Health Technology Assessment of TeCHO+ Programme in Gujarat State

Regional Resource Centre for Health Technology Assessment (HTA-RRC)

Indian Institute of Public Health Gandhinagar (IIPHG)
Gujarat, India

Research Team	
Principal Investigator	
Dr Somen Saha	Associate Professor, Indian Institute of Public Health Gandhinagar
Co- Investigator	
Dr Komal Shah	Assistant Professor, Indian Institute of Public Health Gandhinagar
Dr Apurvakumar Pandya	Economic Evaluation Specialist, Indian Institute of Public Health Gandhinagar
Ms. Yogini Kandre	Programme Associate, Indian Institute of Public Health Gandhinagar
Mr. Devang Raval	Programme Associate, Indian Institute of Public Health Gandhinagar

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List of Abbreviations

Abbreviations	Full Form
ANM	Auxilary Nurse Midwifery
ASHA	Accredited Social Health Activists
ANC	Ante-natal Care
CHC	Community Health Centre
DH	District Hospital
DALY	Disability Adjusted Life Years
FHW	Female Health Worker
GDP	Gross Domestic Product
ICER	Incremental cost-effectiveness ratio
ImTeCHO	Innovative mobile technology for Community Health Operation
LBW	Low Birth Weight
MCTS	Mother and child tracking system
OOPE	Out-of-pocket Expenditure
PMJAY	Pradhan Mantri Jan Arogya Yojana
PHC	Primary Health Centre
PIH	Pregnancy Induced Hypertension
SDG	Sustainable Development Goals
SMA	Severe Maternal Anemia
SAM	Severe Acute Malnutrition
TeCHO+	Technology for Community Health Operations

ABSTRACT

Background: Numerous mobile-based health technologies (mHealth) have been designed and implemented by community health workers to improve coverage and augment health outcomes. Gujarat is implementing such mHealth programme, TeCHO+ (Technology for Community Health Operations), in the entire state based on the cost-effectiveness of the pilot programme, ImTeCHO. A TeCHO+ enabled mobile phone is provided to frontline health workers (particularly, Auxiliary Nurse Midwifery). Despite some research on the effectiveness of mHealth applications on improving maternal and child health outcomes, there is a significant dearth of evidence on the cost-effectiveness of mHealth programmes implemented on a large scale. This report presents the evaluation of the cost-effectiveness of TeCHO+ as compared to E-Mamta in Gujarat.

Methods: A decision tree was parameterized on MS excel spreadsheet to estimate the change in DALY and cost due to implementing TeCHO+ from the health system perspective. All costs, including start-up and implementation costs besides other healthcare costs, were estimated. Two rounds of the survey, one before the implementation of TeCHO+, another after one year of implementation, was carried out from three districts of Gujarat, namely, Devbhumi Dwarka, Panchmahal and Sabarkantha districts. The study participants were surveyed from 48 sub-centres across 24 Primary Health Centres from 6 Talukas of Gujarat's three selected districts. We surveyed 385 postpartum women and mothers of 230 children at baseline and 357 postpartum women and mothers of 157 children after one year of programme intervention in 2020. Programme outcomes were analyzed to improve coverage and concordance analysis to assess data management quality. Propensity score matched samples from the pre-intervention, and post-intervention phases were analyzed using the difference-in-difference method to estimate the impact of the TeCHO+ programme on key outcomes. In addition, health outcomes in terms of changes in service coverage were modelled to estimate maternal and child mortality and DALY averted. One-way sensitivity analysis was conducted by varying model parameters to test the effect of parameter uncertainty on the findings and estimate joint uncertainty in all parameters.

Results: Cost data was collected from a health systems perspective. An incremental costing approach was adopted for the study. The annualized cost incurred for the TeCHO+ programme was estimated to be INR 376,08,26,815. With this investment, around 24,43,020 beneficiaries (12,04,590 pregnant women & 12,48,420 under 2 children**)**, the calculated cost per beneficiary amounted to (INR) 2424. Similarly, for eMamta, the programme cost was estimated to be INR 372,36,18,924. With this investment, around 25,65,544 (14,06,252 pregnant women and 1159292 children), the calculated cost per beneficiary amounted to (INR) 2375. For the management of high-risk cases, the total calculated cost per beneficiary for high-risk management in the TeCHO+ programme was (INR) 4827 and (INR) 4778 for eMamta based on secondary literature.

