *Reprod. Health*, vol. 11, no. 1, p. 8, 2014.

[25] S. Githinji, S. Kigen, D. Memusi, A. Nyandigisi, A. M. Mbithi, A. Wamari, A. N. Muturi, G. Jagoe, J. Barrington, and R. W. Snow, “Reducing stock-outs of life saving malaria commodities using mobile phone text-messaging: SMS for Life study in Kenya,” *PLoS One*, vol. 8, no. 1, p. e54066, 2013.

[26] M. Shieshia, M. Noel, S. Andersson, B. Felling, S. Alva, S. Agarwal, A. Lefevre, A. Misomali, B. Chimphanga, H. Nsona, and Y. Chandani, “Strengthening community health supply chain performance through an integrated approach: Using mHealth technology and multilevel teams in Malawi.,” *J. Glob. Health*, vol. 4, no. 2, p. 020406, Dec. 2014.

[27] P. Seidenberg, S. Nicholson, M. Schaefer, K. Semrau, M. Bweupe, N. Masese, R. Bonawitz, L. Chitembo, C. Goggin, and D. M. Thea, “Early infant diagnosis of HIV infection in Zambia through mobile phone texting of blood test results,” *Bull World Heal. Organ*, vol. 90, no. 5, pp. 348–356, 2012.

[28] D. Zurovac, R. K. Sudoi, W. S. Akhwale, M. Ndiritu, D. H. Hamer, A. K. Rowe, and R. W. Snow, “The effect of mobile phone text-message reminders on Kenyan health workers’ adherence to malaria treatment guidelines: a cluster randomised trial,” *Lancet*, vol. 378, no. 9793, pp. 795–803, 2011.

[29] M. Mitchell, B. L. Hedt-Gauthier, D. Msellemu, M. Nkaka, and N. Lesh, “Using electronic technology to improve clinical care–results from a before-after cluster trial to evaluate assessment and classification of sick children according to Integrated Management of Childhood Illness (IMCI) protocol in Tanzania,” *BMC Med. Inform. Decis. Mak.*, vol. 13, no. 1, pp. 1–8, 2013.

[30] M. McNabb, E. Chukwu, O. Ojo, N. Shekhar, C. J. Gill, H. Salami, and F. Jega, “Assessment of the quality of antenatal care services provided by health workers using a mobile phone decision support application in northern Nigeria: a pre/post-intervention study.,” *PLoS One*, vol. 10, no. 5, p. e0123940, Jan. 2015.

[31] W. Friedman, B. Woodman, and M. Chatterji, “Can mobile phone messages to drug sellers improve treatment of childhood diarrhoea? - A randomized controlled trial in Ghana,” *Health Policy Plan.*, vol. 30, no. May 2004, pp. i82–i92, 2015.

[32] S. Lund, V. Rasch, M. Hemed, I. M. Boas, A. Said, K. Said, M. H. Makundu, and B. B. Nielsen, “Mobile phone intervention reduces perinatal mortality in zanzibar: secondary outcomes of a cluster randomized controlled trial.,” *JMIR mHealth uHealth*, vol. 2, no. 1, p. e15, Jan. 2014.

[33] S. Lund, B. B. Nielsen, M. Hemed, I. M. Boas, A. Said, K. Said, M. H. Makungu, and V. Rasch, “Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial.,” *BMC Pregnancy Childbirth*, vol. 14, no. 1, p. 29, Jan. 2014.

[34] S. Lund, M. Hemed, B. B. Nielsen, A. Said, K. Said, M. H. Makungu, and V. Rasch, “Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: a cluster‐randomised controlled trial,” *BJOG An Int. J. Obstet. Gynaecol.*, vol. 119, no. 10, pp. 1256–1264, 2012.

[35] J. H., L. M., W. L.M., H. Q., Y. D., H. G., B. L.A., and D. M.J., “Effect of short message service on infant feeding practice findings from a community-based study in shanghai, china,” *JAMA Pediatr.*, vol. 168, no. 5, pp. 471–478, 2014.

[36] N. M. Tahir and N. Al-Sadat, “Does telephone lactation counselling improve breastfeeding practices?: A randomised controlled trial,” *Int. J. Nurs. Stud.*, vol. 50, no. 1, pp. 16–25, 2013.

