Cost analysis of implementing m-health intervention for maternal, newborn & child health care through community health workers: Assessment of ReMiND Program in Uttar Pradesh, India.

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Abstract

Background: The main intervention under ReMiND program consisted of a mobile health application which was used by community health volunteers, called ASHAs, for counselling pregnant women and nursing mothers. This program was implemented in two rural blocks in Uttar Pradesh state of India with an overall aim to increase quality of health care, thereby increasing utilization of maternal & child health services. The aim of the study was to assess annual & unit cost of ReMiND program and its scale up in UP state.

Method and Materials: Economic costing was done from the health system and societal perspectives. All resources used during designing & planning phase i.e., development of application; and implementation of the intervention, were quantified and valued. Capital costs were annualised, after assessing their average number of years for which a product could be used and accounting for its depreciation. Shared or joint costs were apportioned for the time value a resource was utilized under intervention. Annual cost of implementing ReMiND in two blocks of UP along and unit cost per pregnant woman were estimated. Scale-up cost for implementing the intervention in entire state was calculated under two scenarios – first, if no extra human resource were employed; and second, if the state government adopted the same pattern of human resource as employed under this program.

Results: The annual cost for rolling out ReMiND in two blocks of district Kaushambi was INR 12.1 million (US $ 191,894). The annualised start up cost constituted 9% of overall cost while rest of cost was attributed to implementation of the intervention. The health system program costs in ReMiND were estimated to be INR 31.4 (US $ 0.49) per capita per year and INR 1294 (US $ 20.5) per registered women. From societal perspective, costs were INR 76.5 ($ 1.21) per capita per year and INR 2382.3 ($ 37.6) per pregnant woman. The per capita incremental cost of scale up of intervention in UP state was estimated to be INR 4.39 (US $ 0.07) when no additional supervisory staffs were added.

Conclusion: The cost of scale up of ReMiND in Uttar Pradesh is 6% of annual budget for 'reproductive and child health' line item under state budget, and hence appears to be financially sustainable. Cost effectiveness of this m-health intervention should be undertaken to assess the value for money.

Background

Despite the rapid improvement in maternal, newborn and child health (MNCH) indicators in India, many districts in the country still face high maternal and infant mortalities (1). On the basis of a composite health index indicator, Government of India (GOI) selected 184 high priority districts across 29 states for focused integrated planning and monitoring of RMNCH+A interventions (2). District Kaushambi in Uttar Pradesh (UP) state is one high priority district with high maternal mortality ratio (MMR) of 283 per 100,000 live births and infant mortality rate (IMR) of 82 per 1000 live births (3) which are way above the national and state averages of 178 & 258 MMR and 40 & 68 IMR respectively (3). Most of these maternal and newborn deaths are preventable if a continuum of care is followed right from pregnancy to newborn care. This includes whole spectrum of services including utilization of antenatal care, institutional delivery, early initiation of breastfeeding, essential newborn care, early recognition and referral for pregnancy and newborn related complications with timely access to quality healthcare (4). In order to strengthen the service provision, National Rural Health Mission (NRHM) was introduced in 2005 to augment primary health care and build capacity of community health workers (CHW) in remote areas to deliver affordable, equitable and accessible care (5). With this aim, concept of Accredited Social Health Activist (ASHA) was envisaged. These are local women who serve as first contact between public health system and communities. They help in addressing community health needs and generating demand for health service utilisation. This huge human resource of 890,000 ASHAs in the country holds immense potential and perform range of services such as mobilizing community for antenatal services during pregnancy, institutional delivery, identification and timely referral for complications related to pregnancy and newborn, home-based postnatal care, universal immunization, prevention of water-borne & other communicable diseases, and nutrition & sanitation (6). With a minimal educational qualification of high school, she is provided

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on job training in various modules as specified by GOI (7, 8). Gradually, Ministry of Health and Family Welfare (MoHFW) realized the need for bolstering their skills (9). It was also realised during the same time that mobile technology based health solutions were increasingly being utilized in health sector in low and middle income countries to strengthen skills of CHWs. Mobile Health (m-Health) as defined by World Health Organization (WHO) is an area of electronic health that provides health services and information via mobile technologies such as mobile phones and personal digital assistants (10). For instance, in Ethiopia, m-health application have been used for improving maternal and child health indicators (11), as web based mobile applicable modules for treatment and follow up of malaria cases along Thai-Myanmar border and for community case management of malaria in Saraya, Senegal (12, 13), as diagnostic and management tool in diabetes (14) and as a cardiovascular risk assessment tool in Nyanga district of Cape town (15). Similarly, a mobile based application was implemented as ReMiND (Reducing Maternal and Newborn Deaths) program in routine health care service delivery through ASHA workers in district Kaushambi of UP state. The overall aim of this intervention was to increase the quality of counselling provided by ASHA by using mobile application as an audio visual aid, thereby increasing utilization of MCH services.

However, a global survey done by WHO highlighted the lack of cost effectiveness data as one of major barrier in justifying implementation of m-health services. It reported that only 13 out of the 112 countries have ever evaluated cost effectiveness of their m-health programs (16). Also, a recent systematic review from India highlighted the lack of sufficient evidence on cost effectiveness of m-health interventions (17). One of the reasons for this paucity of data on efficiency is the dearth of evidence on cost of implementing m-health services (17). In order to fill this gap in evidence base, we undertook a study to evaluate the impact of ReMiND program on utilization of MNCH services & its cost effectiveness. In this paper, we specifically report the cost of ReMiND program in district

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Kaushambi. Secondly, we estimated the scale up cost of this program in Uttar Pradesh state which is relevant from the fiscal planning point of view.

Methods

Study Setting & Background

The ReMiND program was undertaken in district Kaushambi which is one of the high priority districts of Uttar Pradesh. It has a population of 1.6 million with 92% people residing in rural areas (18) . The female literacy rate of district is 52.7% in contrast to state average of 63.9% (3). The district MMR of 283 deaths per 100000 live births, was 25 and 105 points higher than the state and national averages respectively (3). The coverage of full antenatal care checkups; haemoglobin and ultrasound test during routine ANC of pregnant women were 5%, 11.3% & 10.7% respectively (3). Nearly 60% women in the district delivered in health facilities, while 46.9% children had full course of primary immunization during infancy (3).

To improve these maternal and child health indicators, an m-health program named ReMiND was introduced in the two community development blocks namely, Manjhanpur and Mooratganj, of district Kaushambi in 2012. It resulted from collaborative work of two Non- Government Organizations (NGOs) i.e. Catholic Relief Services (CRS) & Vatsalya; and a social technology innovator, Dimagi. The main focus of the program was to improve the counselling skills of ASHA workers with the help of m-health application. The detailed description of m-health application under ReMiND program, its study setting, objectives and methodology are available as a published literature (19).

The preplanning phase of the program started with ten ASHA workers who were trained for piloting an early pregnancy checklist in March 2011. Subsequently, 111 ASHAs from Manjhanpur block were trained in August 2012 followed by training of 148 ASHAs of Mooratganj block in March 2013. These 259 ASHAs were provided Java based phones and trained on use of mobile application to

register and counsel women for various MNCH services. The application had a built-in algorithm in the form of five modules which were used to advice and counsel registered women on the complete continuum of care; right from registration, antenatal care, postnatal &newborn care, identification and referral for pregnancy related complication and newborn sickness as per individualized needs and requirements (20). The data entered by ASHAs were received at Dimagi's online cloud server. All the data collected about pregnant women and other program beneficiaries were de-identified for analysis. No reports generated by Dimagi using commcare include information about individual pregnant women. Data about pregnant women were restricted and were only accessible to a few authenticated users from the program with valid username and password. The ASHA supervisors, also called Sector facilitators, used this data to monitor the timeliness and frequency of antenatal and postnatal care visits by ASHAs to discuss their performance in monthly meetings at block level (20).