Following introduction of TeCHO+, the coverage of full antenatal care (ANC) (80.1% vs 77.9%, p-value<0.0001), consumption of at least 180 iron-folic acid tablets (93% vs 77%, p-value<0.001), early initiation of breastfeeding (42.7% vs 24.2%, p-value<0.001), five home-visits by ANM during the first month after delivery (36.2% vs 27.9%, p-value=0.056), HBV0 vaccination (67.2% vs 35.3%, p-value<0.0001) and Pentavalent 2 (100% vs 95.1%, p-value=0.015) improved. The overall concordance rate for routine maternal health indicators (a measure of data accuracy) improved from 69.1% to 80.5%, while routine child health indicators improved from 86.6% to 92.1%. The launch of TeCHO+ software saved approximately 1.7 hours a day of ANM's productive time and 1.5 hours a day of data entry operator's time. Out of 12 services targeted under TeCHO+, nine services registered a significant improvement as a result of TeCHO+.

Overall, cost-effectiveness analysis indicated that TeCHO+ incurs an incremental cost of INR 1802.84 per DALY averted, which is below the GDP per capita of India.

Conclusion: This study's findings indicate that the TeCHO+ program is cost-effective from a health system perspective and can be considered for replicate in other states or nationwide scale-up. Despite some gaps in the available evidence, the findings indicate that TeCHO+ solutions can significantly improve health service delivery through increased accuracy of data management, high-risk identification, quality, and accessibility of care.

Keywords: mHealth, maternal and child health, cost-effectiveness, TeCHO+, India

INTRODUCTION

Background

As per NFHS 2015-16 data[1], only 30.7% of the pregnant women have received full ante-natal care (ANC), and 50.4% of the children were fully immunized. There is a massive burden on the health system with 38.5% of the stunted children and severe wasting in 9.2% of the children in Gujarat.[1] Reporting and low coverage of services was a concern highlighted in the literature.[2] The mother and child tracking system (MCTS), e-Mamta in Gujarat, was inefficient in reflecting the latest grass root level data due to huge backlog in data entry. Quality of data, duplications, lack of data linking with facility and service were areas of concern. Female Health Workers (FHW) had to fill 92 data columns every month, which had over-burdened them as well as Data Entry Operators (DEOs) at primary health centres (PHCs). The poor coverage of health services and inadequate data management pose obstacles to achieving Sustainable Development Goals.[3,4]

TeCHO^{+} programme in Gujarat

In response to the need to address the above issues, the Health & Family Welfare Department, Gujarat, in collaboration with SEWA Rural, a voluntary organization, piloted a mobile health

programme named ImTeCHO (Innovative mobile technology for Community Health Operation) in two talukas of Bharuch district in Gujarat. Based on the success of the ImTeCHO programme, the Health & Family Welfare Department, Gujarat has scaled up the programme as TeCHO^{+} (Technology for Community Health Operations) across the state. Some significant differences present between ImTeCHO, TeCHO+ and E-Mamta are listed below.

Table 1. Difference between ImTeCHO, TeCHO+ and E-Mamta

ImTeCHO	**TeCHO^{+}**	**E-Mamta**
ICMR supported pilot study implemented by a non-governmental organization in partnership with H&FW Gujarat	Implemented by Department of H&FW, Government of Gujarat	Mother and child tracking system (MCTS) implemented as E-Mamta in the entire State.
Real-time data entry at the point of service	Real-time data entry at the point of service	Entry is done by DEOs at the PHC level
Mobile/Web-based application	Mobile/Web based application	Web-based application
Smartphones were given to all ASHA's (Accredited Social Health Activists) in the intervention area	Smartphones were given to all FHWs	No such logistics supplied
Targeted at improving reproductive, maternal and child health only	Training of all staff done	Training of the only DEO done
Regular training using satellite platform (SATCOM) organized	Regular training using satellite platform (SATCOM) organized	No such orientations done
Nodal officer from Department of H&FW.	Nodal Officer (MBBS) for TeCHO+ cell at the state level	Project Officer (eMamta) at the state level
Coordinator at the district level	Coordinators at the district and taluka level	No such dedicated staff
Piloted in Bharuch District	All FHWs do entry of their area	One DEO has to do entry of whole PHC area
Piloted in Bharuch District	Implemented across the State	State-level programme

Features of TeCHO+

TeCHO^{+} is a mobile & web-based application that essentially enables data entry by the person providing service at the time and place of service delivery to improve the coverage and data quality. The programme encompasses unique features such as real-time data entry, generates alerts for high-risk cases, tracks beneficiaries as well as health workers, a web-based dashboard that enables health officials at different levels to access progress reports, and extends supportive supervision to health workers. These unique features are expected to enhance Gujarat's performance in eleven priority areas. Box 1 presents features of the TeCHO+ programme.

