Strengthening health systems for improved access to maternal, newborn and child health services: Why mHealth should be part of the solution, and why rigorous, theory-based evaluations matter

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Short abstract

The potentials of the field of mobile health (mHealth) have not yet been fully harnessed to improve maternal, newborn and child health (MNCH). An MNCH mHealth pilot named CCPF was launched in Malawi, consisting of a toll-free case management hotline and a mobile messaging service. This paper uses quantitative and qualitative data to assess the impact of CCPF, and discusses opportunities for scale and integration into wider health systems. CCPF had significant impact on bed net use, breastfeeding within one hour, antenatal care initiation, and institutional delivery. A negative effect of facility-based fever treatment suggests that CCPF helped women avoid unnecessary trips to health facilities, an interpretation corroborated in the qualitative data. The Malawi Ministry of Health endorsed the project and is supporting efforts to bring it to scale**.** Most mHealth interventions lack rigorous evaluation designs, and are rarely designed with a roadmap for integration into broader health systems.

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Expanded Abstract

1. Introduction

The rapidly expanding field of mobile health (mHealth) - the use of mobile phones to improve health and health systems - presents a unique opportunity that has not yet been fully harnessed to increase access to health care and improve health outcomes (Mechael, 2015; mHealth Alliance, 2012; WHO, 2011). The declining cost of mobile phones, growth in subscriptions, rapid advances in technology, and increased network coverage have resulted in numerous mHealth projects in low- and middle-income countries (LMICs) since the mid-2000s (Noordam et al., 2011; Mechael et al., 2012; Arie, 2015). Between 2005 and 2010, mobile telephone subscriptions grew almost three-fold in sub-Saharan Africa and more than six-fold in South Asia (World Bank & ITU, 2012). This trend triggered researchers, programmers and policy makers to examine how mobile phones can be used to improve access to healthcare services, and resulted in an overwhelming number of small pilot projects (Tomlinson et al., 2013; Arie, 2015), often initiated by non-profit and academic institutions (Vesel et al., 2015).

Need to prioritize integrated and horizontal strategies that support the broader health systems

Nevertheless, despite the unique opportunity, most of the mHealth projects fail to go to scale. User friendliness of mHealth applications and mobile devices, as well as political and financial commitment influences the sustainability and scalability of these initiatives (Noordam et al., 2015). Financial challenges are linked to the fact that most projects are donor driven and therefore are often terminated at the end of the project cycle. In addition, government involvement and leadership is often a critical missing link (Tamrat & Kachnowski, 2012; Noordam et al., 2015). One of the causes for the lack of financial and political commitment seems to be related to the stand alone nature of these initiatives, and their competition with other initiatives for scarce resources (Labrique, et al., 2013). Even when vertical programs are brought to scale, there is a need for a wide range of activities to address a wider array of health conditions (Tomlinson et al., 2013; Mehl & Labrique, 2014).

It is therefore crucial to shift from vertical programs and initiatives to more integrated and horizontal approaches which address health system failures, leading to wider impact on health services as a whole, and more effective and efficient use of resources (Mehl & Labrique, 2014; Arie, 2015). One of the ways to develop integrated mHealth strategies is moving from a technology focus to addressing health system's needs (Labrique et al., 2013). Simultaneously, there is a need to upgrade the technological infrastructure (Noordam et al., 2015), set up eHealth policies and build a better basis from which more initiatives can drive (Labrique et al., 2013). A major challenge associated with this agenda is the required concerted efforts by partners, including government, funders and the private sector (Tomlinson et al.,

2013). In addition, the evidence on how to implement mHealth initiatives effectively at scale in health systems is limited (Leon et al., 2012).

Rigorous, theory-based evaluations are needed

mHealth interventions are gaining traction in almost all parts of the world, yet the evidence-base to support this trend is relatively meager, the literature shows that many mHealth interventions are pilot projects with limited measures of effectiveness (Tomlinson et al., 2013; Leon et al., 2012). Reviews of the effectiveness of mHealth to improve service delivery noted that out of the 42 controlled trials identified, none was implemented in LMICs, and revealed that many of the studies published suffer from methodological weaknesses or were primarily descriptive rather than analytical in nature (Free et al., 2013; mHealth Alliance, 2013; Noordam et al., 2011). A more scientific approach, which frames and answers critical evaluation questions, is needed to support and inform the expansion of the mHealth field, particularly in sub-Saharan Africa (Fotso et al., 2015a). This assessment aligns with views from mHealth experts who acknowledge that "generating quality evidence through methodologically rigorous research has emerged as a priority for the broader mHealth community" (mHealth Alliance, 2013).