Data collection

Economic costing was done from the health system and societal perspectives to estimate the annual and per-capita cost of implementing the program. The resources spent under three time heads were obtained – preplanning phase extending from October 2010 to March 2012, start up phase from April 2012 to July 2012, and implementation phase from August 2012 to August 2015.

We collected data on cost from all the agencies involved in the program namely, i.e. CRS, Vatsalya, Dimagi and health department of district Kaushambi from May to October, 2015. Since CRS was funding Vatsalya for implementation of ReMiND program, the records for expenses made by Vatsalya were also collected from CRS. Cost data was collected from different sources such as financial records, program budget, audit reports, agreements, etc. Data was also collected from country office of Dimagi & CRS in New Delhi, state office of CRS in Lucknow and health department in district

Kaushambi for health systems costs. The details about the amount spent on development and maintenance of the software were obtained from Dimagi. Maintenance cost of application included any technical assistance from the designers of the application including assistance on bug fixing and update. Along with this, costs on housing, serving, and maintaining files on the cloud, also called hosting service charge, were also obtained from Dimagi. All the cost data were obtained in US dollars, which were converted to Indian Rupees using exchange rates for the respective years. Research costs for two evaluations done during the program namely; baseline study in 2012-13 and mid-term evaluations in 2014 were excluded from the analysis.

Intervention costing methodology

Start-up cost

We included two cost heads i.e. start up cost and implementation cost. Start up costs included all the capital costs incurred during the initial preplanning phase and start up phase. Technically, any cost whose inputs may last for more than one year was considered as capital cost (21). This was categorised as costs levied on modules' development and piloting, development and maintenance of software, equipment cost, mobile phones and overhead costs. Apart from these costs; pre-planning meetings, trainings of ASHAs & their supervisors and translation of modules into local dialect were also taken as capital costs because the effect of these inputs were likely to last for the life of the program.

All the capital costs were apportioned in terms of their time value devoted in ReMiND program out of all the programs running simultaneously by the implementing agencies. The program was piloted in two blocks but it was designed such that it could be launched in 821 blocks of Uttar Pradesh. Accordingly, we apportioned the entire start up expenditure for the two blocks of district Kaushambi

where intervention was actually piloted. After obtaining the apportioned value, costs in dollars were converted to Indian National Rupee (INR) by applying the dollar conversion rates given by the US Internal Revenue Service for a particular year of purchase of equipment (22).The converted rates were then inflated from the year of purchase to the current value of product in 2015 by applying Consumer Price Index in India (23). These inflated values of capital were then annualized as per the average life of utilization of the product at a discount rate of 3% (24). The annual maintenance rates for capital items as given by the implementing agency were used in calculations.

The average life of software was assumed to be 12 years as the cost incurred on software may last either till strategies of the program remained the same; or if there was a change in technology itself. We chose former based on expert consultation as it is unlikely that any drastic paradigm change may happen in the content of the programme for another 12 years. Further, any change in technology would have had only marginal effect on costs if it requires any revision. The hosting charges were annualized for life of the program i.e. 3 years, as these charges would be revised and added again like recurrent cost if the program extends beyond three years. For mobile phones, laptops, furniture and vehicle, the average life were taken as 3.5 years, 5 years, 6 and 10 years respectively as per the policy of the implementing agencies.

Implementation Cost

The implementation costs included recurrent costs which were required to sustain the intervention. All the recurrent costs were categorized as cost on human resource, travel, ASHA data/internet usage charges for mobile application, utilities like office rent, electricity, telephone bills & internet bills and stationary & printing. Other program support expenses at state and national office like the office rent

and salaries, as per time allotted by officials at state and national level to this specific program, were also accounted.

For the recurrent costs, we converted the expenses levied by the partner agencies over 37 month i.e. from Aug 2012 to August 2015, into average annual expense. For converting US dollars into Indian rupees, the average dollar rate for these three years was taken as 1 US $= INR 58.84.

Health System Program cost

Apart from costs spent by implementing agencies, additional costs incurred by district health system were also estimated. It included three components – first, health system cost on routine program implementation; second, incremental cost of service delivery due to increased utilization of MNCH services as the result of intervention and third, incremental effect of intervention on ASHAs payment in terms of incentives.

For program implementation, the extra cost of monthly meetings at the block levels, quarterly meetings at district level and bi-annual meetings at the state level were calculated by apportioning the time devoted by government officials in meetings for review of ASHAs' performance under the program.

The effect of ReMiND program on overall utilization of MNCH services was evaluated using a quasi experimental design with a Difference in Difference analysis (10). The unit costs for these services were obtained from economic evidence available in the Indian context (25-27).

Economic implications of changes in service utilization in the intervention and control blocks in terms of the performance based incentives for ASHA workers were evaluated using data from Health

Management Information System (HMIS) and financial records as obtained from the office of Chief Medical Officer for 2014-15 (19).

Unit costs

For calculation of unit costs, the population under the intervention area was used as denominator for per capita calculation. For cost per pregnant woman, the number of women registered under m-health was used as denominator. A total of 28,169 women have been registered under ReMiND program since its inception (over three years) as per data provided by Management Information System of the implementing agencies, so the annual number of beneficiaries was taken as 9390.

Scale up costs of ReMiND program for Uttar Pradesh State

The intervention was implemented on pilot basis in two blocks of Uttar Pradesh state. Subsequently the estimates on the cost of implementation of ReMiND program in two blocks were used to estimate the scale up cost of this program, if the government of Uttar Pradesh decided to roll out implementation in the entire 821 blocks in the state. The scale up costs of m-health intervention in entire state included costs on purchase of added mobile phones, internet usage, trainings of ASHAs & their supervisors for use of application and health system costs on review meetings in the entire state. For scale up, two case scenarios were assumed. First, it was assumed that the current available human resource in the health system could be utilised for monitoring and supervision of this intervention. In UP, Block Community Managers and Health Education Officers are employed at block and district levels respectively to coordinate and supervise ASHAs' performance. These are regular salaried staff unlike ASHAs whose remunerations were incentive based. In second scenario, a separate supervisory cadre like sector facilitators in ReMiND program were assumed at block level.

At sub-block level also, one ASHA facilitator was employed for monitoring and supervision of 20 ASHAs as guided by the National Health Mission (28), and the same pattern was followed by the implementing agencies. These were promoted ASHAs and did not receive any extra incentives for holding the position. Supervisory training costs of these ASHA facilitators were also included in the scale up cost.

As there was lack of data on time value spent by different supervisors on various activities in our study and Indian literature (9), we assumed the time apportioned on supervisory and monitoring activities as 13% of total activity time based on findings from a similar study (29). Though as per directions given by MoHFW, a block ASHA facilitator shall spend 20 days in field in a month (30).