Box 1. Features of TeCHO+

1. **Real-time data entry:** The health workers enter data offline/online. They receive daily work plan in the application, therefore, daily log-in is mandatory.
2. **Alerts for high-risk cases:** It stratifies risks and generates alerts for high-risk cases which notifies health worker as well as respective health officials like Medical Officer at Primary Health Centre (MO-PHC), District and Taluka TeCHO+ Coordinator (DTC and TTC) for an action.
3. **Tracks beneficiaries.** Artificial intelligence function tracks beneficiaries, their movements (migration), eligible couples and under 5 children for the purpose of immunization, and other reproductive and child health related services.
4. **Dashboard and automatic report generation:** The web interface is updated daily. The State, District and Taluka level reports are auto-generated which can be accessed by the supervisory cadre of health officials.
5. **Supportive supervision and monitoring:** Health workers can seek assistance for any technical problems through help-line number. Any operational or technical troubles faced by health workers are immediately resolved by TTC or DTC who provide supportive supervision when needed. Further, GPS tracker enables real-time monitoring of health workers' visits, services delivered, and automatic updation of dashboard to track the work progress.

Implementation phases of TeCHO+

For effective implementation, the said programme is divided into three phases. The first phase was dedicated to fetching data from e-Mamta and doing family health surveys; the second phase primarily focused on reproductive, and child health indicators, and the third phase will incorporate the remaining components. As of March 2020, the second phase of the TeCHO+ programme was implemented across the state.

Supervisory activities

TeCHO+ programme has created structures for effective supervision of the Programme. At the district level, Chief District Health Officer (CDHO) and Reproductive and Child Health Officers (RCHO) are responsible for overall coordination and supportive supervision. District coordinators are deputed for technical support, whereas CDHOs and RCHOs at the district level and Taluka Health Officers at the taluka level are entrusted with training, supervision, and monitoring of the programme.

One year after implementation, a new cadre of Territory TeCHO+ Coordinators, 1 per 75 FHWs (roughly FHWs of two-three taluka), have been deployed by Emergency Management Institute to provide on-field help and supervision to the FHWs. Their primary role was to monitor the login rate of the FHWs, troubleshooting and escalating software-related issues software development partner, as well as Taluka and District TeCHO Coordinators. However, these positions were discontinued since April 2020.

A state-level TeCHO+ task force, chaired by the Health Commissioner of Gujarat, is established with objectives to oversee the overall coordination, troubleshooting, planning and decision-making. State health officials use WhatsApp and SATCOM (Satellite communication facilitated by Bhaskaracharya Institute for Space Applications and Geo-Informatics – BISAG, Gandhinagar) for troubleshooting and on building the capacity of the staff.

TeCHO+ programme provided much emphasis on service supervision. Supervisory training is being imparted with technical assistance, and contents were standardized. The services delivered by FHWs were validated at three levels. In the initial phase, territorial TeCHO coordinators were deputed who were responsible for supervising 75 FHW and providing supportive supervision to FHWs at the field level. Besides, command and control centre were established at GVK EMRI, where beneficiaries were randomly called to validate the scheduled service provision by frontline workers. At present, territorial TeCHO+ coordinator positions are ceased, and PHC MOs do field monitoring with the help of a web-based interface.

Apart from these above-mentioned dedicated cadres of health workers for the TeCHO+ programme, PHC-MOs were assigned the task to verify the families in case of death of a family member or immigration or emigration of a family or a particular member of the family. Only after the verification, the changes made by the FHW are accepted.

The Programme has robust supervision, monitoring and support mechanism at each level. At the state level, the State TeCHO team includes an allopathic Medical Officer, State Data Manager, IT Technician, Programme Officer and Programme Assistant (both deputed from the e-Mamta division). State Data Manager and Medical Officer are primarily responsible for supervision and monitoring of the TeCHO+ as well as provide feedback to software service company for modification and upgradation of the software.

