Connecting female entertainment workers in Cambodia to healthcare services using mHealth: an economic evaluation of Mobile Link

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Submitted to: JMIR Formative Research
on: September 13, 2023

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Abstract

Background: Mobile Link is a mobile phone-based intervention to increase access to, and use of, healthcare services among female entertainment workers (FEWs) in Cambodia who face higher risks for specific diseases and gender-based violence. A multisite randomized controlled trial showed that Mobile Link connected FEWs with outreach workers for information and escorted referrals after six months but did not lead to statistically significant improvements in HIV and STI testing, contraceptive use, and condom use.

Objective: The objective of this study is to conduct a three-part economic evaluation of Mobile Link to understand its costs, value, and affordability.

Methods: We conducted cost, cost-effectiveness, and budget impact analyses of Mobile Link using cost and outcomes data from the Mobile Link trial and other sources. For the cost analysis, we estimated the total, per-person, and incremental costs of Mobile Link compared to usual care. Using a probabilistic decision-analytic model, we estimated the one-year cost-effectiveness of Mobile Link from payer and combined payer and patient perspectives by converting trial outcomes to disability-adjusted life years (DALYs) averted. Finally, we estimated the financial costs of scaling up Mobile Link's messaging and outreach services to 70% of FEWs in five years.

Results: The incremental costs of Mobile Link were $199 from a payer perspective and $195 per person from a combined payer and patient perspective. With an average of 0.018 (95% CI -0.014, 0.05) DALYs averted, Mobile Link's cost-effectiveness was $11,244 per DALY from a payer perspective ($11,039 per DALY averted from a payer and patient perspective). The costs of Mobile Link would have to decrease by 88%, or its effectiveness would have to be 10 times higher, for the intervention to meet the upper limit of recommended cost-effectiveness thresholds in Cambodia ($1,643 per DALY averted). The five-year cost of scaling Mobile Link to 34,790 FEWs was estimated at $1.64 million or $46 per person per year.

Conclusions: This study provided a comprehensive economic evaluation of Mobile Link. We found that Mobile Link is not likely to be cost-effective unless its costs decrease or its effectiveness increases. Scaling up Mobile Link to more FEWs is estimated to cost less than the costs of the trial. Future research should evaluate the long-term cost and outcomes of Mobile Link. Clinical Trial: NCT03117842

(JMIR Preprints 13/09/2023:52734)

DOI: https://doi.org/10.2196/preprints.52734

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Full title: Connecting female entertainment workers in Cambodia to healthcare services using mHealth: an economic evaluation of Mobile Link

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ABSTRACT

Background

Mobile Link is a mobile phone-based intervention to increase access to, and use of, healthcare services among female entertainment workers (FEWs) in Cambodia who face higher risks for specific diseases and gender-based violence. A multisite randomized controlled trial showed that Mobile Link connected FEWs with outreach workers for information and escorted referrals after six months but did not lead to statistically significant improvements in HIV and STI testing, contraceptive use, and condom use.

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Results

The incremental costs of Mobile Link were $199 from a payer perspective and $195 per person from a combined payer and patient perspective. With an average of 0.018 (95% predicted interval -0.088, 0.126) DALYs averted, Mobile Link's cost-effectiveness was $10,955 per DALY from a payer perspective ($10,755 per DALY averted from a payer and patient perspective). The costs of Mobile Link would have to decrease by 85%, or its effectiveness would have to be 5.56 times higher, for the intervention to meet the upper limit of recommended cost-effectiveness thresholds in Cambodia ($1,671 per DALY averted). The five-year cost of scaling Mobile Link to 34,790 FEWs was estimated at $1.64 million or $46 per person per year.

Conclusions

This study provided a comprehensive economic evaluation of Mobile Link. We found that Mobile Link is not likely to be cost-effective unless its costs decrease or its effectiveness increases. Scaling up Mobile Link to more FEWs is estimated to cost less than the costs of the trial. Given the importance of linking FEWs to essential services, future research should focus on enhancing the effectiveness of Mobile Link or developing new mHealth interventions for this population.

Keywords:
female entertainment workers

Cambodia
mHealth
economic evaluation
stigmatized populations

INTRODUCTION

Female entertainment workers (FEWs) in Cambodia face many structural barriers to accessing and using health services, such as stigma and criminalization of sex work [1]. As a result, despite facing higher risks of HIV and other sexually transmitted infections (STIs), gender-based violence (GBV), and being forced to drink while working, FEWs infrequently use health services and can be hard to reach by healthcare workers [2]. To improve the health of FEWs, achieve broader public health goals (e.g., reduction of HIV burden), and advance health equity, new tools that effectively and efficiently engage FEWs in health services are critical and necessary.

Mobile phone-based health interventions, often referred to as mHealth interventions, have been developed and tested in several settings globally to better reach stigmatized populations, such as FEWs. However, results from those studies have been mixed [3–6]. In Cambodia, an mHealth intervention called Mobile Link was developed, following formative participatory research [7], to engage with and connect FEWs to essential prevention, care, and treatment services using automated short message service (SMS) and voice messages (VMs). Its effectiveness in reducing risk behaviors and increasing the use of healthcare services was evaluated in a randomized controlled trial (RCT) conducted in March 2018-June 2019 in five sites [8]. The trial found that Mobile Link helped connect FEWs with outreach workers for information and escorted referrals but did not lead to statistically significant improvements in HIV and STI testing, contraceptive use, and condom use in adjusted models [9].

The adoption and scale-up of Mobile Link and other mHealth interventions will depend on their effectiveness, value, and financial costs [10]. In this study, we conducted a three-part economic evaluation of Mobile Link to understand its costs, cost-effectiveness, and budget impact. We aim to estimate the costs of Mobile Link, the financial requirements and affordability of a potential scale-up, and the short-term value of the intervention using disability-adjusted life years (DALYs) averted as a measure of health benefit. Findings from this study can be used by decision-makers considering the rollout of Mobile Link in other Cambodian jurisdictions, as well as to inform future economic evaluations of other mHealth interventions [11].

METHODS

Study Design

This study involves three distinct empirical and model-based evaluations. The cost analysis determines the total, per-person, and incremental costs of Mobile Link using expenditure data from the trial and other data sources. The model-based cost-effectiveness analysis (CEA) evaluates whether Mobile Link offers “value for money” based on the efficacy results of the trial and the results of the cost analysis. Finally, the budget impact analysis estimates the financial or monetary cost of scaling up Mobile Link to more FEWs in Cambodia. We followed guidelines in economic evaluation, including the ISPOR principles of good practice for budget impact analysis, Consolidated Health Economic Evaluation Reporting Standards, and specific guidance for evaluating mHealth and digital health technologies [10–13]. We used payer and combined payer and patient perspectives in this study. The Impact Inventory [14] (Multimedia Appendix 1) lists the costs and benefits included in each perspective. Patient-level data were analyzed using Stata/SE 15.1 (StataCorp LLC, College Station, TX), and economic analyses were done in Microsoft Excel (Microsoft Corp, Redmond, WA).