[37] S. C. Watkins, A. Robinson, and M. Dalious, “Evaluation of the Information and Communications Technology for Maternal, Newborn and Child Health project,” 2013.

[38] J. C. Fotso, L. Bellhouse, L. Vesel, and Z. Jezman, “Strengthening the home-to-facility continuum of newborn and child health care through mHealth: Evidence from an intervention in rural Malawi,” *African Popul. Stud.*, vol. 29, no. 1, p. 1663, 2015.

[39] A. Martínez-Fernández, I. Lobos-Medina, C. A. Díaz-Molina, M. F. Chen-Cruz, and I. Prieto-Egido, “TulaSalud: An m-health system for maternal and infant mortality reduction in Guatemala.,” *J. Telemed. Telecare*, vol. 21, no. 5, pp. 283–91, Jul. 2015.

[40] E. Borkum, A. Sivasankran, S. Sridharan, D. Rotz, S. Sethi, M. Manoranjani, L. Ramakrishnan, and A. Rangarajan, “Evaluation of the information and Communication Technology (ICT) Continuum of Care Services (CCS) Intervention in Bihar,” 2015.

[41] J. Kaewkungwal, P. Singhasivanon, A. Khamsiriwatchara, S. Sawang, P. Meankaew, and A. Wechsart, “Application of smart phone in ‘Better Border Healthcare Program’: a module for mother and child care,” *BMC Med Inf. Decis Mak*, vol. 10, no. 69, pp. 1472–6947, 2010.

[42] M. Mitchell, B. L. Hedt-Gauthier, D. Msellemu, M. Nkaka, and N. Lesh, “Using electronic technology to improve clinical care - results from a before-after cluster trial to evaluate assessment and classification of sick children according to Integrated Management of Childhood Illness (IMCI) protocol in Tanzania.,” *BMC Med. Inform. Decis. Mak.*, vol. 13, no. 1, p. 95, 2013.

1. Jo Y, Labrique AB, Lefevre AE, Mehl G, Pfaff T, Walker N, et al. (2014) Using the Lives Saved Tool (*LiST*) to Model mHealth Impact on Neonatal Survival in Resource-Limited Settings. PLoS ONE 9(7): e102224. doi:10.1371/journal.pone.0102224 [↑](#endnote-ref-1)
2. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2395571/ [↑](#endnote-ref-2)
3. http://www.who.int/maternal\_child\_adolescent/epidemiology/maternal-death-surveillance/case-studies/ghana/en/ [↑](#footnote-ref-1)
4. Tahir, Norzakiah Mohd, and Nabilla Al-Sadat. "Does telephone lactation counselling improve breastfeeding practices?: A randomised controlled trial." *International journal of nursing studies* 50.1 (2013): 16-25. [↑](#footnote-ref-2)
5. http://sc4ccm.jsi.com/countries/malawi/ [↑](#footnote-ref-3)
6. http://www.unicef.org/partners/Partnership\_profile\_2012\_Mwana\_Zambia\_V2\_approved.pdf [↑](#footnote-ref-4)
7. https://www.hfgproject.org/wp-content/uploads/2014/05/Mobile-Money-Case-Study\_D-Tree.pdf [↑](#footnote-ref-5)
8. https://www.povertyactionlab.org/evaluation/increasing-vaccination-coverage-using-mobile-phone-application-mozambique [↑](#footnote-ref-6)
9. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2978233/ [↑](#footnote-ref-7)
10. Lund, Stine, et al. "Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial." *BMC pregnancy and childbirth* 14.1 (2014): 1. [↑](#footnote-ref-8)
11. http://www.intrahealth.org/files/media/msakhi-an-interactive-mobile-phone-based-job-aid-for-accredited-social-health-activists/mSakhi%20brief\_final.pdf [↑](#footnote-ref-9)
12. http://mpedigree.net [↑](#footnote-ref-10)
13. http://www.rethink1000days.org/programme-outputs/mobile-academy/ [↑](#footnote-ref-11)
14. http://www.who.int/bulletin/volumes/93/12/15-160267/en/ [↑](#footnote-ref-12)
15. http://www.mtrac.ug/content/how-mtrac-works [↑](#footnote-ref-13)
16. https://www.rethink1000days.org/programme-outputs/kilkari/ [↑](#footnote-ref-14)