PERSPECTIVE

Prioritizing integrated mHealth strategies for universal health coverage

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As countries strive toward universal health coverage, mobile wireless technologies—mHealth tools—in support of enumeration, registration, unique identification, and maintenance of health records will facilitate improved health system performance. Electronic forms and registry systems will enable routine monitoring of the coverage of essential interventions for individuals within relevant target populations. A cascading model is presented for prioritizing and operationalizing the role of integrated mHealth strategies.

The goals of universal health coverage (UHC) are shaping the global health agenda (*1*, *2*), emphasizing that all people, irrespective of socioeconomic status, should have access to health services they need, without incurring financial hardship. These ideas, echoing the 1948 Universal Declaration of Human Rights, were reinforced as a central strategy for global health in the World Health Organization (WHO) 2010 World Health Report and a 2012 United Nations General Assembly Resolution (*3*, *4*). Achieving UHC, while addressing proximal and distal contributors to poor coverage and quality of care, often requires rectifying decades-old dysfunction in supply-and-demand aspects of health systems. Creative financing and private-sector engagement may offset some basic health service costs but are unlikely to do so at the scale required to cover the millions who need care. Innovations are required that improve unrestricted access to, and full use of, affordable quality services.

Meanwhile, for two decades, plummeting costs have led to nearly ubiquitous access to telecommunications technologies (*5*); this has occurred independently of the global health or development communities, driven by market forces and consumer demand. The ability of even simple phones to connect to complex digital systems is proving transformative for low- and middle-income country (LMIC) populations (Fig. 1). As health program implementers struggle to scale up and integrate public health interventions of known efficacy (such as vaccines, micronutrients, and skilled birth attendance), strategies leveraging mobile wireless technologies—mHealth—are increasingly part of a systems-thinking approach to resolving these challenges (*6*).

Global health agencies are beginning to advocate the prudent use of mHealth solutions, guided by evidence demonstrating their usability, functionality, reliability, and impact under real-world conditions (*7*). Country-level health information systems that enable national aggregate record-keeping and facility-level medical records have been facilitated by low-cost, open-source robust systems such as District Health Information Systems (DHIS2) and Open Medical Record Systems (OpenMRS). Enterprise-grade mHealth systems are also gradually emerging. The past 5 years have seen substantial maturation of the field, with at least three WHO-led initiatives [mHealth Technical and Evidence Review Group (mTERG), eHealth Technical Advisory Group (eTAG), and the International Telecommunications Union–WHO Mobile Health for Non-Communicable Diseases Initiative], accompanied by numerous other mHealth communities of practice. Several hundred randomized trials are under way worldwide, measuring the efficacy of mHealth strategies (*8*). However, most of these innovations remain vertical in their approach; that is, addressing single problems faced by health systems. A framework to help prioritize investments and opportunities for collaboration has been absent, especially given the complexity of health systems, where the receipt of quality care by clients is often contingent on several preceding layers of enabling conditions. Knowing who is in need of services, having the necessary human resources and commodities in adequate supply, and connecting these together at the right time and place are elements critical to success. Government agencies have been slow to consider innovations that help with each of these challenges, such as those being developed in the mHealth space, perhaps because the harmonization of innovations across these health system layers is a daunting task. Drawing from seminal work in health systems analysis, we provide a novel framework for visualizing and planning how mHealth innovations can be applied to help surmount common and persistent constraints along the pathways toward the achievement of UHC goals.

Fig. 1. D-tree International nutrition program to identify and treat early childhood malnutrition, Urban District, Zanzibar. [Credit: Mark Leong/World Health Organization]

People-centered integrated care requires numerous coordinated inputs. In 1978, Tanahashi (*9*) proposed a cascading model to illustrate how health systems lose performance because of bottlenecks at successive levels, each dependent on the previous layer. Gaps in information, training, quality, and equitable distribution contribute to accumulated losses of potential, leading to diminished health system performance. Tanahashi's model helps identify opportunities for improvements in particular strata of the system, with cascading benefits to each layer above it (*10*). As mHealth moves from an era of experimentation—dominated by targeted vertical solutions—toward cross-sectoral health systems that integrate numerous mHealth strategies, we have adapted Tanahashi's model to illustrate where digital investments can have the greatest impact toward the achievement of UHC. Previously, we proposed that mHealth innovations be viewed not as a direct way to achieve a health outcome but as a strategy to overcome obstinate barriers to the delivery of known efficacious interventions (*7*). This reframing allowed researchers to focus on measuring the catalytic role of mHealth tools: how a mobile intervention was able to improve efficiency or the coverage of an intervention, such as childhood vaccinations, that has previously been shown to save lives. Although this helped bridge the dialogue between mHealth innovators and health systems policy-makers,