Overview of Mobile Link Trial

Details on the Mobile Link RCT are available in a previously published protocol [8] (trial registration NCT03117842 in ClinicalTrials.gov), and the trial results are presented in separate publications [9,15]. In summary, FEWs were recruited by community health workers in Phnom Penh, Battambang, Banteay Meanchey, and Siem Reap and randomly assigned to the treatment and control arms of the trial. Participants in the treatment arm received health information, reminders, and referral resources in Khmer through SMS or VMs. FEWs in the control arm received usual care, which included in-person counseling, HIV and STI testing and condoms, and access to a toll-free hotline with trained counselors. Health messages were developed after a series of formative participatory research and a review of behavior change theories [7]. Themes covered in messages included cervical cancer; contraception; HIV and STI prevention; miscarriage, pregnancy, and pregnancy termination; alcohol use at work; vaginal health and hygiene; GBV; and general health information. Messages were delivered twice a week for 10 weeks, and messages about each theme were repeated every 10 weeks for 60 weeks. Each health message was followed by another message giving FEWs the option to be linked to an outreach worker. Participants who chose this option were contacted by a Mobile Link staff who provided individualized information via phone or in person and escorted participants to services when requested.

After losing 730 participants in the follow-up, the final analytic sample included 388 participants, 218 in the treatment group and 170 in the control group (Multimedia Appendix 2). The dropout rate is notable though not unexpected in research involving hard-to-reach and stigmatized populations [16]. Statistical analyses found no significant differences between the participants who dropped out of the study and those who stayed in the trial. In crude tests of association, statistically significant differences by province and entertainment venue were identified between the treatment and control groups.

Outcomes and measures

The primary outcome measures were (1) HIV testing, (2) STI testing when experiencing symptoms, (3) modern contraceptive use, (4) condom use with non-paying partners, and (5) condom use with paying partners. Secondary outcome measures were (1) contact with outreach workers; (2) use of referrals while being escorted by outreach workers (i.e., escorted referrals); (3) forced drinking at work; and (4) experience with GBV (full descriptions of these outcomes are available in the trial protocol and report [8,9]). Outcomes were measured using self-reported data collected using questionnaires administered via a tablet. Data were collected at three-time points—baseline, midline (6 months after the baseline), and endline (12 months after the baseline).

Multimedia Appendix 3 and 4, respectively, show the primary and secondary outcomes from the trial analyzed per protocol. No statistically significant differences between intervention and control groups were observed for any primary outcome in fully adjusted multi-level logistic regression models with mixed effects controlling for venue type, province, cohabitation, age, education, and outreach worker contact [9]. Among the secondary outcomes (Multimedia Appendix 4), contact with an outreach worker in the last six months, escorted referrals in the last six months, and no forced drinking at work in the last three months were all found to be associated with the intervention in crude analyses. After adjusting for venue type, province, cohabitation, age, and education in logistic regression, only two secondary outcomes—escorted referral and forced drinking at work—were associated with Mobile Link.

Cost Analysis

Using a top-down or gross approach [10,17], we estimated costs from the perspective of payers and patients. Payer costs, including startup (i.e., fixed) costs and other variable costs, were estimated using expenditure data collected during the trial (Table 1). The Global Fund to Fight AIDS, TB, and Malaria (Global Fund), which supports several programs for FEWs in Cambodia, assumed most of the costs, including activities and services associated with usual care available to participants in the control and treatment groups. Additional costs associated with the implementation of the Mobile Link intervention were borne by L' Initiative/Expertise France, the trial funder. We evenly divided the Global Fund costs among all participants in the control and intervention groups, while Mobile Link costs were apportioned to participants in the treatment group only.

Table 1. Payer costs (in US$) from Mobile Link trial

Cost category	L' Initiative/Expertise France	Global Fund
Diagnosis and treatment		
Consumables	NA	70,871
Personnel	NA	3,800
Subtotal	NA	74,671
Information, education, and communication		
Consumables	125,767	64,754
Personnel	34,314	254,433
Subtotal	160,081	319,186
Program management		
Consumables	NA	2,500
Personnel	3,099	
Subtotal	3,099	2,500
Total	163,180	396,357

Table 1 caption: Costs have been roughly classified by activity (diagnosis and treatment; information, education, and communication; and program management) and type of input (consumables and personnel). Global Fund costs were spent on both control and intervention groups, while Expertise France costs were only spent on the intervention arm.
NA, not applicable.

The primary patient cost we considered was time costs associated with seeking health services [18], which were reduced by contacting an outreach worker. Based on interviews with trial participants, the average time to access health services after contact with an outreach worker was 36 minutes (0.6 hours); without outreach workers, the time to access health services was 2.2 hours. Therefore, the net time benefit to FEWs was 1.6 hours per contact with an outreach worker. Based on baseline data from the trial [15], we assumed that participants engaged with FEWs at least twice during the trial, for a total of 3.2 hours in net time benefits.

Following best practices [18], we used earnings data among FEWs to value their time costs. With average weekly earnings of $270 (Multimedia Appendix 1) and assuming an average of 40 work hours per week, the estimated savings from care-seeking after contact with an outreach worker is $21.60 ($6.75 earnings per hour*3.2 hours). We multiplied this cost by the proportion of FEWs who contacted an outreach worker in each trial arm to get the total patient cost savings and then subtracted the result from the total payer costs. Since basic healthcare services like sexual and reproductive health services are available for free to FEWs through government- and grant-funded programs, we did not include out-of-pocket spending. Due to data limitations, we excluded

transportation costs and other costs associated with particular illnesses, such as STIs.

We present total costs, cost per participant, and incremental costs between usual care and the Mobile Link intervention. All costs are reported in 2019 US dollars (US$), the year the RCT concluded.

Cost-effectiveness Analysis

An overview of the CEA is shown in Figure 1. Costs (C_M and C_U in Figure 1) were based on the cost analysis described previously. The health effects of Mobile Link (E_M and E_U in Figure 1) were estimated using the efficacy results from the trial, which we translated into DALYs averted. Because the Mobile Link trial found no statistically significant differences in primary outcomes between the control and intervention groups, we used a probabilistic model that incorporates the uncertainty around the treatment effects. Several factors, such as sample size and the types or anticipated incidence of outcomes, affect whether studies are sufficiently powered to estimate treatment effects [19,20]. In the Mobile Link trial specifically, the high (65%) dropout rate among FEWs may have affected the results. Thus, null results from hypothesis testing do not automatically denote zero treatment effects [20,21]. Our probabilistic economic evaluation is designed to determine the probability that Mobile Link is cost-effective compared to usual care, given the uncertainty in the available evidence [22–24].