As a result of the limited evidence base on the effectiveness of mHealth interventions, and thelimited understanding of the challenges associated with the integration of these interventions in the existing structures or in national health policies, strategies and regulations, only a few mHealth projects have been brought to scale (Noordam et al., 2015; Lemaire, 2011).

The aim of this paper which builds on our previous work (Fotso et al., 2015a; Fotso et al., 2015b; Higgins-Steele et al., 2015; Larsen-Cooper et al., 2015) is three-fold. First, it seeks to contribute to expanding the evidence base on the effectiveness of mHealth interventions, investigating the impact of an MNCH mHealth project known as CCPF (health center by phone) on uptake of home-based and facility-based practices for MNCH in a rural district of Malawi. Second, it adds to the current debate on impact evaluation built on mixed and theory-driven methods to answer critical questions on what works and why. Third, it seeks to showcase the lessons learned on CCPF's journey to scale with health systems strengthening in mind, and the associated opportunities and challenges.

2. Data and Methods

The MNCH mHealth Project

The mHealth intervention, known as *Chipatala cha pa foni* (CCPF) – meaning health center by phone – was piloted between July 2011 and June 2013 in Balaka District in the Southern region of Malawi. Its aim was to increase knowledge and use of home- and facility-based MNCH services. To achieve these objectives, the intervention offered a toll-free case management hotline and an automated and personalized mobile messaging service. Community volunteers, trained and provided with phones, conducted community mobilization in the intervention sites and facilitated access to services to those

without phones (For details, see: Crawford et al., 2014; Fotso et al., 2015a; Fotso et al., 2015b; Higgins-Steele et al., 2015; Larsen-Cooper et al., 2015).

Evaluation design and source of data

The evaluation opted for a mixed methods approach. The quantitative component used a two-arm quasi-experimental, pre-post design to quantify the impact of the intervention on knowledge and use of home-based and facility-based care for mothers and children (Fotso et al., 2015a; Higgins-Steele et al. 2015). The neighboring Ntcheu District in the Central region was selected to serve as comparison, as it was deemed most likely to exhibit similar MNCH outcomes as Balaka district. Cross-sectional household surveys were conducted at baseline (June-July 2011) and endline (April-May 2013) in both the intervention and comparison sites. As shown in Table 1, a total of 6,453 households (2,810 at baseline and 3,643 at endline) were successfully visited (Higgins-Steele et al. 2015; Fotso et al., 2015b).

Variables

A total of 14 variables in four categories are analyzed in this paper:

- **Use of home-based practices for maternal health**: 1) bednet use during pregnancy - women who had a live birth in the last 18 months (n=2,813).
- **Use of home-based practices for child health**: 2) initiation of breastfeeding within one hour of birth – Last child of women who had a live birth in the last 18 months (n=2,813); 3) exclusive breastfeeding until six month of age; 4) bednet use by under-five child during the previous night; and 5) oral rehydration salt (ORS) use - children who had experienced diarrhea in the past two weeks (n=1269). Items 3 and 4 are for all children (n=6,846).
- **Use of facility-based services for maternal health**: 6) received the correct dosage of the tetanus toxoid (TT) vaccine during pregnancy; 7) received a Vitamin A dose during pregnancy; 8) received the recommended four ANC consultations; 9) started ANC in the first trimester; 10) gave birth under the supervision of a skilled birth attendant; and 11) received one postnatal care (PNC) check-up within two days of birth. All questions were asked of women who had a live birth in the last 18 months (n=2,813).
- **Use of facility-based services for child health:** 12) child was fully immunized by the first birthday - children between 12 and 24 months of age (n=1,610); 13) health facility care was sought for child with symptoms of acute respiratory infections (ARI) - children with symptoms of ARI in the past two weeks (n=1,895); and 14) health facility care was sought for child with fever - children with symptoms of fever in the past two weeks (n=2194).

In the multivariate analyses we control for variables at the community level (mean distance to the health center), household level (DHS-type household wealth, number of under-five children, and ethnicity and religion of the household head), woman level (access to phone, education, marital status and age), and child level (age and sex). For a list of control variables, see Fotso et al., 2015a; Fotso et al., 2015b; Higgins-Steele et al., 2015.