Programme theory

The TeCHO+ programme aims to improve service coverage and data quality by early identification of the morbid condition and timely treatment. The figure below illustrates the steps to manage cases of maternal and child complications.

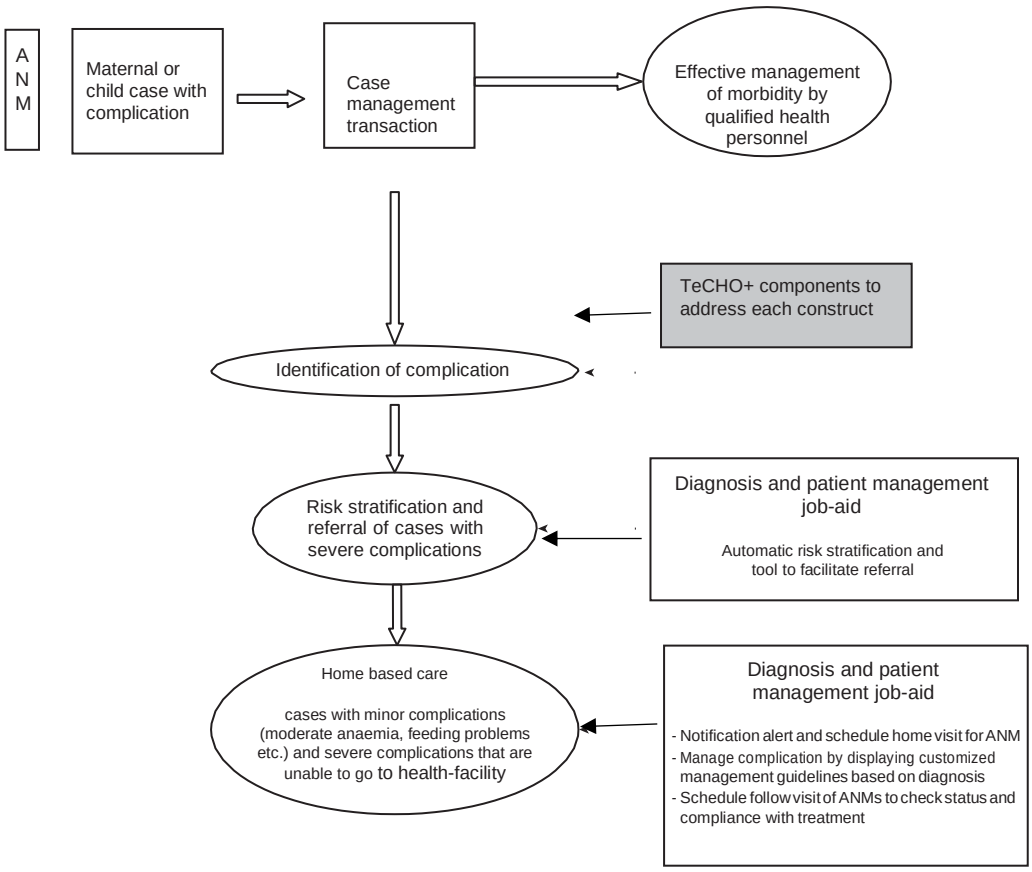


Figure 1: TeCHO+ programme theory

Evidence Synthesis

mHealth has been an approach used for service delivery, including Communicable and Non-Communicable diseases, overall General Health and mainly for Reproductive and Child Health. Also, mHealth has been used globally in supply chain management.

A systematic review of the current literature was carried out. The objective of the systematic review is to assess the effectiveness of mHealth interventions for maternal, newborn and child health (MNCH).

Participants, Intervention, Comparator and Outcome of the study

Box 2. PICOT of the study

Participants	• Pregnant and Lactating Women, Children under two years of age
Intervention	• mHealth
Comparator	• Conventional / routine care
Outcome	Primary outcomes: • all outcome measures indicative of maternal mortality; maternal morbidity; newborn and child mortality; newborn and child morbidity, identification and referral of high-risk cases Secondary outcomes: • Number of planned antenatal and postnatal visits; institutional delivery; quality of life; cost-effectiveness; immunization cover; and mHealth intervention-related adverse events.
Timeline	Studies published between 2000-2020. The rationale is that most mobile–health technology interventions started in the last two decades.