From the perspective of UP state, there would be no requirement to change the content of the software or the built in audio-visual support as the same dialect could be understood in the entire state. Therefore, the start up capital costs which included the costs on development of software, preplanning meetings, initial translation of modules were not included in scale up cost. The hosting charges which depends on the number of registered beneficiaries, were taken at the current rate of approximately 1$/ beneficiary/ year over initial 50 beneficiaries who were provided service free of cost. Table 1 describes the different types of costs calculated in the study.

Sensitivity Analysis

An extensive univariate sensitivity analysis was undertaken to analyse the effect of uncertainty in base prices, discount rates, values and resources consumed & the extent of coverage of ReMiND program on overall annual and unit costs. Various input indicators were varied to see the overall effect on the scale up cost. The costs were estimated assuming different case scenarios. First, if the intervention was developed only for the two community development blocks of district Kaushambi and hence capital

costs are not apportioned as per 821 blocks in UP state. Second, if the discount rates on capital were 5% & 8% and life of program was varied to 5 & 15 years. . It was assumed that the mobile data charges may fluctuate to 20%. Similarly there could be a reduction in mobile phones prices by 20%, training cost of ASHAs to 10% fluctuation, training cost of supervisors could go down by 20% as many of the meetings were done in private costlier locations, while a reduction in cost can be achieved if the same were done in Government set-up, the hosting charges could be reduced by a quarter and the apportioned time of supervisors for monitoring activity was increased to 50%. Sensit 1.51 software was used for the analysis.

Societal Perspective

A societal perspective is important to consider in costing studies as it includes all costs and all benefits and thus helps detecting shift in the costs between the sectors which are not captured under health system costs. Aiming societal perspective helps in adopting policies that intend to maximize the mass gains and minimize the losses. The findings of the impact evaluation suggested an increase in IFA intake (12.7%), increases identification of danger signs during pregnancy (13.20%) and after delivery (19.5%) attributable to ReMiND program. In order to estimate the societal costs of this increased service coverage, we used the cost incurred by the health sytem and out of pocket (OOP) payments borne by households to meet this increase in demand for services (10). The data on mean OOP for utilization of specific MNCH services was obtained from a household survey undertaken to evaluate the impact of ReMiND and its cost effectiveness (10). The detailed information about the household survey and its methodology are described in details in our protocol paper and impact assessment paper (10, 19). The household questionnaire included questions to assess any cost borne by patients and their families for treatment, consultation from doctors, purchase of drugs and consumables, travel, lodging

& boarding, indirect loss in the form of loss of wages or any money spent elsewhere during were

collected. 'Figure 1 illustrates the conceptual framework of costing process of ReMiND program

explaining both health system perspective and societal perspective.

Results

Total annual cost and unit cost for ReMiND program .

The annual cost for rolling out ReMiND in two blocks of district Kaushambi was INR 12.1 million (US $191,894). Out of this, start up cost and implementation cost contributed 9% and 91% of the total annual cost respectively. Government health system contributed 4.8% of the total implementation cost. The unit costs of implementing ReMiND program were INR 31.4 (US $ 0.49) per capita and INR 1294 (US $ 20.5) per registered pregnant women. Figure 2 shows the proportional distribution of total expenditure on ReMiND program in district Kaushambi. 'An additional file provides detailed description of start up and implementation costs contributing to annual intervention cost for ReMiND [see Additional file 1]'.

Start-up Cost

The start-up cost for the ReMiND program was INR 1.1 million ($17,526). A major portion of this cost was for training of ASHAs and their supervisors (33%) followed by development of software & modules and its piloting (30.3%), mobile phones (29.2%), equipment (5.4%) and programmatic expenses (2.2%). Figure 3 shows the proportional distribution of start up costs of ReMiND program in district Kaushambi.

Implementation Cost

The annual implementation cost of m-health intervention in two blocks of Uttar Pradesh was INR 11 million (US $174,368). The costs were predominantly constituted by human resources (62.5%), followed by travel (15.4%), program support cost at national and state office of CRS (8.2%), utilities (5.2%), internet use (3.6%) and health system programme support cost (4.8%) (See Figure 4)

Health System Program Cost

The cost of monitoring the intervention from the government health system as during the review meetings was estimated to be INR 94,750 (US $ 1496.8), INR 3,133 (US $ 49.5) and INR 2,230 (US $ 35.2) per year at block, district and state levels respectively. The costs included apportioned time value of government officials for supervisory activities, with small contribution from travel and overheads.

 We estimated that health system in intervention area had to spend INR 4,30,582 ($6,802) in order to cater the increase coverage of MNCH services attributable to the intervention. The incremental cost borne by the health system during implementation of ReMiND program was INR 39.9 ($ 0.63) per pregnant woman. This cost included the additional cost borne by government on monitoring and supervision of the program; increased utilization of MNCH services by pregnant and lactating mothers and increased performance based incentives to ASHAs as a result of ReMiND program. However, there was no increase in ASHA payments, hence the incremental health system cost represent the former two, i.e., cost of monitoring & supervision and cost of increase in service utilization. The detailed description of the start-up and implementation costs is given in the Additional Information File 1.

Scale up costs

In first case scenario where intervention has to be scaled up from two blocks in Kaushambi to 821 blocks in state using the existing human resources for monitoring and supervision, we estimated a scale-up costs of INR 876 million (US$ 13.8 million). The unit cost of scale up in Uttar Pradesh state is INR 4.39 (US $0.07) per capita and INR 175.3 (US $2.77) per pregnant women.

In second case scenario, additional human resource was assumed to be recruited for monitoring of ASHAs in every block of state. In this case, government has to spend around INR 993 million (US $15.7 million) with INR 4.97 (US $ 0.08) and INR 198.8 (US $ 3.14) as per capita unit cost and unit cost per pregnant woman (Refer Table 2). 'An additional file describes the details of scale up costs [see Additional File 2]'.

Sensitivity Analysis

Sensitivity analysis was conducted to estimate costs in various alternate scenarios. Firstly, the total annual cost was estimated assuming that the development of software was done for two blocks of Kaushambi only. In this case, the start up cost was INR 4,644,121 (US $ 73,367) which is 30% of the total annual intervention cost of INR 15 million (US $247,734). The incremental costs of intervention were INR 1670 (US$ 26.4) per pregnant woman and INR 40.52 (US $ 0.64) per capita.

Secondly, the discount rates were varied to 5% and 8% instead of 3%, and the average life of program was taken as 5 and 15 years. On applying the discount rate of 5%, the incremental costs were estimated to be to INR 1302 ($ 20.6) per pregnant woman and INR 31.60 ($ 0.49) per capita. For 8% discount rate, the unit incremental cost was INR 1316 ($ 20.8) per pregnant woman and 31.93 ($0.50) per capita. On assuming the life of programs to be 5 and 15 years, the incremental costs per pregnant woman were changed to INR 1338 ($ 21.14) and 1287 ($ 20.34) respectively while per capita costs were 32.5 ($0.51) and 31.23 ($0.49) respectively.

Finally we undertook a univariate sensitivity analysis to assess the effect of variation in input costs on both the cost of implementation of current intervention, and scale up cost. Figure 5 showed that the total program cost varied significantly with various input costs. The annual program cost was most sensitive to the cost on human resources (90.7% swing) followed by travel cost (5.5% swing) while

start up costs like training of ASHAs (0.3% swing), purchase of equipments (0.3% swing) and development of the software (0.0%) had little influence.

Figure 6 showed the sensitivity analysis for the scale up cost of the ReMiND program in the state of Uttar Pradesh. Mobile data charges lead to maximum swing (40.5%) followed by hosting charges (39.5%) and purchase of mobile phones (10.3%).