Methods of analysis

We assess the impact of the intervention using the difference-in-difference (DID) method, the most widely used method for impact evaluation in the context of quasi-experimental designs (Heckman, 2005; Meyer, 1995). The analysis is carried out in three steps. **First**, we estimate the simple DID for a given outcome Y as follows:

$$DID(Y) = \left(\overline{Y}_{IE} - \overline{Y}_{CE}\right) - \left(\overline{Y}_{IB} - \overline{Y}_{CB}\right) \quad (1)$$

where $\overline{Y}_{IE}$ and $\overline{Y}_{CE}$ represent the average at endline in the intervention site and comparison area, respectively, and $\overline{Y}_{IB}$ and $\overline{Y}_{CB}$ represent the average outcome at baseline in the intervention site and comparison area, respectively.

The DID estimate in (1) can also be calculated within a regression framework as follows:

$$Y_{ivt} = \beta_0 + \beta_1 T_v + \beta_2 P_t + \beta_3 (T * P)_{vt} + \varepsilon_{ivt} \quad (2)$$

where Y_{ivt} is the outcome measure for a woman/child i, in village v, at time t. T_v is a dummy variable taking the value 1 for individuals in treatment areas and 0 for individuals in comparison areas, P_t is a dummy variable taking the value 0 for the baseline data and 1 for the endline data, and ε_{ivt} is the idiosyncratic error, clustered by health center catchment area. The DID estimator of interest is the coefficient β_3 of the interaction between T_v and P_t and is the same as the estimate obtained in equation (1). Since CCPF was offered but not compulsory, this estimate is to be interpreted as intention-to-treat (ITT) effect (Have et al., 2008).

Next, we estimate the adjusted effect using regression-based DID in equation (2) controlling for possible confounders. **Finally**, we estimate the treatment effect on the treated (TOT) which, in contrast to the ITT, compares the individuals who actually used the services to similar individuals in the comparison area (Have et al. 2008, Angrist et al., 1996).

Qualitative data

Qualitative investigations were undertaken at both baseline and endline, as shown in Table 2. For this paper, we used the endline Focus group discussion (FGD) data to gain insights into the utility of the services offered by the intervention to support both home-based care when appropriate and referrals to facility-based care. FGDs were conducted in each of the four intervention villages with women users and non-users of the CCPF intervention.

3. Results

3.1. The effectiveness of the CCPF platform

The distribution of the control variables at baseline and endline and across the study sites has been presented elsewhere (Fotso et al., 2015a; Fotso et al., 2015b; Higgins-Steele et al., 2015). Our results show that at end line, the awareness of the services in the intervention area was at around 77%. Among the individuals who heard about CCPF (n=1,929), less than 25% used the services, a proportion which represent about 18% of the total sample of women at end line. Table 3 presents the levels of the selected indicators and the resulted unadjusted difference-in-difference estimates. It appears that the

intervention had a strong, negative effect on the visits to health facility for child fever; a small, negative effect on child use of bednet; and a small, positive effect on exclusive breastfeeding. Adding control variables into the intention-to-treat model (see Table 4) only resulted in minimal changes.

In Table 4, the treatment on the treated model shows a markedly different picture. The intervention had a strong, positive impact on five MNCH indicators: Child use of bednet ($p<0.01$); ANC initiation during the first trimester of pregnancy ($p<0.01$); use of bednet during pregnancy ($p<0.05$); breastfeeding within one hour of birth ($p<0.05$); and institutional delivery ($p<0.01$). On the other hand, there was a negative TOT effect of CCPF on TT vaccine during pregnancy ($p<0.05$).

The negative effect on the visits to facility for child fever ($p<0.01$) deserves further exploration. In Table 3, the proportion of children with fever who visited a health facility dropped by 15.4 percentage points in the intervention site (from 67.5% to 52.1%), and by contrast increased by 3.6 percentage points in the control area (from 59.1% to 62.7%). The qualitative data suggest that the intervention equipped caregivers to handle conditions like fever at home, and avoid unnecessary trips to the health facility for care that could be provided at or closer to home, through the pharmacy or community health workers, for example. The intervention thought to have strengthened the home-to-facility continuum of newborn and child health care (Fotso et al., 2015b). A woman in a focus group discussion explained:

> "*We first talk to CCPF worker before we decide to go to the health center … and if it is not a serious problem, he tells us what to do. But if the problem is serious, he advises us to take the child to the health center*."