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frustration remained because of the proliferation of these solutions without a roadmap to guide their integration into health systems. One can imagine the chaos that would be created by 100 architects trying to repair a Victorian mansion without a blueprint. Our modification of Tanahashi's model extends this approach to illustrate how integrated mHealth systems solutions can be leveraged to improve existing implementation plans and reduce health service bottlenecks, to realize improvements in the quality, cost, and coverage drivers necessary for UHC (Fig. 2). In essence, we drew from a time-tested conceptual framework that captures the complexity and interdependences of health systems to build a new guide for policy-makers to conceptualize how distinct mHealth strategies, even if developed independently, could be integrated and applied together, simultaneously strengthening the various layers of a health system.

Increasing accountability—capturing denominators

Population enumeration, which is the responsibility of government, poses a challenge to constructing a true denominator of those to whom the health system is accountable. Paper-based civil registration systems have degraded; few LMICs can claim universal citizen registration. Routine paper registers, used to profile and track client subpopulations and account for services, often contain suspect data. Systems are typically slow to aggregate data and extract disease trends or performance patterns, resulting in inefficient or delayed health system responses. Equitable delivery of health services by frontline health workers (HWs) often relies on highly localized microcensuses of specific target populations (such as pregnant women).

In Fig. 2, the "total population" represents all individuals, known and unknown, in an area; "target population" is a subset characterized by demographic or health profile, defining eligibility for specific interventions (such as infants receiving vitamin A supplementation). "Accountability coverage" is the proportion of those in the target population registered into the health system; e.g., through civil registration and vital statistics (CRVS) mechanisms, population census, issuance of a national or health identifier, or electronic medical record (EMR).

Because total and target populations are extant but unknown quantities, accountability coverage becomes the point of entry for mHealth interventions. mHealth tools can bolster population enumeration and CRVS systems in remote areas (*11*), even at national scale, as in Uganda (*12*), where community-based volunteers report births via mobile device to the appropriate civil agency, which verifies the information and issues a birth certificate. HWs in India and Bangladesh use tablet-based Open Smart Register Platform (OpenSRP) and mCare systems that connect registers with EMR systems and, through the use of shared unique identifiers, facilitate continuity of care across providers and facilities.

Registration and EMR approaches, combined with electronic forms for profiling client health status, establish a common denominator that can be shared between civil and health systems, as well as tools to document individuals' health profiles and service needs and the ability to monitor and respond promptly to epidemiological trends. Digital reporting offers supervisors real-time insight about performance issues and opportunities for responsive actions to time-sensitive information.

Improving supply of services

In most LMICs, poor finances, inadequate facilities, a strained health workforce, and aging supply management operations have resulted in health systems struggling to meet populations' needs. Clients may encounter a lack, or poor quality, of supplies ("availability of commodities and equipment"); insufficient, unmotivated, or