The review is reported according to the requirements of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[5] We assessed studies that have investigated the effectiveness of mHealth interventions for improving MNCH.

Search strategy

An electronic search of five online databases (PubMed/Medline, Scopus, Cochrane, Embase, and Google Scholar) was performed. The online electronic databases were searched between 2000 to 2020 to identify studies exploring the role of mHealth solutions in improving preventive maternal and child healthcare services. There was no restriction of the country of the study. The search strategy is presented in detail in Box 3 and 4.

Box 3. Search strategy

1. (eHealth or e–Health).mp.
2. (mHealth or m–health or mobile health).mp.
3. Telemedicine/ or (telecare or telehealth care or mobile telehealth care or mobile telemedicine or mCare or m–care).mp.
4. apps or mobile applications/
5. (mobile communication or mobile technology or mobile devic*).mp.

6. Computers, Handheld/ or Microcomputers/ or (tablet computers or mobile tablet computers or mobile technolog*).mp.
7. Cellular phone/ or (cellular phone* or cell phone or mobile phone).mp.
8. Text Messaging/ or (texting or text messag* or messag* or text* or short message or SMS or multimedia technol* or multimedia messag* or multi–media messag*).mp.
9. (Personal digital assistant* or PDA).mp.
10. (Smartphone or smart–phone).mp.
11. (Global positioning system or GPS).mp.
12. or/1–11
13. Pregnancy/ or Pregnant women/ or Pregnancy outcome/
14. Childbirth.mp.
15. Obstetrics/
16. Maternal Health Services/ or matern*
17. (pregnan* or maternal or maternal health).mp.
18. Delivery, Obstetric/
19. institutional delivery.mp.
20. Postpartum period/ or puerperium.mp.
21. Delayed delivery.mp. or three delays.mp.
22. Pregnancy complications/ or Obstetric Labor complications/ or Obstetric Labor, Premature/ or Puerperal Disorders/ or Depression, Postpartum/ or Maternal Mortality/
23. Infant, Newborn/ or neonat*.mp.
24. Prenatal Care/ or Perinatal Care/ or Postnatal Care.mp.
25. (Antenatal care or intrapartum care or postpartum care or post–partum care or puerperal care).mp.
26. (Perinatal complication* or postnatal complication*).mp.
27. Breastfeeding/ or (breastfeeding or breast–feeding).mp.
28. Intervention studies/ or experimental studies.mp.
29. analytical stud*.mp.
30. Clinical trial/ or Controlled Clinical Trial/ or Randomized Controlled Trial/ or (clinical trial or controlled clinical trial or randomized controlled trial).mp.
31. Double–Blind Method/ or Single–Blind Method/ or (double–blind design or single–blind design).mp.
32. Placebos/ or Random Allocation/ or random*.mp.
33. (Controlled before and after stud*).mp.
34. Interrupted time series.mp.
35. Cohort studies/ or (cohort stud* or cohort).mp.
36. (control or healthy control).mp.
37. Case–control studies/ or case–control stud*.mp.
38. systematic review or meta analysis

Box 4. Search strategy: free–field format

(mHealth or m–Health or eHealth or e–Health or telemedicine or mobile health or mobile telehealth care or mobile phone or cellular phone or personal digital assistant or mobile tablet computers or smart phone or mobile technology or apps or mobile applications or text messag* or short messag* or SMS or multimedia messag*)
AND
(child* or infant* or baby or babies or neonatal or newborn* or preterm* or prematur* or pregnan* or pregnant women or mother* or obstetric labor or obstetric labour or obstetric delivery or obstetric labor complications or midwifery or traditional birth attendant or perinatal care or prenatal care or antenatal care or intrapartum care or postnatal care or perinatal complications or postnatal complications)
AND
(analytical stud* or epidemiologic* or compar* or evaluat* or follow–up or follow up or prospective or retrospective observation* or cohort or case–control or trial* or RCT or controlled before and after study or interrupted time series or intervention* or prospective or retrospective or control* or double–blind or single–blind or random*)

Inclusion and exclusion criteria

The target groups were women in the antenatal, intra-natal, and postnatal periods; newborns; children aged 0–5 years; and health workers through which interventions aimed at these groups are mediated. Men, non–pregnant women or those not recently having given birth, and children over the age of 2 years were excluded. We included studies evaluating interventions delivered through mobile health technology and considered the various delivery modes through which this might be achieved. Studies published in English, randomized controlled trials (RCTs), variations of RCTs, controlled before and after studies, interrupted time series studies and observational studies (cohort, case-control) and systematic reviews, meta-analyses were included. We excluded expert opinions, reports, discussion papers, case reports. Authors were contacted for access to unpublished research. We excluded related information technology-based interventions delivered via fixed-line internet or standard telephone line, interventions labelled ‘mobile’ which did not involve cell phones, such as Mobile Maternal Health Clinics, which are touring buses staffed by health care professionals.