3.2. CCPF's evaluation design: strengths and how it generated critical learning

The evaluation of CCPF was theory-based, to some extent. The endline evaluation started with the drafting of a theory of change, which outlined the context, barriers and assumptions that existed before the project was implemented, and detailed the transformational steps, which are believed to follow from the intervention's activities. The baseline and endline evaluation used a mixed method approach, with baseline qualitative explorations informing the quantitative data collection, and the endline qualitative data supporting the interpretation of the quantitative findings and helping answer some of the "why" questions.

The quasi-experimental design was critical in assessing the impact of the intervention. With the low uptake of the CCPF intervention (at 18%), the ITT estimates are not likely to provide a fair indication of the impact of the intervention. The TOT method attempted to adjust for two critical self-selection biases. There are individuals in the control area who would not be able or willing to use the services even if they were offered. A mere comparison of the control and intervention areas as in the ITT principle, without accounting for this selection would lead to biased impact estimates (Angrist et al., 1996, Bertrand et al., 2004). The second self-selection bias accounted for in the TOT method is the fact that only a subgroup of the individuals assigned to the intervention area actually used the services, and this selection was non-random (Have et al 2008).

3.3. CCPF's journey to scale

After reviewing the evaluation results, particularly the strong evidence of effectiveness, the Reproductive Health Unit (RHU) of the Malawi Ministry of Health (MoH) endorsed CCPF in early 2014 and is encouraging a national scaling up of the intervention. The RHU serves as a coordinating body which ensures that partner support for mHealth services in the area of reproductive, maternal and child health prioritizes the expansion of CCPF services instead of investing in new services. This direction from the MoH has attracted direct financial support for CCPF from other development partners. VillageReach, the implementing organization of CCPF, works closely with the mHealth Technical Working Group and the Safe Motherhood Technical Working Group within the ministry of health to ensure that there is no duplication of services between CCPF and other current or future mhealth initiatives in Malawi.

Currently, CCPF operates from Balaka District Hospital and serves four out of 28 districts in the country, with plans and resources in place to expand to five additional districts in 2015. However, scale and sustainability requires integration of CCPF into governmental budgets through the Sector Wide Approach plan (SWAp) and into the ministry's annual budgets and plans. VillageReach is actively working with the RHU and the Department of Planning at the MoH to ensure that this integration happens by 2017. Discussions are also underway to operate CCPF from Lilongwe (the country's capital city). This move is expected to increase the proximity with development partners, and contribute to the planning for an eventual handover to the ministry of health. It will also provide better infrastructure capacity to handle the technological requirements of hosting a national hotline call center.

Integration into the broader health system is critical for the national scale of CCPF. Currently, the service is moving forward with plans for integration of services with existing mHealth, eHealth and MNCH projects. Furthermore, VillageReach is finalizing a long-term partnership with Malawi's leading mobile network operator, to provide zero-rated service, expand CCPF's district coverage and marketing, broaden its health focus to other health related issues and provide triage to physicians for complicated cases. With its prospects of integration into broader health system strengthening initiatives, CCPF has the opportunity to scale nationally and be sustained through ownership by the ministry of health and partners' support. This notwithstanding, the journey to national scale is a long one requiring time, resourcing, and coordination of multiple, often disparate, stakeholders.

4. Discussion and discussion

We will discuss these findings and draw lessons for integration of multiple mHealth functions, with health systems strengthening and scale in mind. The functions of interest to the field of MNCH include client education and behavior change communication; data collection and reporting; electronic health records; registries and vital event tracking; provider work planning and scheduling; provider training and education; financial transactions and incentives; and supply chain management (Labrique et al, 2013).