Societal Cost

As discussed in methodology, to calculate cost of ReMiND program from societal perspective, the proportion of people bearing OOP expenditure for seeking various MNCH services and the mean OOP expenditure at various levels of health centres in both public and private sector were taken from the Impact Assessment study (10). It was estimated that the incremental out of pocket expenditure for seeking various health care services in the intervention block was INR 15 million (US $ 240,333). Thus, from a societal perspective, the overall cost of the ReMiND program was INR 2382.3 ($ 37.6) per pregnant woman and INR 76.5 ($ 1.21) per capita.

Discussion

Use of technology in health and other sectors has been promoted by GOI from the highest level (31). Several other policy discourses have encouraged the application of m-health. The High-Level Expert Group on Universal Health Coverage called for harnessing technology for promoting utilization of services (32). Small to medium scale pilot interventions have been initiated in a variety of geographic settings in India involving a diverse range of health services such as maternal and child health to non-communicable diseases (33, 34). Various studies from elsewhere have also shown that the application of m-health results in better delivery of health education, increased awareness & improved uptake of preventive as well as curative services (12, 35-37).

In Indian context, the introduction of ASHA under the National Health Mission holds strong potential for generating demand for health services (30). However, several evaluations have shown that the knowledge and skills of ASHA workers to counsel pregnant women for their health care needs during pregnancy and nursing babies requires strengthening (9). In light of this, use of mobile technology for improving the quality of her counselling can serve as a major strategy for improving knowledge and awareness among community which can directly augment demand for services. However, it is important to understand the feasibility of implementation of the intervention as part of routine care and its financial implication on the government. Hence our economic analysis holds a significant value for the policy makers in order to estimate the economic implications for implementing and scaling up of such m-health interventions. The researchers can also use costing studies for carrying out cost effectiveness analysis of such m-health interventions.

Our study showed that the introduction of m-health intervention costs INR 31.4 (US $ 0.49) per capita and INR 1294 (US $ 20.5) per pregnant woman registered. The unit costs for scale up within Uttar

Pradesh state were INR 4.39 ($0.07) per capita and 175.3($ 2.77) per pregnant women. The overall annual scale up cost for Uttar Pradesh to implement the same intervention in the entire state would be at least INR 876 million (US $ 13.8 million) if no additional human resource were employed for the program monitoring and support. As per our knowledge, this is the first cost outcome analysis targeting MNCH services in India (35).

Fiscal Sustainability

From the point of state budget, the total annual money allotted for Reproductive & Child health(RCH), Maternal health (MH) and ASHA incentives for year 2015-16 in Uttar Pradesh were INR 14.6 billion, 6.99 billion and 1.22 billion respectively (38). The introduction of m-health intervention and its scale up in the entire state of Uttar Pradesh will represent 6.0%, 12.5 % and 71.7 % share in the total budget for RCH, MH and ASHA incentive program respectively. It is important to note, this scale up amount does not include introduction of any new cadre of supervisors, and rather considers training the already available cadre for supervision. As per the guidelines of Financial Management Group of National Health Mission-India's flagship health program, it is recommended to increase the budget on each listed main item in program implementation plan by 10-15% every year. Moreover, this increase in budget allocation is recommended to be at least 30% for the high priority districts (39). Considering the cost for scale up of ReMiND intervention to be 6% of the total budget allotted to 'Maternal and child health' line item under the NRHM budget of UP state, the intervention appears financially sustainable.

The World Health Report 2005 published a working paper series on scaling up of maternal and newborn interventions to reach universal health coverage by 2015. It estimated that for delivering the whole package of MNCH care (with 95% coverage) for countries in Health System Constraint

Category 2 –where India fits – has an incremental cost of $ 1.53 per capita. On inflating this value to the current value of dollar by applying CPI rates in India, the current incremental cost would be $ 2.35 (INR 149.3). The WHO benefit package comprises of universal provision of comprehensive maternal, newborn and child health care services (40). Our study shows that scale-up of m-health in UP state will incur an incremental cost of INR 4.77 ($0.07) per capita, which is 3% of the total incremental value proposed by WHO for achieving universal coverage of MNCH services. This again shows that the scale-up of m-health is sustainable from fiscal viewpoint.

Policy Implications

The need to introduce a service or intervention in the benefit package of care is usually justified based on the burden of health problem which it addresses. However the amenable burden or the reduction in the health problem which the intervention can potentially bring about is usually not considered. In light of this it is also important to understand that such m-health application for RMNCH would thus be more useful in weaker states where the reasons for poor coverage are linked more with the demand for service. For example, the Coverage Evaluation Survey reported that poorer states such as Bihar and Uttar Pradesh have low rates of RMNCH service utilization, a large portion of which is explained by lack of awareness and knowledge about the importance of services (41). The findings from our impact assessment study suggested an increase in knowledge and thereby utilization of MNCH services after introduction of ReMiND program (10). Hence, such an intervention which aims at improving counselling of ASHAs, which translates into improved knowledge of community and its demand for health services, is likely to be more beneficial in these states.

Findings in context of existing evidence

Average cost of providing one antenatal visit to a pregnant woman, post natal care per mother and routine immunization per child, as reported in a study from North India, were INR 525, 767 and 97 respectively in 2012. These values when inflated to current year come out to be INR 677 (US $10.7), 989 (US $15.6) and 125 (US $ 1.9) respectively. Thus, the unit cost of INR 1294 (US $ 20.4) per pregnant woman for providing counselling through m-health is 32.1% of the cumulative cost of providing package of 3 ANC visits, primary immunization and postnatal care visits. Therefore, introduction of intervention needs to be evaluated from perspective of cost effectiveness (25).

Limitations

Our study had few limitations. Firstly, during data collection we could not obtain the detailed year wise breakup of the expenses during the implementation phase, i.e., August 2012 to August 2015. We assumed that the same amount of expenses happened every year and averaged the cost, which might not be the case in the real situation. Second, in order to know the present worth of the capital involved in the study, we inflated the costs from 2012 to 2015 considering the CPI Index for calculation of inflation and 3% discount rates. There is a possibility that advancement in technology over time may have actually reduced the price of capital items such as mobile phones, software etc, though the inflation increased. While this was not considered in the base case, we did undertake a sensitivity analysis to understand the impact of this assumption.

Third, since the retrospective data was collected and many of the officials in implementing agencies who worked at the time of preplanning and start up phases had left, so there is a possibility of recall bias. However, since much of the data was retrieved from records, possibility of recall bas influencing the validity of our results is relatively less.

Fourth, scale-up costs are estimated in the ideal conditions without considering any bottlenecks in the implementation of programme which may deviate to some extent in the real life situations. The sudden changes like political & economic instability and introduction of newer programs may affect the program in one way or other. These uncertainties could not be accounted for in our analysis. Also, we acknowledge the lack of data on time spent by ASHA supervisors on supervisory and monitoring activities for which the data was taken from another study.

Finally, as there is a keen interest globally for the use of mobile health interventions, it is furthermore important to assess the cost- effectiveness of such interventions in terms of incremental cost incurred on averting per DALY or death' along with the number of the number of maternal and newborn deaths averted. Our analysis is a cost-outcome description and an attempt to study the scale-up costs to understand the fiscal challenges of scale-up.