Data extraction and synthesis

At least two reviewers independently screened the titles and abstracts of identified studies, assessed the full text of potentially eligible studies against the inclusion and exclusion criteria, and abstracted relevant study data onto a customized data extraction sheet. Two reviewers have

independently extracted data using a data extraction sheet. The following information were extracted:

- Author and year,
- National affiliation of author and funding source,
- Country in which the study took place,
- Study design,
- Healthcare setting,
- Target users,
- Type of mHealth intervention – device; delivery mode; application type; stated purpose of intervention; theoretical basis if specified,
- Range of outcome measures described
- Key findings from each included study

Assessment of risk of bias

The methodological quality of intervention studies was assessed independently by at least two reviewers, following the recommendations of the Cochrane Effective Practice and Organization of Care Group.[6] Observational studies were assessed using the Effective Public Health Practice Project quality assessment tool.[7] Discrepancies were resolved by team consensus.

Findings of systematic review

Of 1252 titles screened after duplication, 169 potentially relevant abstracts were obtained. Out of 169 abstracts, 42 abstracts were shortlisted. The full text of 42 articles was reviewed using a data extraction sheet. A total of 23 full-text studies were included in the final analysis.

Of these, fourteen were intervention studies, three were descriptive studies, and five were systematic review and meta-analysis. Given the heterogeneity in outcomes, settings and study designs, results could not be polled to conduct a meta-analysis. Data synthesis, therefore, aimed to give a narrative review of mHealth interventions and results. The quantitative results of intervention studies were summarized in an evidence table according to study type: randomized controlled trial (RCT) and non-randomized study (NRCT).[8] A narrative synthesis of the results was reported as enhanced transparency in reporting the synthesis of qualitative research (ENTREQ) guideline.[9]

Risk assessment

Intervention articles generally performed well in their risk of bias for the selection of study population (66% low risk), completeness of data (83% low risk), clear definition of outcome (100% low risk) and confounders (50% low risk, with the remainder unclear). Several studies displayed a high risk of bias in sequence generation (58%), allocation concealment (41%), or origin of data (25%).

Narrative synthesis of quantitative results

Maternal and neonatal service utilization and outcomes

All studies addressing maternal and neonatal service utilization showed significant increases. For maternal service utilization, several studies showed positive effects on antenatal care (ANC) attendance. The Wired-Mothers intervention of Lund et al. more than doubled the odds of a woman receiving four or more ANC visits (OR 2.39, 95% CI 1.03 to 5.55).[10] The pre-post intervention study in Thailand of Kaewkungwal et al. also showed higher ANC attendance rates after reminders were sent via text messaging (ANC visits: OR 2.97, 95% CI 1.60 to 5.54).[11] In Sierra Leone, the mHealth intervention showed a positive net effect on facility-based service utilization for the following indicators: first and fourth ANC visit (0.7 and 11.3%-points, facility delivery (8.2%-points), and first, second and third PNC visit (10.1, 10.6 and 14.9%-points).[12] Oyeyemi and Wynn found a significantly higher facility utilization rate within the area in Nigeria taking part in a mHealth intervention (43.4% versus 36.7%, $p = 0.0001$).[13] They defined facility utilization rate as the number of deliveries in a particular health facility to the number of ANC registrations in that same facility.[13]

Skilled attendance at birth was increased in the study by Lund et al. (60% in the intervention group compared to 47% in the control group), especially for women in an urban area (OR 5.73, 95% CI 1.51 to 22.81).[14] Two studies in Thailand[11,15] addressed the effect of mHealth interventions on the emotional aspects of pregnancy. Jareethum et al. observed significantly higher satisfaction scores in the antenatal and perinatal period and high confidence scores and low anxiety levels when educational text messages were sent twice per week.[15]

A systematic review of 14 studies conducted in 2017[16] found mHealth interventions effective in improving antenatal care and postnatal care services. This review suggested that mHealth solutions can improve preventive maternal healthcare services and maternal outcomes.