Figure 1. Cost-effectiveness analysis overview

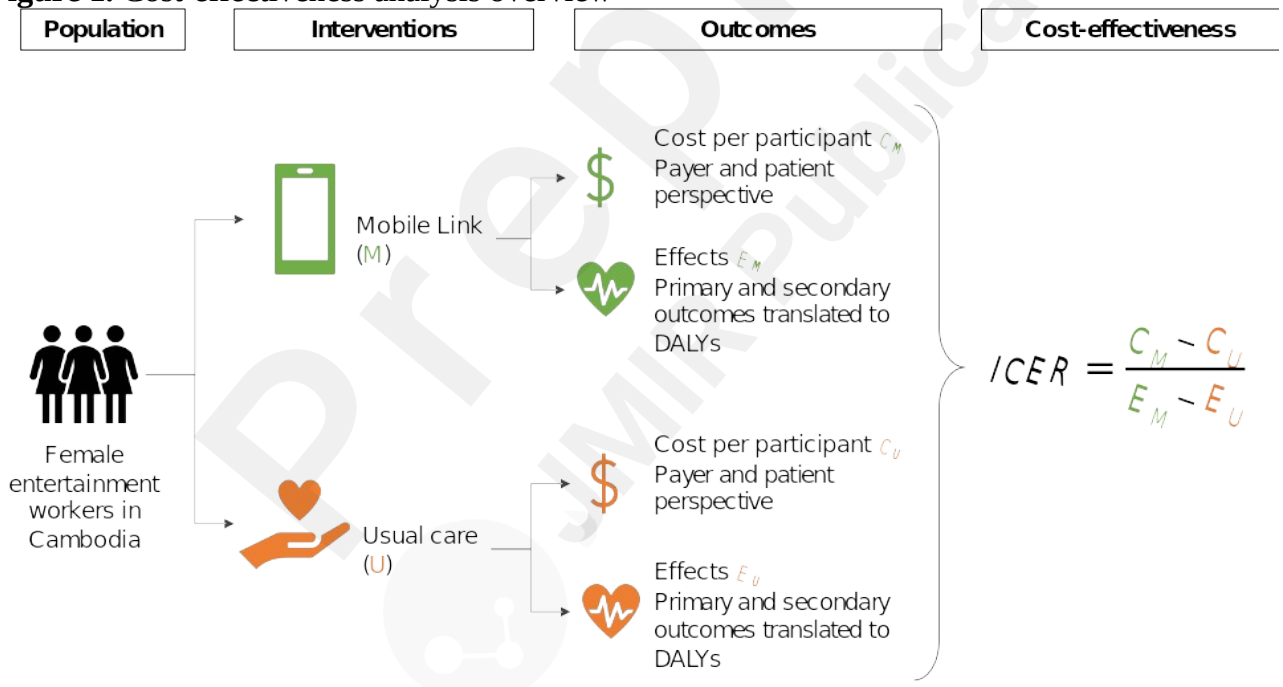


Figure 1 caption: This graphic provides an overview of the analytical approach used in the cost-effectiveness analysis. Costs and benefits were estimated and valued for Mobile Link and usual care separately using data from the trial and other sources. The incremental cost-effectiveness ratio was then calculated by dividing the incremental costs by the incremental benefit.
E, effect; C, cost; DALY, disability-adjusted life year; ICER, incremental cost-effectiveness ratio; M, Mobile Link; U, usual care.

Estimating health effects

We included five outcomes from the trial in the CEA: HIV testing, STI testing, modern contraceptive

use, forced drinking at work, and experience with GBV. These outcomes were selected because they could be translated into DALYs, a commonly used measure of health and disease in low- and middle-income countries [25]. DALYs measure mortality and morbidity in one metric and are calculated by adding years of life lost (YLLs) and years of life with disability (YLDs). Because the time horizon of the analysis is one year, no YLLs were included, and the DALYs associated with each outcome were equal to the disability weights used to estimate YLDs.

Disability weights range from 0 (perfect quality of life) to 1 (disease burden equivalent to being dead). We took disability weights from the 2019 Global Burden of Diseases (GBD) study [26] and the Marie Stopes International Impact 2 Model (version 5) [27,28], a simulation model that estimates the effect of contraceptive use on maternal and child health outcomes (Table 2). For HIV and STI testing, we made further adjustments to the disability weights to reflect the prevalence of the disease and the probability of being treated after a positive test (full details are in Multimedia Appendix 5). For the probabilistic analysis, we assigned beta distributions to each disability weight and used the mean values and standard deviations to estimate the alpha and beta parameters.

Table 2. Disability weights assigned to the Mobile Link outcomes

Outcome of Mobile Link trial[a]	**Description**	**Mean disability weight (SD)**	**Source**
HIV testing	Disability associated with undiagnosed and untreated early HIV infection	0.147 (0.085)	GBD 2019
STI testing	Disability associated with a mild and acute STI episode	0.006 (0.002)	GBD 2019
Modern contraceptive use	Maternal disability associated with non-use of modern contraceptives	0.014 (0.008)	Impact 2
Forced drinking at work	Disability associated with very mild alcohol use disorder	0.123 (0.063)	GBD 2019
Gender-based violence	Disability associated with physical and mental harms and injuries	0.211 (0.109)	GBD 2019

GBD, Global Burden of Diseases study; HIV, human immunodeficiency virus; SD, standard deviation; STI, sexually transmitted infection.

To estimate the total DALYs averted by Mobile Link, we summed the product of the absolute risk difference (ARD) and the DALYs for each of the five outcomes, represented by the index i in Textbox 1. When interpreting and applying non-significant results, the ARD (also called absolute risk reduction) is recommended to communicate the potential magnitude of effect of an intervention [29]. We calculated ARDs by subtracting the risk (or probability) of each outcome in the usual care group (R_U) from the risk of each outcome in the Mobile Link group (R_M) at endline (Table 3) [30]. It is worth noting that for HIV testing and modern contraceptive use, Mobile Link is associated with a negative ARD, which means it performs worse on these outcomes than usual care on average (Table 3).

Textbox 1.

$$Total\ DALYs\ averted = \sum_{i=1}^{5} \left(R_{M_i} - R_{U_i}\right) DALY_i$$

Table 3. Absolute risk differences for primary and secondary outcomes

	Risk in control group, %[a]	**Risk in intervention group, %**	**Absolute risk difference in percentage points**
Primary outcomes			
Tested for HIV, last six months	70.25 (5.93)	68.93 (5.82)	-1.32[b]
Tested for STIs, most recent symptoms	29.17 (2.46)	39.1 (3.3)	9.93
Use of modern contraceptives to prevent pregnancy	41.47 (3.5)	40.05 (3.38)	-1.42[b]
Secondary outcomes			
No forced drinking at work, last three months	66.36 (5.6)	67.85 (5.73)	1.49
Low or no gender-based violence	40.09 (3.39)	48.23 (4.07)	8.14

Table 3 caption: Only participants with data at the midline and endline periods were included in calculating risks. Means and standard deviations in parentheses are provided.
[a]The incidence of the outcome in the control or unexposed group is also called baseline risk.
[b]In the base case, Mobile Link performed more poorly than standard of care for these outcomes, though the differences were not statistically significant.
HIV, human immunodeficiency virus; STI, sexually transmitted infection.

To characterize the uncertainty in ARDs, we assigned normal (base-case assumption), beta, and uniform distributions to each group's endline risk and generated 10,000 estimates of the ARD for each outcome. Following recommended procedures [29,31], we derived the lower and upper values of each risk using the confidence intervals of odds ratios reported in the trial (Multimedia Appendix 2 and 3). We assumed that risks reported in the trial were the mean values, and the standard deviation was equal to the difference between the mean value and upper limit divided by 1.96.

Incremental and sensitivity analyses
We summarized the cost-effectiveness results in incremental cost-effectiveness ratios (ICERs). The ICER is calculated by dividing the net costs of intervention by its net effectiveness (Figure 1) and represents the cost of each DALY averted. ICERs expressed in cost per DALY averted can be compared to context-specific cost-effectiveness threshold to determine whether an intervention is efficient. From a supply-side perspective, the threshold is a measure of opportunity cost or the amount of health displaced by additional spending in the health sector [32]. Alternatively, from a demand-side perspective, the threshold represents a decisionmaker's willingness to pay for an additional unit of benefit. While a cost-effectiveness threshold has not been empirically measured for Cambodia, several ranges based on the country's per-capita gross domestic product have been proposed [33–35]. In this study, we used 50-100% of Cambodia's 2019 per-capita GDP as the cost-effectiveness threshold range ($835-1,671 per DALY averted) [36].

We calculated average ICERs across 10,000 model simulations and the associated 95% predicted interval which represents the 5th and 95th percentiles of the simulated results. We also constructed a cost-effectiveness acceptability frontier, which plots the intervention that is most likely to be cost-

effective over a range of cost-effectiveness thresholds.