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Table 1. Number of survey respondents by population group at baseline and endline

	Baseline survey			End-line survey			Total
	Compari-son	Interven-tion	Total	Compari-son	Interven-tion	Total	
Health facility catchment areas	2	4	6	Same as at baseline			6
Villages[1]	10	8	18	39	38	77	NA
Households[2]	1,112	1,698	2,810	1,284	2,359	3,643	6,453
Women 15-49[2]	1,119	1,721	2,840	1,344	2,509	3,853	6,693
Under-5 children[2]	1,365	2,220	3,585	1,075	2,186	3,261	6,846

[1]Random selection of villages (primary sampling units) in the catchment areas of all six qualified health centers in the intervention (4 health centers) and comparison (2 health centers) sites

[2]All households in the selected villages, and all women and children under-five in those households

Table 2. Description of the qualitative component

		Number	Description
Focus group discussion (FGD)	Baseline	15	12 with women and 3 with men, in both the intervention and the comparison sites
	Endline	12	With women in the intervention area who had used CCPF, heard but not use, or had not heard of CCPF
In-depth interview (IDI)	Endline	16	With women who had used CCPF and their husbands, and those who had heard but not use it
Key Informant interview (KII)	Endline	47	With health facility staff, community health workers, District Health Management Team members, and implementation team members
Hearsay	Baseline	48	Hearsay ethnography is a method for studying conversations and social interactions in their "natural" social settings. Was done in the intervention site.
	Endline	46	

Table 3. Unadjusted difference in difference (DID) on the effects of the interventions on home-based and facility-based MNCH care

		Baseline	Endline	DID
1. Home-based care for maternal health				
% Using a bed net during last pregnancy	Intervention	0.868	0.930	-0.005
	Comparison	0.846	0.914	
2. Home-based care for child health				
% Last child breastfed within 1 hour of birth	Intervention	0.907	0.947	0.001
	Comparison	0.902	0.941	
% Child breastfed exclusively until 6 months of age	Intervention	0.931	0.941	0.014*
	Comparison	0.945	0.940	
% Under 5 child slept under a bed net last night	Intervention	0.818	0.952	-0.090**
	Comparison	0.706	0.929	
% Under 5 child receiving oral rehydration salts to treat diarrhoea	Intervention	0.747	0.728	0.017
	Comparison	0.663	0.626	
3. Facility-based care for maternal health				
% Received correct dosage of TT vaccine during pregnancy	Intervention	0.860	0.858	0.044
	Comparison	0.930	0.884	
% Received Vitamin A dose during pregnancy	Intervention	0.729	0.715	0.068
	Comparison	0.632	0.549	
% Attended at least 4 ANC consultations	Intervention	0.617	0.554	0.085
	Comparison	0.619	0.638	
% Started ANC first trimester	Intervention	0.264	0.389	0.009
	Comparison	0.206	0.323	
% Gave birth in a medical facility	Intervention	0.919	0.961	-0.010
	Comparison	0.908	0.961	
% Received post-natal check-up within 2 days of birth	Intervention	0.039	0.053	0.017
	Comparison	0.057	0.054	
4. Facility-based care for child health				
% Children 12-23 months of age fully immunized	Intervention	0.788	0.781	0.013
	Comparison	0.777	0.758	
% Children with ARI who visited health facility	Intervention	0.639	0.641	-0.030
	Comparison	0.676	0.708	
% Children with fever who visited health facility	Intervention	0.675	0.521	-0.189***
	Comparison	0.591	0.627	

Statistical significance: *p<0.10, **p<0.05, ***p<0.01

Table 4. Adjusted effects of the intervention on home-based and facility-based MNCH care

	ITT effect	TOT effect
1. Home-based care for maternal health		
% Using a bed net during last pregnancy	-0.008	0.210**
2. Home-based care for child health		
% Last child breastfed within 1 hour of birth	-0.001	0.114**
% Child breastfed exclusively until 6 months of age	0.011	0.006
% Under 5 child slept under a bed net last night	-0.094**	0.568***
% Under 5 child receiving oral rehydration salts to treat diarrhea	0.013	-0.006
3. Facility-based care for maternal health		
% Received correct dosage of TT vaccine during pregnancy	0.040	-0.104**
% Received Vitamin A dose during pregnancy	0.069	0.083
% Attended at least 4 ANC consultations	0.079	0.055
% Started ANC first trimester	0.008	0.444***
% Gave birth in a medical facility	-0.012	0.110**
% Received post-natal check-up within 2 days of birth	0.016	0.022
4. Facility-based care for child health		
% Children 12-23 months of age fully immunized	0.009	0.012
% Children with ARI who visited health facility	-0.025	-0.083
% Children with fever who visited health facility	-0.181***	-0.499***

Statistical significance: *p<0.10, **p<0.05, ***p<0.01