Conclusion

This study is the first costing analysis of an m-health intervention for maternal & child health services in India. Our estimates on cost are useful for policy-makers and program managers in order to plan health programs. Overall the study findings on cost of m-health are favourable from fiscal sustainability point of view. However, it is desirable to undertake a full economic evaluation in order to understand whether the increased investments made on m-health can justify health gains or not.

Abbreviations

AMR   Annual Maintenance Rates

ASHA   Accredited Social Health Activist

CEAHH   Cost Effectiveness Analysis Household Survey

CHW   Community Health Workers

CHV   Community Health Volunteers

CPI   Consumer Price Index

CRS   Catholic Relief Services

IMR   Infant Mortality Rate

INR   Indian National Rupee

m-Health   Mobile Health

MH   Maternal health

MNCH   Maternal, Newborn and Child Health

MMR   Maternal Mortality Ratio

MoHFW   Ministry of Health and Family Welfare

NGO   Non- Government Organizations

NRHM   National Rural Health Mission

OOP   Out of Pocket

RCH   Reproductive & Child health

ReMiND   Reducing Maternal and Newborn Deaths

UP   Uttar Pradesh

USAID   United States' International Aid Agency

WHO   World Health Organization

Declarations

Ethical approval

The Institute Ethics Committee of the Post Graduate Institute of Medical Sciences, PGIMER, Chandigarh approved the study vide letter no. 'Program No IEC-01/2015-108'.

Competing Interests

The authors' declare that they have no competing interests.

Availability of data and dataset:

Data is under the custody of lead author and is the guaranteer for data. However, a data sharing agreement was signed prior to the start of study between the implementing agency (Catholic Relief Services) and evaluating agency (Post Graduate Institute of Medical Education and Research, Chandigarh) which prevents any data sharing without prior permission of implementing agency. Any request for data sharing may be sent to lead author at his email address:shankarprinja@gmail.com. Data will be shared to interested researchers subject to approval from Catholic Relief Services.

Funding

Authors' Contribution

Conception of study: SP

Study design and preparation of tool: AG, SP, PB

Data collection: AG, RN

Data Analysis: AG, SP

Written first Draft: AG

All authors reviewed the manuscript, provided critical inputs for revision, and approved the final version.

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Table 1: Various types of cost with the data sources and methodology

Area	Type of cost	Type of Data collected	Source of data	Method of data collection
At two block levels	Start up/Capital cost	Cost on Module development, translation & piloting. Development of software, Equipment and mobile cost, overheads. Preplanning meetings, ASHA trainings	Official documents of CRS, Vatsalya & Dimagi. Annual budget reports, bills receipts, Personal Interviews	Primary data collection. Time value contributed over the average age of the program
	Implementation cost	Salaries, travel, ASHA internet usage, utilities like office rent, electricity, telephone bills, stationary and printing. Program support cost at state and national office	Official documents like bills, annual budget reports, Personal interview	Primary data collection. Time apportioned as per the time value spent/utilized on the activities related only to ReMiND program
	Health system cost	Health system cost on program implementation. Incremental cost of service delivery due to increased utilization of MNCH services. (Out of Pocket expenditure & unit cost for per service utilization) Incremental effect of intervention on ASHA payment.	Financial documents on ASHA incentives from Chief Medical officer's Office, Personal Interviews, Observations during meetings at block, district and state level. OOP from Impact assessment study. Literature review for unit cost per service utilization	Primary data collection. Apportioning of the salaries of the officials as per the time spent on attending meetings at block, district and state level.
	Annual Program cost	It is sum of startup cost and implementation cost	-----------	Derived indicator

|	Overall annual unit cost per pregnant women	Annual programmatic cost divided by average annual number of women registered under ReMiND	Management information system (MIS) data from CRS on number of registered women	Derived indicator
	Unit health system cost per pregnant women	Annual health system cost divided by average annual number of women registered under ReMiND	MIS data from CRS	Derived indicator
At state level – Uttar Pradesh	Scale up cost	Number of ASHAs in entire state, training cost of ASHA and supervisors, mobile phone cost, hosting service charges, health system cost	NRHM website, Observations, Calculations from available data	Unit costs of pilot at two blocks were expanded to 821 blocks in Uttar Pradesh state.
	Per capita scale up cost	Total scale up cost divided by Total population of state	Census 2011	Derived indicator
	Per pregnant women scale up cost	Total scale up cost in Uttar Pradesh divided by average number of pregnant women in the state in an year	Crude Birth Rate	Derived indictors

Table 2: Summary of scale up costs of m-health intervention in Uttar Pradesh in two case scenarios

Cost Description	Scenario1 When currently employed staff is used for supervisory activities INR (US$)	Scenario 2 When additional human resource is employed at the level of blocks INR (US$)
Annual cost of scale up	87,63,69,067 (13,844,693)	99,38,73,262 (15,700,999)
Annual cost per beneficiary	175 (2.77)	198.8 (3.14)
Annual cost per capita	4.39 (0.07)	4.97 (0.08)

Figure1.ppt: Conceptual framework for costing process of the ReMiND program.

Description: The flow chart describes the procedural detail of costing ReMiND program. The costing was undertaken from both the health system and societal perspectives.

Conceptual framework for costing process of ReMiND project.
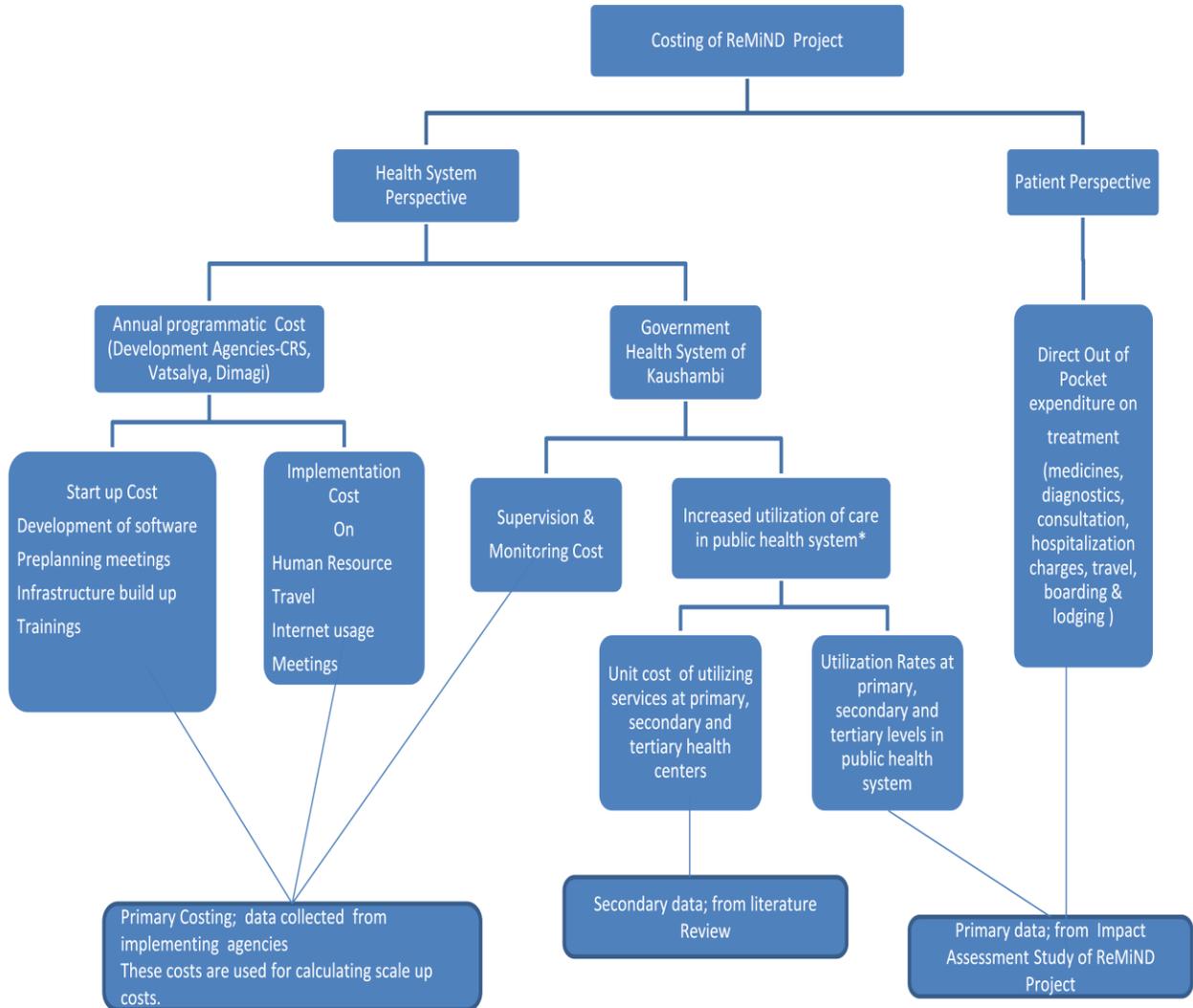
*It includes the costs of increased utilization of maternal and child care services in primary, secondary and tertiary level public health facilities as a result of increased demand from community as an after effect of introduction of m-health intervention in the area. The services included were increased utilization of antenatal care services, increased care seeking for complications during pregnancy, after delivery and for newborns.