Budget Impact Analysis

We conducted a budget impact analysis to estimate the undiscounted financial cost and affordability of delivering Mobile Link to FEWs in Cambodia [13]. We focused on the costs of scaling up Mobile Link's messaging and outreach services and excluded the costs of healthcare services used by FEWs or any potential long-term savings from improved healthcare service utilization among FEWs. We assumed a five-year time horizon where an additional 14% (6,958 FEWs) of the 50,000 estimated FEWs in Cambodia [37] are provided access to Mobile Link annually, culminating in a 70% overall coverage rate. The analysis was conducted from a payer perspective.

We used capital costs (e.g., mobile platform development, beta testing) from Table 1 in the budget impact analysis. We only applied these fixed costs in the first year since they can be leveraged to scale up Mobile Link across Cambodia without additional investments in the short- to medium-term. We also used two variable costs to reflect the expected economies of scale with expanding Mobile Link. The cost of providing messaging services to each additional FEW was estimated to be $2.66, which included all costs associated with weekly SMS to FEWs (Mobile Link trial team, personal communication). Assuming 280 FEWs per outreach worker, we assumed a per-person annual cost of $9.54 for outreach workers, which included salaries and costs for training, communication, and travel.

RESULTS

Cost Analysis

The cost of the Mobile Link intervention from a payer perspective was $352,382 or $429 per person (Multimedia Appendix 7). After subtracting the costs of usual care ($207,155 or $230 per person), the incremental cost of Mobile Link was $145,226 or $199 per person. From a combined payer and patient perspective, the incremental cost per person of Mobile Link was reduced to $195.

Cost-effectiveness Analysis

Table 4 presents the average DALYs averted from the probabilistic models. Two outcomes—HIV testing and modern contraceptive use—were associated with negative mean DALYs averted, which implies that usual care produced with fewer DALYs than Mobile Link across 10,000 simulations. The remaining three outcomes—STI testing, modern contraceptive use, and forced drinking at work—were associated with positive mean DALYs averted, though 95% predicted intervals in all 3 models included negative values.

Table 4. Average DALYs averted by outcome and assumed distribution of risks

Outcome	**Mean DALYs averted**		
	Normal distribution[a]	**Beta distribution**	**Uniform distribution**
HIV testing	-0.002 (-0.022, 0.019)	-0.002 (-0.023, 0.018)	-0.0004 (-0.042, 0.04)
STI testing	0.0006 (-0.0014, 0.0027)	0.0006 (-0.0014, 0.0027)	0.0003 (-0.0021, 0.0027)
Modern contraceptive use	-0.0002 (-0.0024, 0.0019)	-0.0002 (-0.0024, 0.002)	-0.0001 (-0.004, 0.0039)

Forced drinking at work	0.002	(-0.018, 0.022)	0.002	(-0.018, 0.022)	0.0004	(-0.042, 0.043)
Gender-based violence	0.017	(-0.084, 0.121)	0.018	(-0.087, 0.118)	0.003	(-0.117, 0.121)
Total	0.018	(-0.088, 0.126)	0.018	(-0.092, 0.122)	0.003	(-0.131, 0.135)

Table 4 caption: DALYs averted were calculated by comparing Mobile Link with usual care. Means and 95% predicted intervals in parentheses from 10,000 model simulations are presented under different assumptions around the distribution of endline risks among control and intervention groups (normal, beta, and uniform).
[a]Base-case assumption
DALY, disability-adjusted life year.

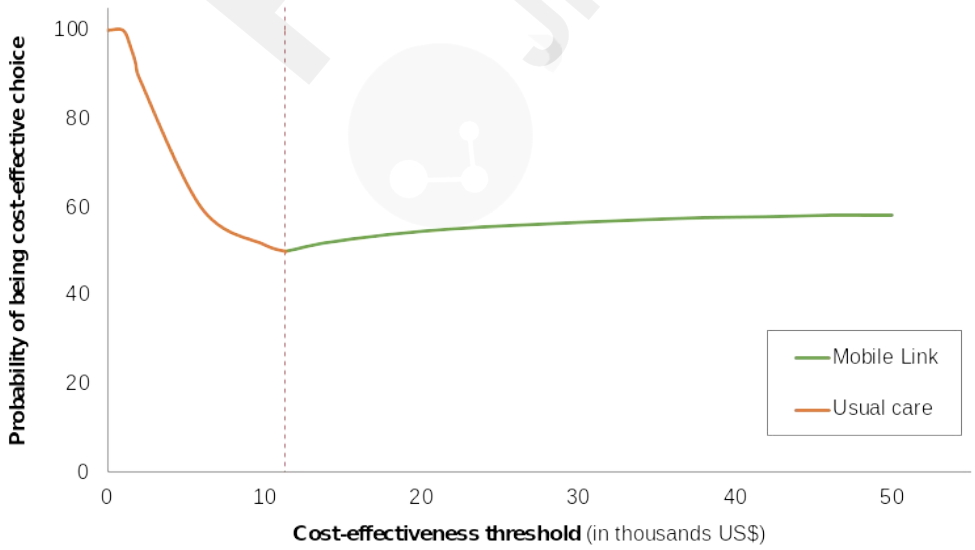
Using the per-person incremental costs ($199; Multimedia Appendix 7) and the base-case DALYs averted (0.018; Table 4), the ICER of Mobile Link was $10,955 per DALY averted from a payer perspective and $10,755 per DALY averted from a payer and patient perspective. These ICERs are more than 600% of the per-capita GDP of Cambodia in 2019.

The model estimated that the incremental cost of Mobile Link would have to be reduced by 85% (from $199 to $30 per person) for the ICER of Mobile Link to meet the $1,671 per DALY averted cost-effectiveness threshold without any corresponding changes in its effectiveness. Alternatively, the DALYs averted of Mobile Link would have to be 5.56 times higher (from 0.018 to 0.119) for Mobile Link to meet the same cost-effectiveness threshold without changes in its cost.

The results of the sensitivity analysis are shown in Figure 2. At a threshold of $1,671 per DALY averted, the model found that usual care has a 100% probability of being the cost-effective option. Assuming normal and beta distributions for risks, the probability that Mobile Link was the cost-effective intervention (vs. usual care) increased as the threshold increased. However, assuming a uniform distribution for risks, usual care was most likely to be the cost-effective intervention event at higher threshold values (i.e., ≤$50,000 per QALY gained).