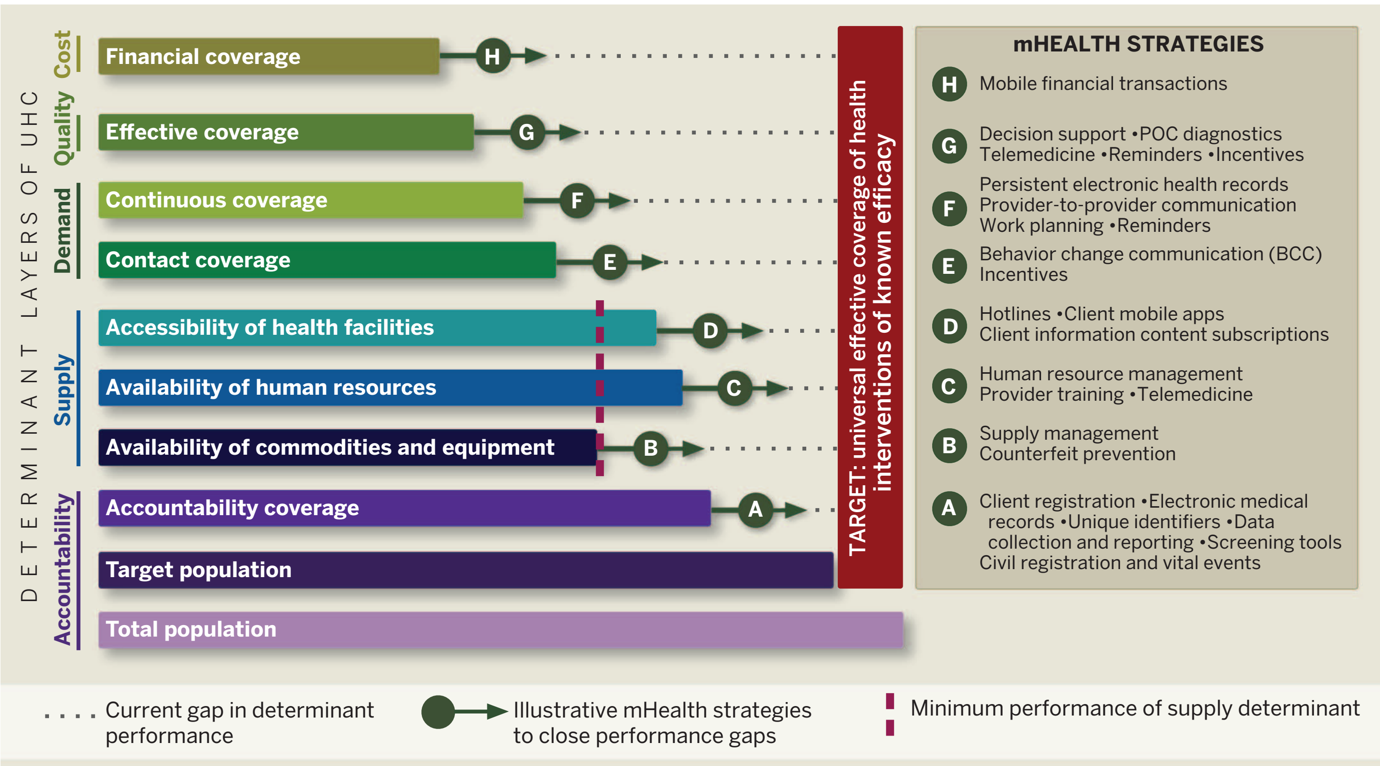


Fig. 2. A cascading model to prioritize and select integrated mHealth strategies for achieving UHC [adapted from (*7*) and (*9*)]. This framework shows how eight key ingredients are required before a target population (a subset of the total population at the bottom of the cascade) can all receive the quality, timely, and adequate care they need. These components of health system performance are grouped into categories of accountability, supply, demand, quality, and cost. As illustrated, each layer not only builds on the performance of the layer below it but also falls short (dotted lines) of the optimal, desired level. A suite of mHealth strategies (labeled A through H) exists that could contribute to efforts in strengthening any given category. This framework helps facilitate dialogue between mHealth innovators and health system policy-makers to strategically plan how independently developed solutions can work in an integrated approach to addressing health system challenges across numerous layers.

dysfunctional health staff ("availability of human resources"); and lack of "accessibility of health facilities"—any of which would hinder the supply of appropriate services.

mHealth innovations, in the form of text messaging with linked Web dashboards, have been used to track essential supplies and reduce the time for restocking at health centers. Sproxil and mPedigree enable HWs and clients to scan barcodes to verify counterfeit and expired commodities; in Tanzania, mHealth supply-chain management tools reduce stockouts of antimalarials (*13*).

mHealth tools targeting the availability of an effective health workforce focus on training approaches, incentive mechanisms, and supervisory support to strengthen skills and enforce compliance with standards. Training and in-service refresher content [for example, eMocha TB Detect's multimedia content for continuous medical education (*14*)] can strengthen HWs' ability to provide quality care. In Rwanda, mHealth tools facilitate documentation of service delivery, providing real-time data streams designed for benchmarking and data-informed feedback by supervisors.

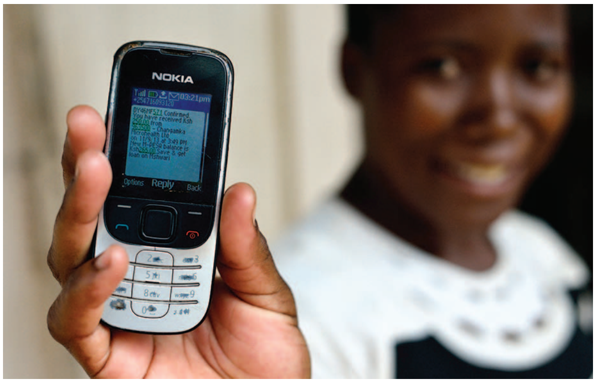
Many barriers prevent or delay clients from accessing needed information, commodities, or other services in a timely manner (*15*). To reduce barriers to accessing services, mHealth strategies use behavior change communication content for client health engagement and mechanisms for remote diagnosis and management of illness. Tools include phone apps for client self-management; hotline and interactive voice response (IVR)–based approaches that facilitate client-initiated, structured information content retrieval; and access to counseling, diagnostics, and referral mechanisms.