Figure 2: Proportional distribution of total expenditure on ReMiND program from 2011-2015.

Description: The figure shows the proportional distribution of start up cost and implementation cost in the total expenditure of ReMiND program.
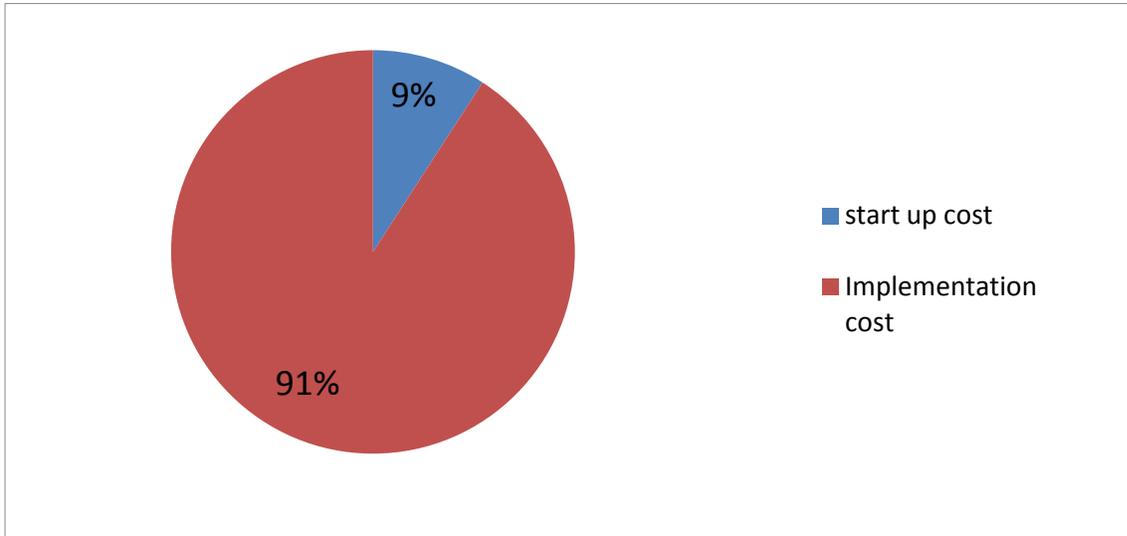

Figure 3: Proportional distribution of start up costs of ReMiND program in intervention area of district Kaushambi.

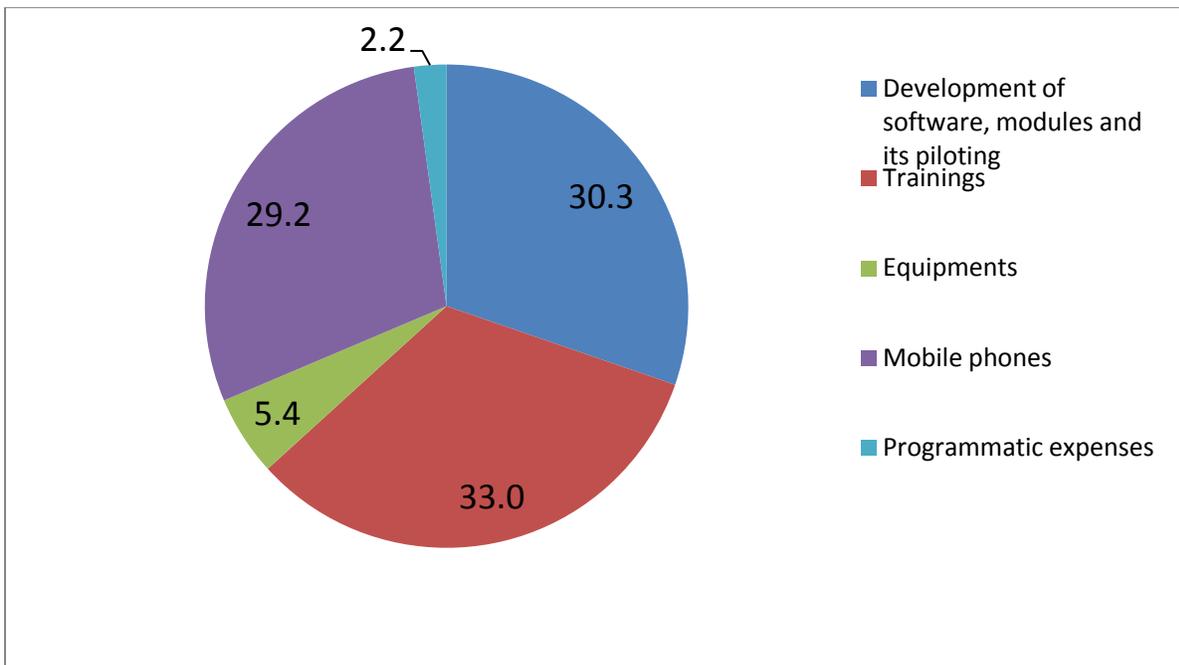Description: The figure shows the proportional contribution of different start up costs in the total start up cost of ReMiND program

Figure 4: Proportional distribution of annual cost of implementation of ReMiND program in district Kaushambi.