Figure 2. Cost-effectiveness acceptability frontiers

A. Normal distribution[a]



B. Beta distribution

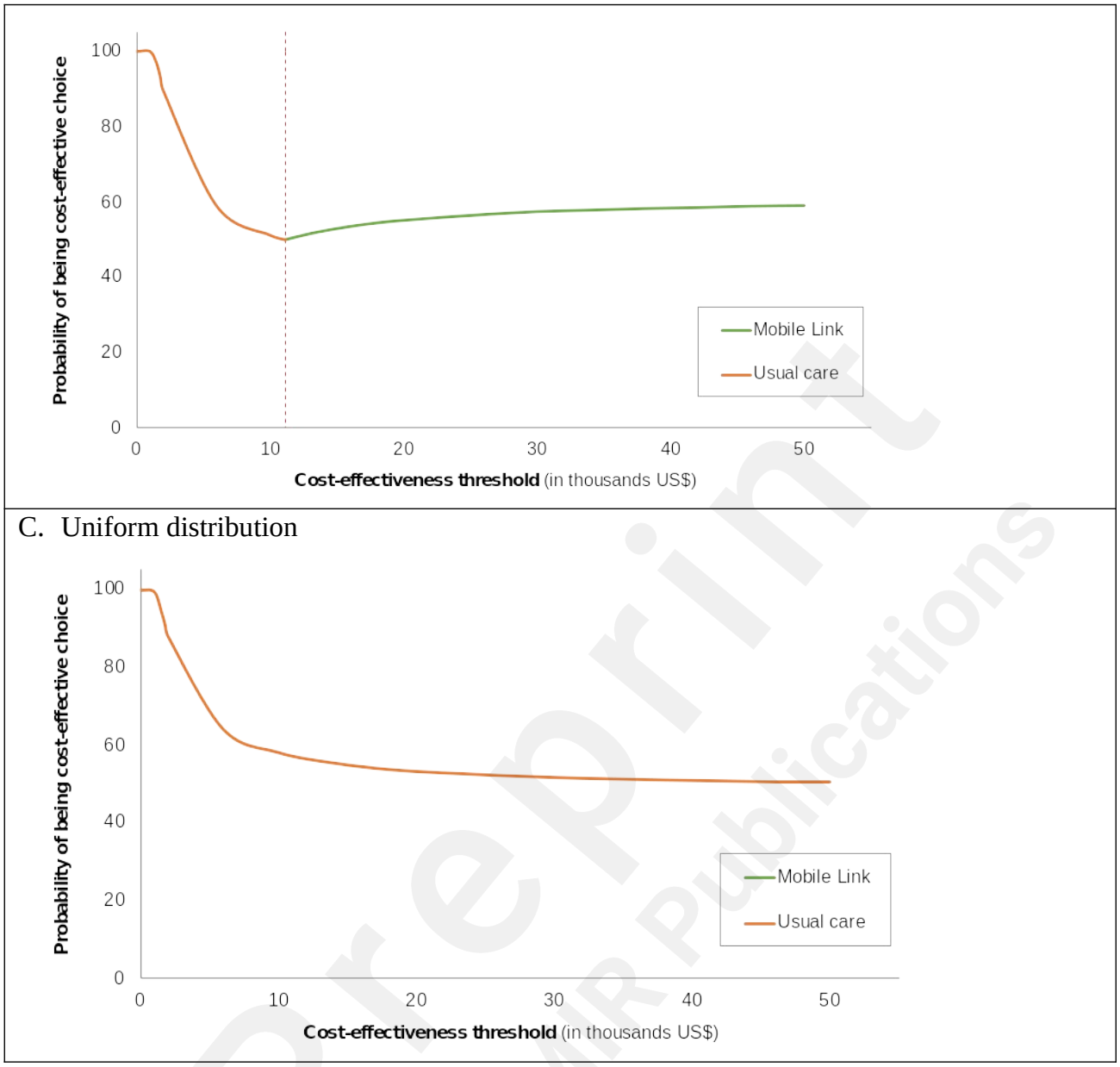


Figure 2 caption: A cost-effectiveness acceptability frontier shows the uncertainty around the optimal intervention across a range of cost-effectiveness thresholds. Frontiers were generated for each assumed distribution of endline risks (normal, beta, and uniform). The red dashed line denotes the cost-effectiveness threshold where the optimal strategy changes.
[a]Base-case assumption

Budget Impact Analysis

The results of the budget impact analysis are shown in Figure 3. The five-year budget impact of scaling up Mobile Link to 70% of FEWs (34,790 FEWs) was about $1.59 million. 62% of the total costs were associated with increasing the number of outreach workers, and 17% were from the messaging service. The average annual cost was approximately $318,000 or $46 per person.

Figure 3. Five-year budget impact of scaling up Mobile Link in Cambodia

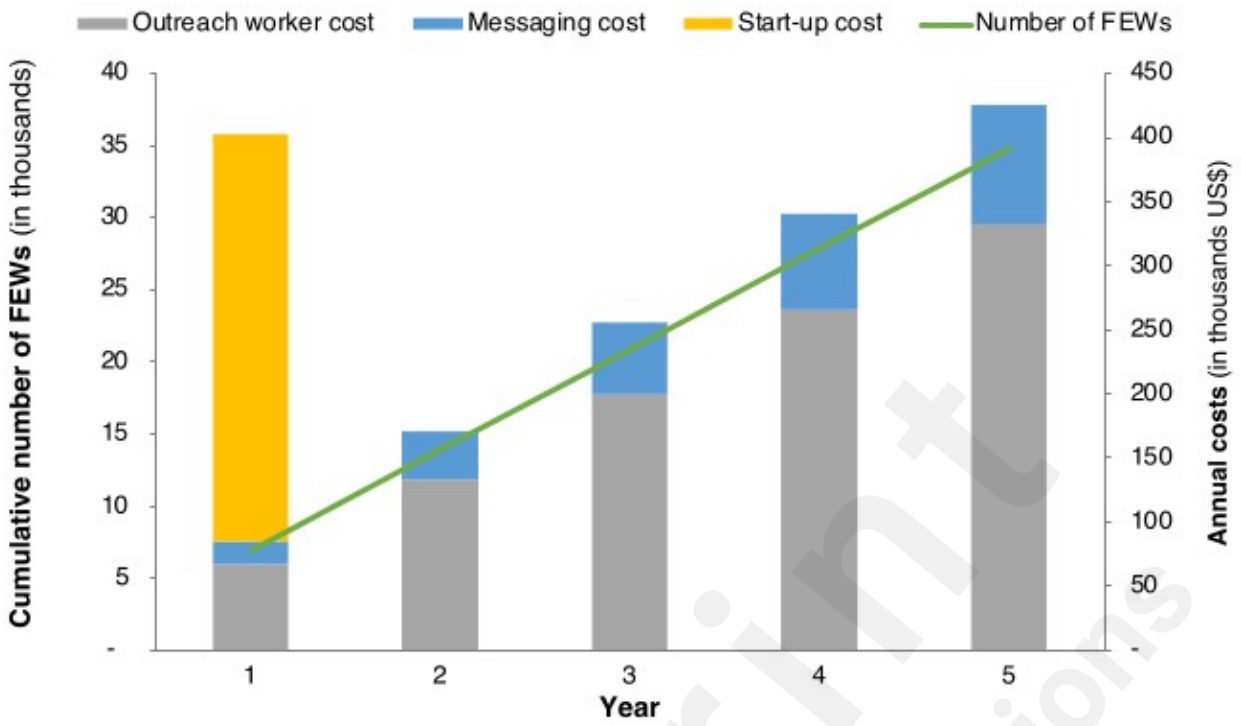


Figure 3 caption: This graph has two axes; the left axis shows the cumulative number of FEWs receiving the Mobile Link intervention. The right axis plots the total annual cost (in US$) of the scale-up disaggregated by the type of cost (start-up, messaging, and outreach workers).
FEW, female entertainment worker.

DISCUSSION

Principal Results

This economic evaluation estimated the costs, cost-effectiveness, and budget impact of Mobile Link, an mHealth intervention designed to increase access to healthcare services among FEWs in Cambodia. We translated five trial outcomes to DALYs averted and found that Mobile Link is likely to avert more DALYs than usual care in our probabilistic model. However, we also found that Mobile Link has a low probability of being a cost-effective intervention in Cambodia.