Driving demand, increasing access

Even where health interventions are available, there may be barriers to target populations accessing them. "Contact coverage" is the proportion of clients who have contact with relevant facilities, providers, and services among the total population requiring a health intervention. Typically, this reflects a difference in the characteristics defining the available interventions and the target population's expectations, mediated by barriers including affordability, acceptability, and client/provider interaction experiences. Variations in demand or ability to access services within a target population may be characterized by stratifications of age, social or economic status, geography, and gender. To improve access to information, some mHealth strategies provide personalized message content. In South Africa, the MAMA project employs multiple mobile communication channels (voice, text message, IVR, Mxit, and mobile Web) to inform pregnant women from different social strata about appropriate nutrition and to remind them of antenatal care (ANC) practices and available services.

Health interventions often require multiple interactions with the health system for maximum effect. For instance, WHO recommends that pregnant women have at least four ANC visits, a mark seldom achieved in LMICs. "Continuous coverage" refers to the extent to which the full course of intervention required to be effective is achieved. mHealth strategies that support client-side reminders and provider-side alerts for health interventions, such as vaccinations linked to specific schedules, help reinforce timely health services.

mHealth strategies have focused on streamlining health providers' client management tools. HWs with the Ananya Project in India, for example, use mobile phones to register clients, record service delivery information, and consult a client's medical history. Using unique digital identifiers, client health data are synchronized between phones of multiple HWs, and providers receive notifications when scheduled cases are missed, further ensuring continuity of care.



Woman receiving financial voucher confirmation message, Changamka Microhealth maternal health voucher payment program, Kenya. [Credit: Mark Leong/WHO.HRP]

Enhancing quality, improving efficiency

For health interventions to offer maximum benefit, they need to be administered following evidence-based guidelines, representing minimum standards of inputs and processes. "Effective coverage" refers to the proportion of individuals receiving satisfactory health services, among those in need (the target population) (*16*). Health interventions that are delivered suboptimally, such as when health providers are inefficient or fail to abide by treatment protocols, result in reduced effective coverage.

In LMICs, ensuring effective coverage is inherently challenging. mHealth tools that reinforce best practices, or facilitate beneficiary feedback on service quality, can mitigate bottlenecks that compromise the potential of interventions (*17*). mHealth decision support algorithms, such as electronic Integrated Management of Childhood Illness, guide frontline HWs in step-by-step diagnosis and management of diseases (*18*). In Zambia, mHealth technology improves access to cervical cancer point-of-care screening; digital cervicography informs consultative telemedicine expert review determining the need for immediate referral or cryotherapy treatment (*19*).

Telemedicine and closed-network provider-to-provider communication mHealth solutions such as Switchboard work to eliminate obstacles preventing providers from seeking supportive guidance or arranging patient referrals. mHealth provider-to-patient approaches facilitate free communication (voice and messages), enabling direct follow-up about specific care regimens or services.

Ensuring protection from health costs

Direct and indirect financial costs can have catastrophic financial effects (for instance, for the uninsured). "Financial coverage" is the proportion of patients protected from impoverishment due to health interventions.

Across sub-Saharan Africa and Asia, mobile phone–based banking has spawned microinsurance and incentive schemes, leveraging technology to connect health and financing. Mobile money reduces financial barriers: It can incentivize clients to seek health care, subsidize transportation to health facilities, ensure treatment completion, and encourage savings to offset health costs. In Madagascar, Marie Stopes used mobile phone–based short message service money transfer systems to more efficiently deliver vouchers to reimburse service providers, offset client costs, and increase poor people's access to voluntary family planning services (*20*).