Description: The figure shows the proportional contribution of different recurrent costs in the annual implementation cost of ReMiND program
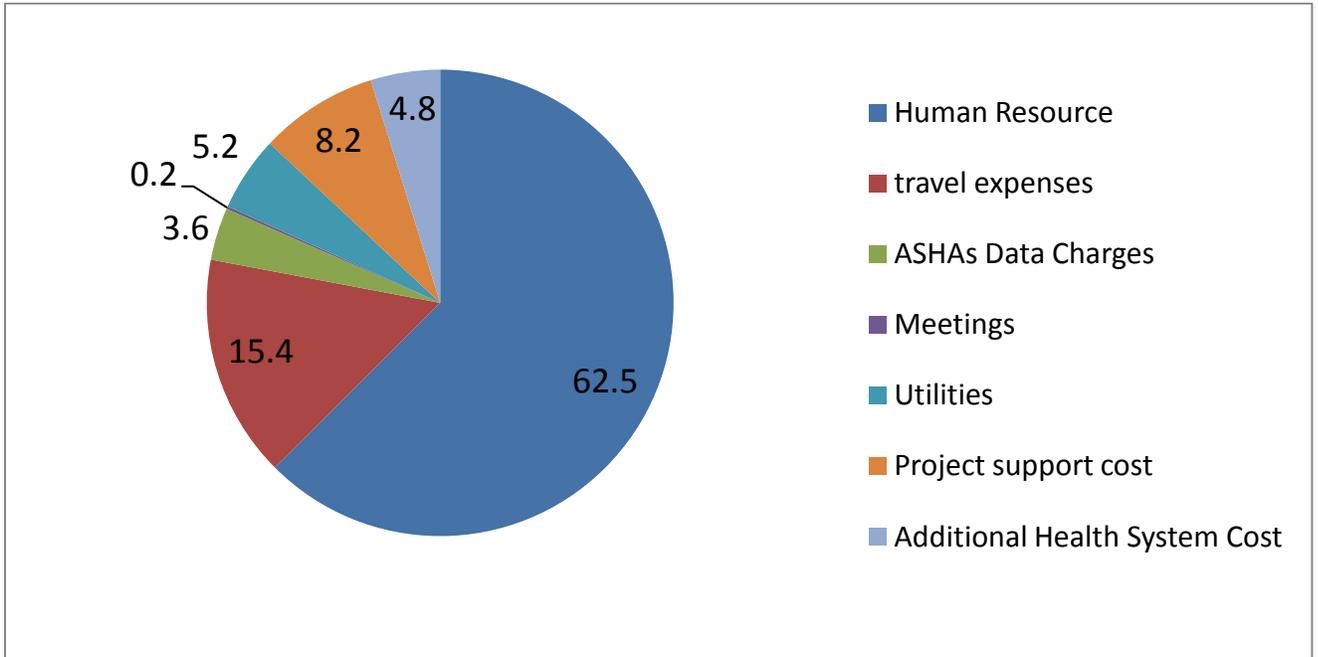
Figure 5: Tornado diagram illustrates the sensitivity analysis for various input factors on the annual cost (INR) of ReMiND program.

Description: The figure shows the sensitivity analysis with the help of tornado diagram to show the effect of variation in different input factors on total annual cost of ReMiND program in two blocks of Kaushambi district.
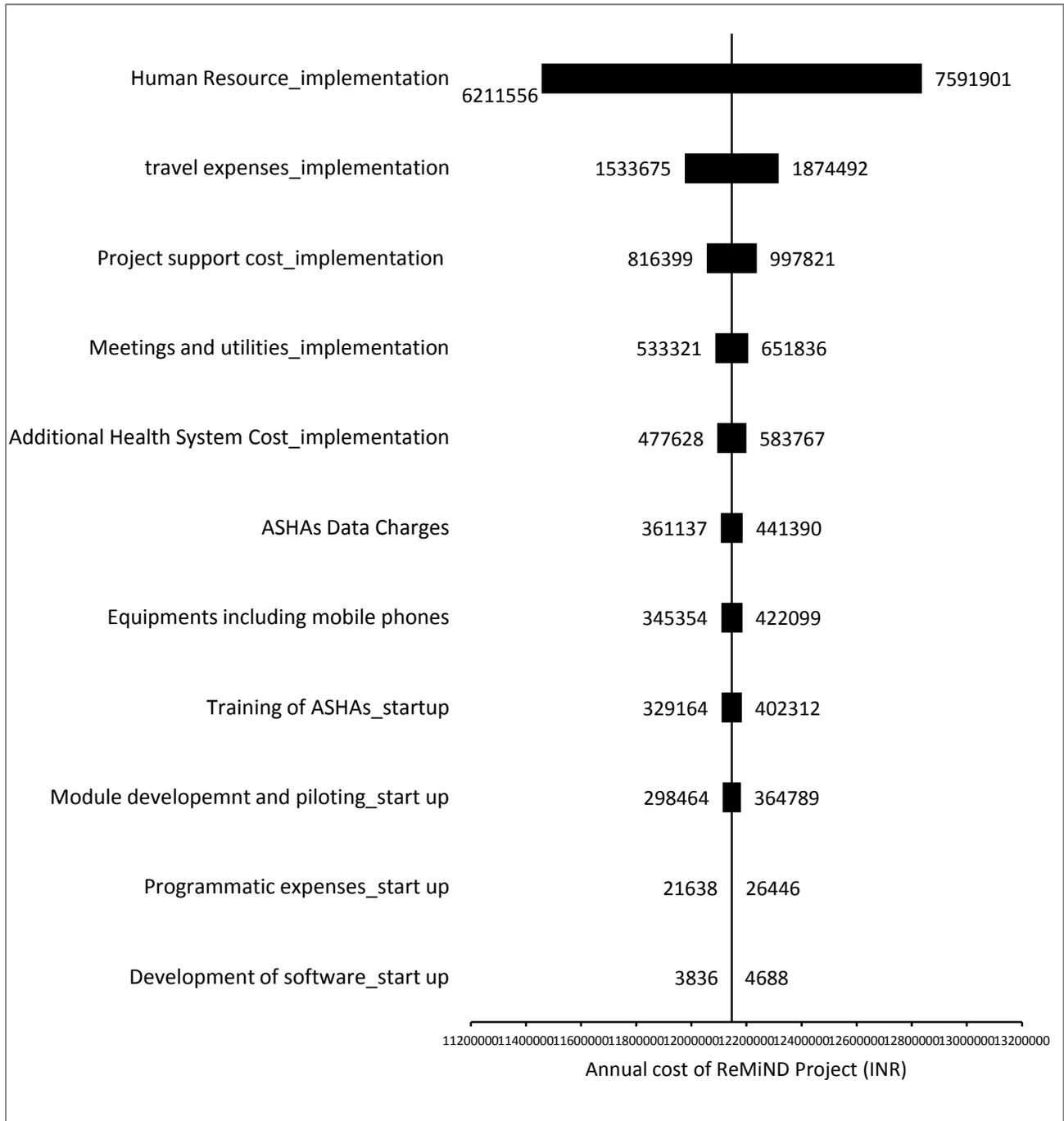
Figure 6: Tornado diagram illustrates the sensitivity analysis for various input factors on the scale up cost (INR) of ReMiND program in entire Uttar Pradesh.