Using cost data from the trial, we found that the ICER of Mobile Link—from both payer and combined patient and payer perspectives—was higher than the commonly used cost-effectiveness thresholds in Cambodia. Our model suggests that Mobile Link's costs would need to decrease, or its effectiveness would need to increase, for the intervention to be considered cost-effective. With sufficient economies of scale, Mobile Link may reach the cost thresholds needed to lower its ICER. For example, our budget impact analysis suggests that the financial cost of scaling up Mobile Link is $46 per FEW, only 23% of the trial-based cost estimate. This figure is likely overestimated because we did not account for possible cost savings to the healthcare system. A microcosting study that identifies the essential inputs in scaling up Mobile Link can be conducted to determine the total financial costs outside of a trial setting.

Limitations

Several limitations in this study must be noted to guide the interpretation of the results. First, our cost analysis and CEA used a one-year time horizon, and many of Mobile Link's longer-term benefits

may have been underestimated or excluded. For example, STI testing leads to higher rates of treatment, which may reduce STI rates among FEWs and their clients. A follow-up study among the trial participants can evaluate whether Mobile Link has lasting benefits beyond one year that should be valued and included in an economic evaluation. Second, the use of trial costs may bias our estimates. Protocol-driven costs often overestimate the actual costs of intervention because significant resources are allocated to ensure adherence to trial design, such as blinding, conducting multiple follow-ups, and sampling procedures [22,24]. In practice, economies of scale may reduce the cost of scaling up Mobile Link to larger numbers of FEWs, and we partially addressed this issue by using the expected marginal cost of Mobile Link in the budget impact analysis. Third, many of the trial's outcomes were intermediate measures of health (e.g., STI testing, contact with an outreach worker), which we translated into DALYs averted using commonly used methods. As a result, we may have underestimated the total health effects of Mobile Link, which future studies should explore. Fourth, the trial experienced a high dropout rate from participants, which is often expected when working with stigmatized populations such as FEWs [16]; however, this may have affected the ability of the study to identify statistically significant differences between the control and intervention groups. We addressed this limitation in our CEA by conducting a probabilistic analysis that accounted for the uncertainty in trial outcomes. Additional research efforts that use effective retention strategies can re-evaluate the effect of Mobile Link and other mHealth interventions on care-seeking among FEWs. Finally, we used a limited perspective in our economic evaluations, which may have undervalued the non-health benefits of Mobile Link. Future studies may include other healthcare sectors and societal costs [10].

Comparison with Prior Work

Prior economic evaluations have shown that mHealth interventions can be cost-effective in various low-resource settings [38,39]. For example, a CEA of an mHealth intervention designed to increase postabortion family planning in Cambodia found that it had a high probability of being cost-effective when the highest thresholds were used [40]. A recent systematic review also found that mHealth interventions for pregnant women are low-cost or cost-effective [41]. In India, a few mHealth interventions for maternal, child, and infant health have been shown to provide high value [42–44].

The high ICERs reported in this study may reflect several factors, including our use of trial costs and the difficulties associated with reaching and serving a highly stigmatized population such as FEWs in Cambodia. The criminalization of sex work has driven FEWs into riskier environments and arrangements, and the informal nature of their work prevents them from organizing and demanding better work conditions [1,8,45]. Without changes to the structural barriers to care, interventions targeted to FEWs may continue to be costlier and less effective than interventions for less stigmatized populations.

Finally, Mobile Link may still offer good value if it achieves other healthcare goals, such as equal access to services and equity [46]. Previous qualitative research on Mobile Link has demonstrated that FEWs appreciate the convenience, benefits, and resources offered by the intervention [47]. These aspects are difficult to include in an economic evaluation but should be included in deliberative decision-making.

Conclusions

This economic evaluation provided estimates of the cost, cost-effectiveness, and budget impact of Mobile Link, an mHealth intervention that engages and connects FEWs in Cambodia to essential healthcare services. Using cost and outcomes data from the Mobile Link trial and other sources, this

study found that Mobile Link may improve the health and healthcare access of FEWs in Cambodia, but it is unlikely to offer sufficient economic value. Given the importance of linking FEWs to essential services, future research should focus on enhancing the effectiveness of Mobile Link or developing new mHealth interventions for this population.

Acknowledgements

Author contributions

ALVA conceived and planned the study, wrote the first draft of manuscript, built and collected data for the model, performed the simulations, and is the guarantor of the study. PK, ST, and SY collected and analyzed data for the model, contributed to the writing of the manuscript, secured funding for the study. CB conceived, planned, supervised, and secured funding for the study and contributed to the writing of the manuscript. All authors contributed to the interpretation of the results of the analysis, provided comments on the manuscript, and approved the final version. The guarantor attests that all listed authors meet authorship criteria and that no other meeting the criteria have been omitted.

Funding

The authors received support from the 5% Initiative and Expertise France (URL: https://www.expertisefrance.fr/; Grant No. 16SANIN210) to conduct this study. The funders had no role in the design, analysis, or write-up of this study.

Ethics statement

This study used secondary data and did not involve human subjects; therefore, it is exempt from ethical review. The Mobile Link trial was approved by the National Ethics Committee for Health Research (NECHR, No. 142NECHR) of Ministry of Health in Cambodia and Touro College Institutional Review Board (No. PH-0117).

Conflicts of INTERESTS

None.

Abbreviations

ARD: absolute risk difference
CEA: cost-effectiveness analysis
DALY: disability-adjusted life year
FEW: female entertainment worker
GBD: Global Burden of Diseases
GBV: gender-based violence
Global Fund: The Global Fund to Fight AIDS, TB, and Malaria
HIV: human immunodeficiency virus
ICER: incremental cost-effectiveness ratio
mHealth: mobile health
RCT: randomized controlled trial
SMS: short message service
STI: sexually transmitted infection
VM: voice message
YLD: year of life with disability
YLL: year of life lost

Multimedia Appendix 1

Impact Inventory.

Multimedia Appendix 2
Baseline characteristics of final analytical sample (n=388) in the Mobile Link trial.
Multimedia Appendix 3
Primary outcomes among analytic sample from Mobile Link randomized controlled trial.
Multimedia Appendix 4
Secondary outcomes among analytic sample from Mobile Link randomized controlled trial.

Multimedia Appendix 5

Disability weights from the Global Burden of Diseases study used in the cost-effectiveness analysis.

Multimedia Appendix 6

Calculating disability weights for each Mobile Link trial outcome.

Multimedia Appendix 7

Total cost of Mobile Link and average cost per participant from payer and combined payer and patient perspectives.