Conclusion

For mHealth strategies to be recognized as integral to the achievement of UHC, the field needs to invest intellectual and financial resources to move beyond vertical solutions addressing single problems. Alongside targeted, single-focus innovations, integrated evidence-based packages of interoperable solutions must emerge, optimizing health systems across multiple determinants of UHC. Such "best of breed" agglomerates may be championed by single public- or private-sector entities, such as a corporate solution provider or health agency, or be fostered through the adoption of global standards. Granted, horizontal solutions are seldom easy to develop or adopt, especially in the public sector, but guiding frameworks such as this one can help governments set realistic expectations and prioritize investments across critical health system layers. Likewise, in the absence of targets for integrated mHealth strategies, donors will continue to invest primarily in siloed innovation, neglecting comprehensive approaches with real potential for scale. A coordinated donor investment mechanism, such as the CRVS Scaling Up Investment Plan and Trust Fund, is needed for mHealth to ensure that governments have the means to guide mHealth into this next era of maturity, with integrated solutions becoming the norm. WHO and other stakeholders will need to issue guidance to help prioritize and accelerate government mHealth adoption. Already, multiple efforts are under way to synthesize evidence, from WHO's mTERG to USAID's periodic Evidence Summits. In the future, these efforts could be guided by this framework to direct strategic investment toward key foundational layers of struggling health systems in an integrated manner. Our modified Tanahashi model facilitates a systematic approach toward constructing integrated mHealth strategies that together address multiple gaps in the pathway to UHC, improving performance in the quality, cost, and coverage necessary to provide care to all in need.

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PERSPECTIVE

How to transform the practice of engineering to meet global health needs

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More of the world's population has access to cell phones than to basic sanitation facilities, a gap that can only be closed if the engineering and international aid communities adopt new approaches to design for scarcity and scalability.

Engineers have known how to produce safe drinking water and how to build toilets and roads in developing countries for more than 100 years. Yet, global access to such technologies is far from uniform. Approximately 768 million people do not have access to safe drinking water; 2.5 billion lack basic sanitation, and 1 billion practice open defecation (*1*). More than 50% of people who have no access to water and sanitation live in middle-income countries (*1*). Use of these technologies can mean the difference between life and death; diarrheal illness, 90% of which is related to inadequate access to clean water and sanitation, kills more children under 5 than AIDS, malaria, and measles combined (*2*).

Why is it so difficult to translate technologies that have improved public health in wealthy countries into solutions that equitably improve lives around the world? It is primarily because these solutions were developed to satisfy constraints of high-resource settings. In many cases, they cannot be easily adapted to work in low-resource settings; they are too expensive or rely on infrastructure or expertise that does not exist. For example, a recent survey of anesthetists in Uganda reported that only 20% had a constant supply of electricity for the equipment necessary for basic surgery (*3*). Between 2005 and 2011, the President's Emergency Plan for AIDS Relief (PEPFAR) invested over $1 billion to strengthen clinical laboratories to improve HIV/AIDS care, primarily in sub-Saharan Africa (*4*); yet maintenance and repair of the necessary laboratory equipment, designed for high-resource settings, is a continued challenge across PEPFAR countries (*4*), where intermittent power can render equipment unusable, and there is limited in-house technical support to repair medical equipment (*5*). If we are to resolve global inequities in access to innovations that improve health, we must adopt new approaches to engineering design that reflect the unique needs and constraints of low-resource settings.

Design for scarcity

Engineers design new technologies to meet societal needs in the face of economic constraints; in contrast, frugal design—designing through the lens of scarcity—begins first with the assumption that material and human infrastructure are limited and not systematically integrated. These resource and infrastructure limitations dictate the constraints that frugal designs must satisfy but may also lead to reuse or repurposing of available commodities in ways that are not anticipated. For example, early efforts to scale up provision of injectable vaccines in low-resource settings led to a wave of unsafe injections, where disposable syringes were reused. It has been estimated that as many as 30% of injections in low-resource settings are unsafe because of reuse of syringes (*6*); this practice continued despite efforts to educate practitioners about the dangers of reusing disposable syringes. A "cultural resistance to waste" drove continued reuse of syringes, "regardless of training, advocacy, and regulatory factors" (*7*).

Next, it's important to engage users early. Projects pursued from the perspective of adapting high-resource design principles to low-resource settings without firm evidence of user need beg the question of adoption and can lead to one-off projects that are scaled on the basis of donor priority without evidence that they improve outcomes. For example, the nongovernmental organization (NGO) PlayPumps (Fig. 1) was initially heralded for its ability to use children's play on a merry-go-round to provide a much-needed community service: pumping of water to a community storage tank. With relatively little target community feedback, the U.S. government and other donors committed $16 million to scale up the implementation, and PEPFAR announced a plan to raise an additional $44 million. However, it quickly became apparent to users that, not only were the spare parts and technical expertise required to fix the PlayPump difficult to find, but also that the 27 hours of playtime needed to meet the required minimum daily water requirement was simply infeasible (*8*). In the end, the community users preferred the efficiency and reliability of traditional hand pumps.

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