Description: The figure shows the sensitivity analysis with the help of tornado diagram to show the effect of variation in different input factors on the total scale up cost of ReMiND program in entire Uttar Pradesh state
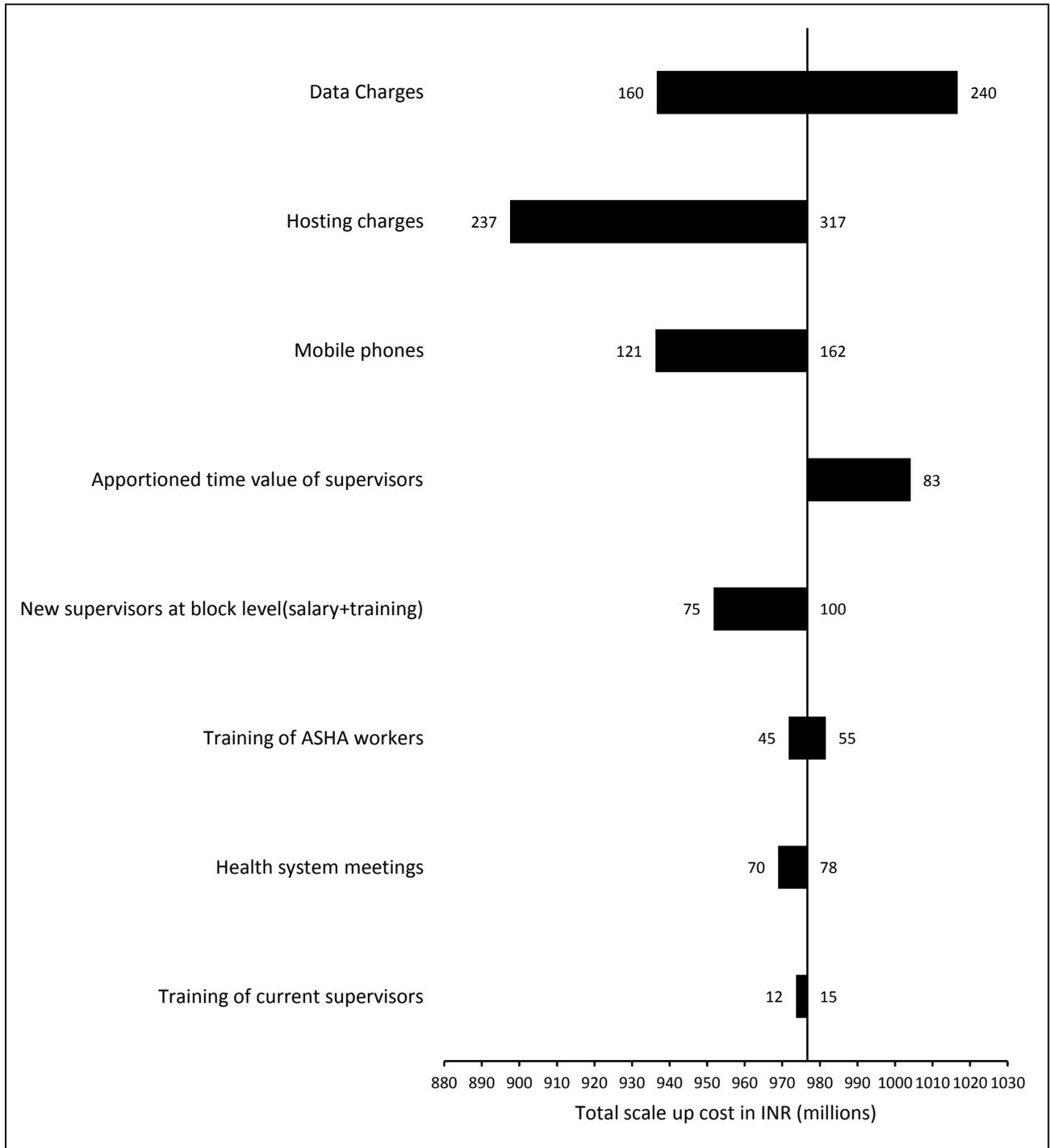
Additional File 1

Title: Summary table for annualized start up and implementation costs of ReMiND program in district Kaushambi.

	Cost Category	Expenditure in INR (USD)	%age of total expenditure
1.	**Total start up cost**	**11,09,395 (17,526)**	**9.0**
1.1	Development of software	4,262 (67.3)	0.04
1.2	Training of ASHAs and Supervisors	3,65,738 (5,778)	3.0
1.3	Equipments	59,599 (942)	0.5
1.4	Purchase of mobile phones	3,24,127 (5,121)	2.7
1.5	Programmatic cost	24,042 (379.8)	0.2
1.6	Development of module and piloting	3,31,627 (5,239)	2.7
2	**Annual Cost of implementation**	**1,10,37,461 (174,368)**	**91**
2.1	Human Resource	69,01,728 (109,032)	56.8
2.2	Travel expenses	17,04,083 (26,921)	14.0
2.3	Data/Internet Charges of Mobile phones	4,01,263 (6,339)	3.3
2.4	NGO Meetings	20,774 (328)	0.2
2.5	Utilities*	5,71,804 (9,033)	4.7
2.6	Project support cost (National &state office of CRS)	9,07,110 (14,330)	7.5
2.7	Health system cost Programme support Cost	5,30,698 (8383)	4.3
	Total annual intervention cost	1,21,46,856 (191,894)	100
	Unit cost per pregnant woman	1293.6 (20.5)	
	Unit cost per capita	31.4 (0.49)	

*Utilities include recurrent cost like office rent, electricity & communication, internet expenses, printing and stationary.

Project support costs include apportioned cost of Human resource, office rent, travel made for ReMiND project at state and national level offices of implementation partners.

Additional health system cost includes extra cost on the health system due to increased utilisation of services in the intervention area as a result of effect of counselling on the care seeking patterns and utilisation of health services and on meetings held at block, district and state level for review of ASHA work under ReMiND project

Additional File 2.docx

Title: Scale up costs for implementation of mobile health in the entire state of Uttar Pradesh in two case scenarios.

Costing Heads* @ Annualized unit cost/ year (INR)	Number of units	Scenario 1: utilising the existing human resource INR (US $)	Scenario2: Recruiting new cadre of human resource INR (US $)
ASHA Training cost @ INR 384/ASHA/year	Total number of ASHAs in UP =129312	49,607,076	49,607,076
Mobile phones @ INR 1251/ASHA/year		161,828,404	161,828,404
Annual Data Charges @1549/ASHA/year		200,340,413	200,340,413
Training of supervisor for M& E @ INR 2160/supervisor/year	75 HEO+ 75 DCPM+ 821 BCM+ 6000ASHA facilitators (=6971 supervisors)	15,054,223	15,054,223
Additional staff –salary @ 10,000 per month	1 supervisor per block =821 additional supervisors	Not Applicable	98,520,000
Additional Staff-Training @2160* /person/year	821 new supervisors	Not Applicable	1,773,360
Monitoring and supervisory cost =13% of total salary of supervisory staff	HEO=35000 pm DCPM=31000pm BCM=15000 pm AF=3000 pm New supervisor=10,000	55,013,400	67,821,000
Expenditure on meetings for review of m-health within health system			
block level @ 94,751 (scenerio1)/block @100104 (scenario2)/block	Total blocks in UP= 821	77,790,513	82,185,384
district level @3134(scenario1)/district @3245(scenerio2)/district	Total districts in UP= 75	235,037	243,401
Hosting charges @1 US $/ beneficiary/year) (1 US$=INR 63.3)	50 lakh beneficiaries	3,16,50,0000	31,65,00,000
Total cost of scale up		876,369,067(13,844,693)	993,873,262 (15,700,999)
Unit cost per beneficiary		175 (2.77)	198.8 (3.14)
Unit cost per capita		4.39 (0.07)	4.97 (0.08)