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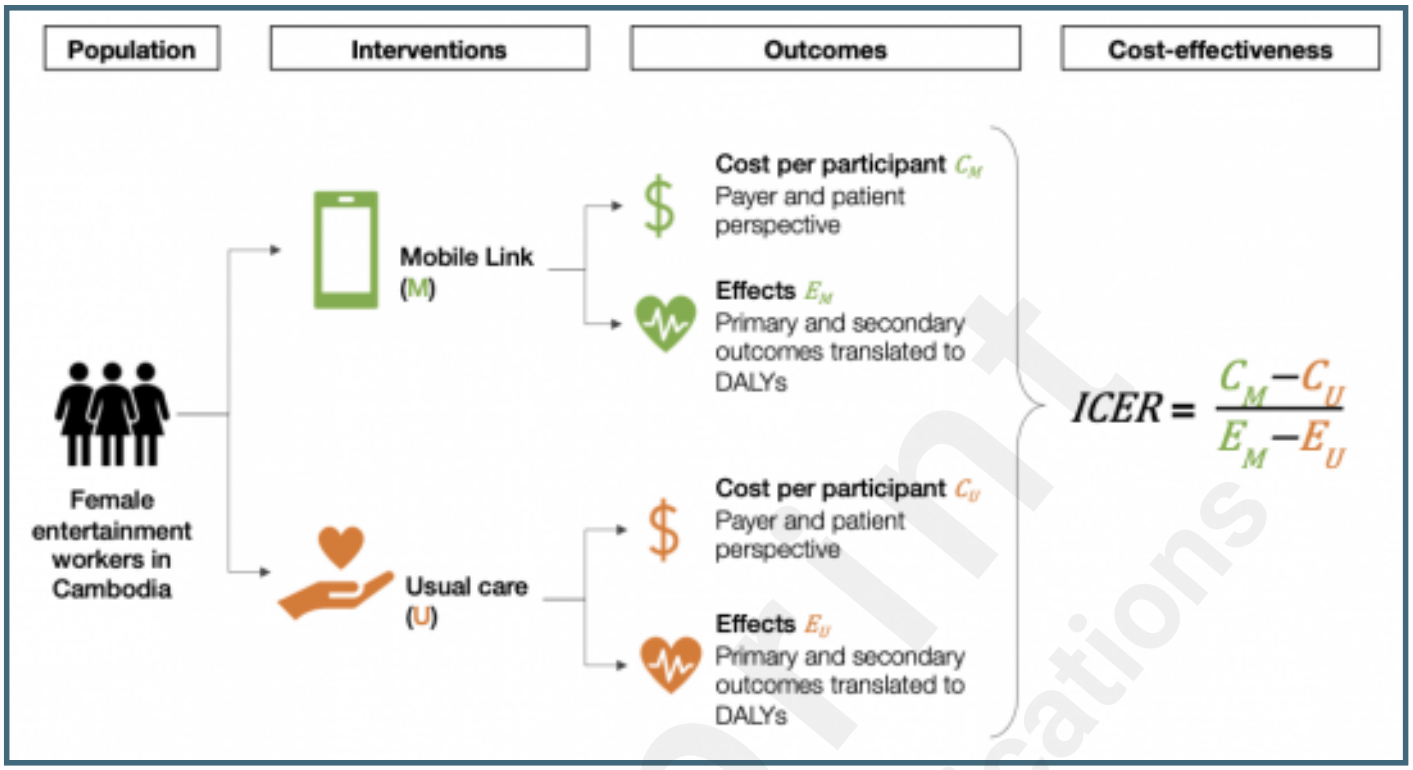
PMID:33209915

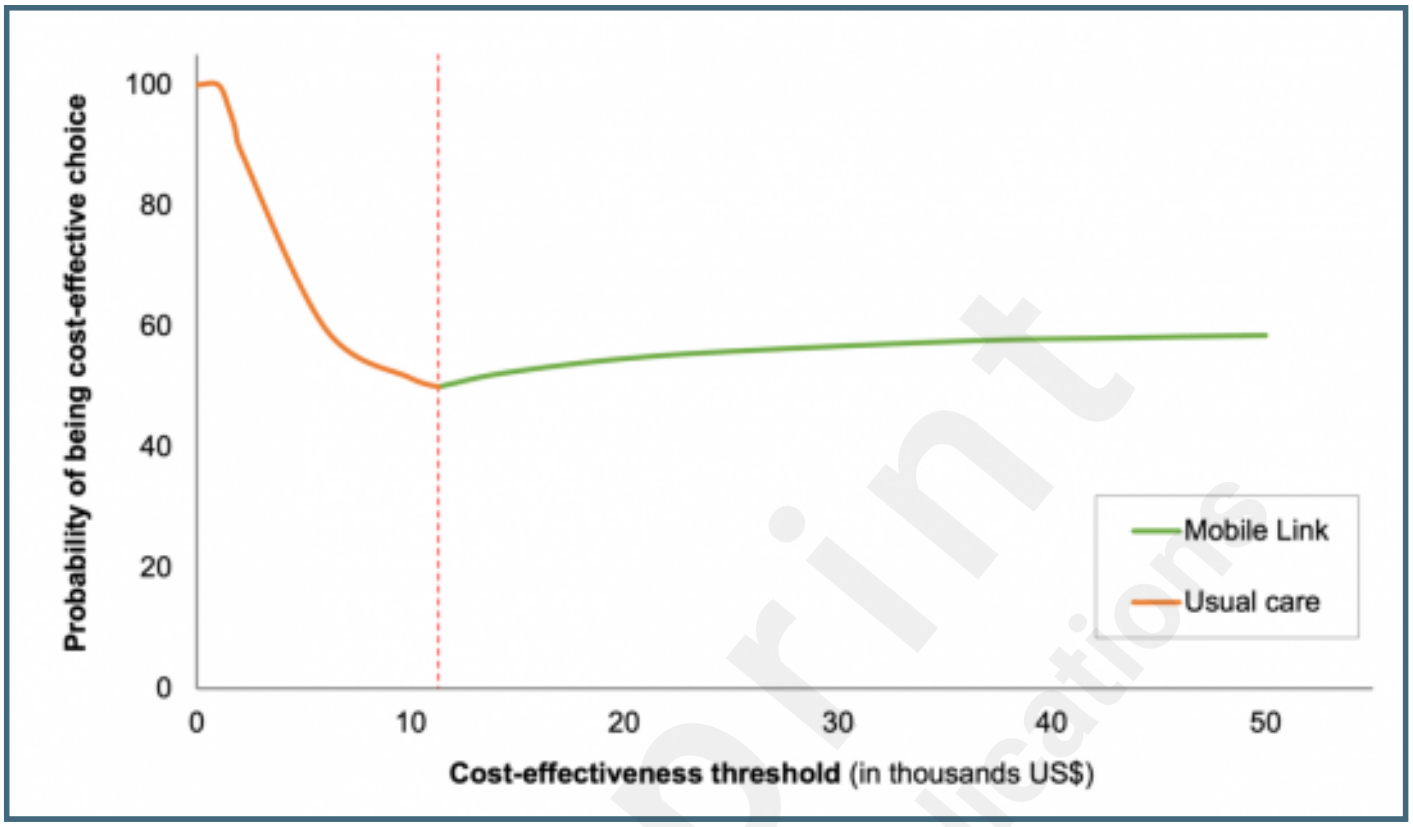
Supplementary Files

Figures

Cost-effectiveness analysis overview.



Cost-effectiveness acceptability frontiers.



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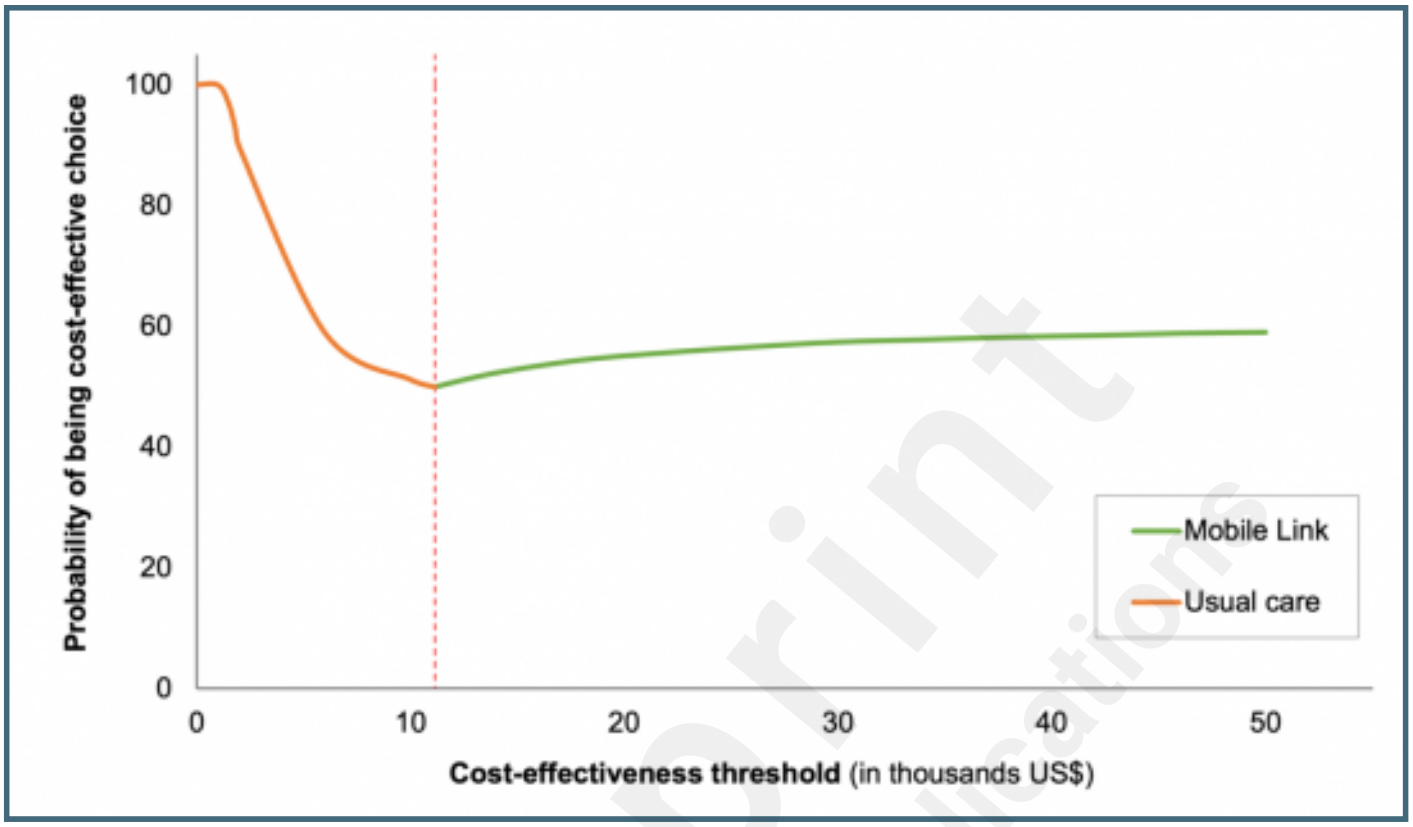

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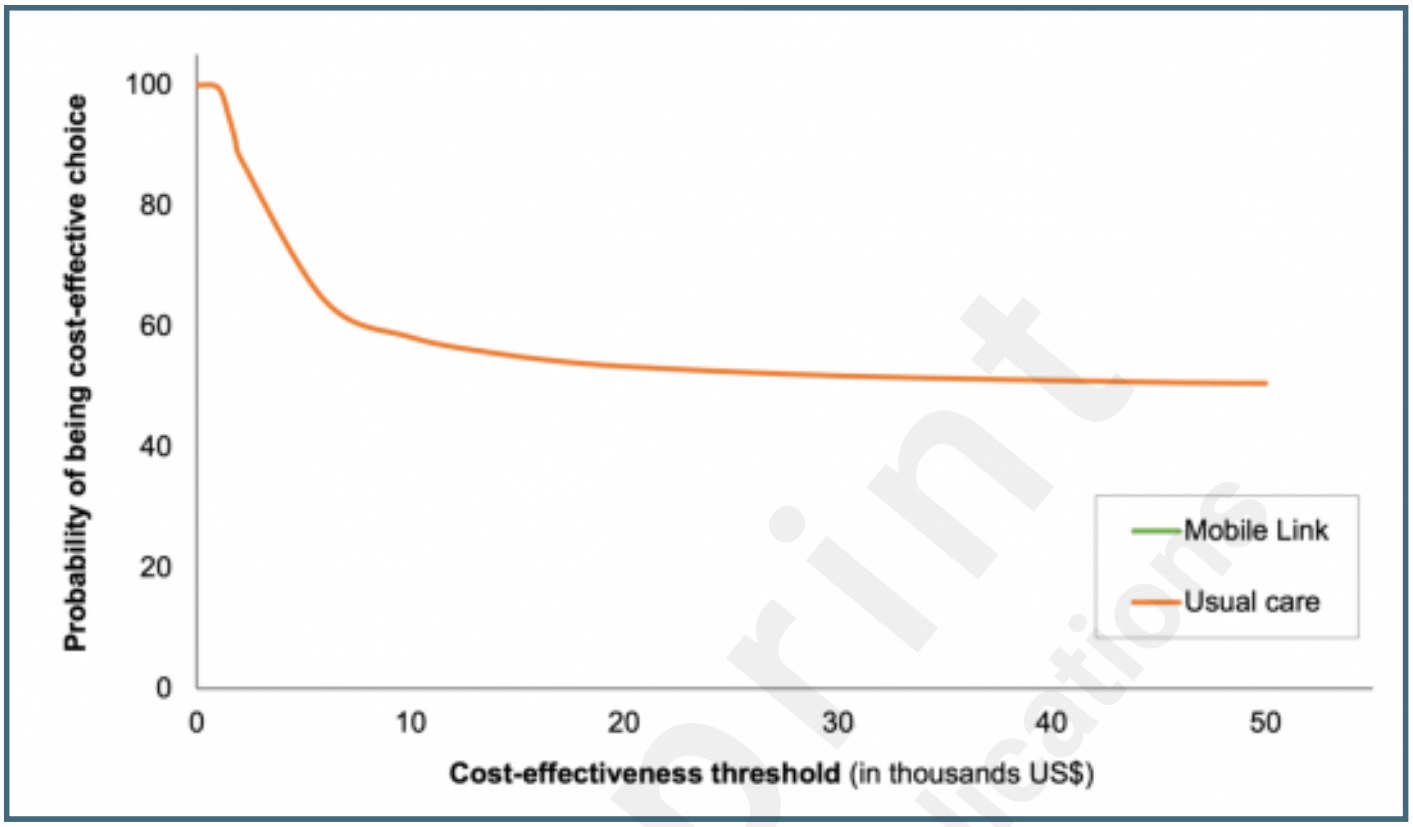

Multimedia Appendixes

Impact Inventory.
URL: http://asset.jmir.pub/assets/398888e78a993e4aaccec50236ddcc8c.docx

Baseline characteristics of final analytical sample (n=388) in the Mobile Link trial.
URL: http://asset.jmir.pub/assets/d8e1f0c97d2f2fc1dfbe431e1fb158b8.docx

Primary outcomes among analytic sample from Mobile Link randomized controlled trial.
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Secondary outcomes among analytic sample from Mobile Link randomized controlled trial.
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Disability weights from the Global Burden of Diseases study used in the cost-effectiveness analysis.
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Calculating disability weights for each Mobile Link trial outcome.
URL: http://asset.jmir.pub/assets/243e26f2c2df2a6a6f019917d73cd324.docx

Total cost of Mobile Link and average cost per participant from payer and combined payer and patient perspectives.
URL: http://asset.jmir.pub/assets/1fca1cc5ed3ff054a89e1b41d8b770e3.docx