Lund et al.[17] observed a significant effect on perinatal mortality in their study conducted in Zanzibar using mHealth intervention. Their mHealth intervention combined unidirectional text messaging and direct two-way communication in a free call voucher system to provide education on pregnancy, reminders for antenatal care visits and an emergency medical response system. They found a significant decrease in the perinatal mortality rate of 50% (OR 0.50, 95% CI 0.27 to 0.90).[17] The total perinatal mortality rate based on stillbirth and neonatal mortality was 27 per 1000 births, 19 per 1000 births in the intervention group compared to 36 per 1000 births in the control group.[17] Jareethum et al. assessed the effect of two educational text messages sent weekly in Thailand, found no differences for infant birth weight and preterm delivery.[15]

ImTeCHO intervention – mHealth application piloted in Gujarat[18] had reported several additional effects in averting malnutrition and maternal health and improving coverage of essential maternal and newborn services. The increase in preventive service coverage leads to a reduction in illness during pregnancy as well as after childbirth and during the neonatal period. The implementation of ImTeCHO[12] resulted in saving 11 infant deaths per 1,000 live births in the study area at an annual incremental cost of 163,841 USD or 28,474 USD per 1,000 live births.[18] Overall, ImTeCHO was proven to be a cost-effective intervention from a programme perspective at an incremental cost of INR 2,523 (39 USD) per life-years saved and INR 172,442 (2,649 USD) per death averted.[18]

Another mHealth application known as ReMiND[19] was implemented in 2012 through 259 ASHAs in two blocks of Kaushambi district of Uttar Pradesh state of India. This intervention resulted in a reduction of 0.2% maternal and 5.3% neonatal deaths. The incremental cost of ReMiND programme was INR 12,993 (USD 205) per DALY averted and INR 371,577 (USD 5,865) per death averted.[19]

The absence of a consistent translation of improved attendance on the continuum of maternal and neonatal health services were also observed in previous reviews.[20-24] This may be due to the quality of the evidence with moderate risk of bias across studies, especially with non-randomized study designs. Another factor may be substandard care provided at facilities. In fact, mHealth has been proposed as a catalyst to identify those areas where strengthening is needed.[25]

This systematic review suggests that mHealth interventions targeted at pregnant women can increase antenatal and postnatal care attendance, facility-based deliveries, skilled attendance at birth, and vaccination rates.[26-27] No consistent effects of mHealth interventions on maternal and neonatal health outcomes were observed, though two Indian studies[12,13] describe benefits regarding reduced maternal and neonatal mortality and improved uptake of maternal and childcare services. Other health outcomes such as anaemia, gestational age at delivery, mode of delivery, neonatal birth weight, preterm delivery, stillbirth and neonatal mortality were not significantly affected by mHealth interventions.

TeCHO+ is a comprehensive state-wide scaled-up programme in the country; however, evidence on cost-effectiveness is unknown. Therefore, present HTA was undertaken to assess the cost-effectiveness of TeCHO+ for reducing maternal and child mortality in Gujarat, thereby providing an opportunity for scale up of the programme and providing evidence for its nationwide uptake.

Aims and Objectives of HTA

Aim: Health Technology Assessment of TeCHO+ programme in Gujarat state.

Objectives:

Health technology assessment of TeCHO+ programme has four objectives,

1. Assess the incremental cost of delivering TeCHO + solutions,
2. Assess key outcome indicators for measuring programme impact,
3. Estimate the incremental cost-effectiveness ratio of the programme, and
4. Assess pathways to the observed programme outcomes.

The details regarding “Participants, Intervention, Control, Outcome and Timeline (PICOT)” is presented in Table 2.

Table 2: Participants, Intervention, Control, Outcome and Timeline (PICOT) for the HTA

Bird view of PICOT for the HTA of TeCHO+ programme	
Participants:	FHWs, supervisors, women and new-born (Phase 1) and the entire family (Phase 2)
Intervention:	Service delivery facilitated by TeCHO+
Control:	Baseline data validated from e-Mamta (Mother and Child Tracking System)
Outcome:	Adherence and coverage, improved data quality, morbidity management and mortality (in phases) and cost-effectiveness
Timeline:	Data were collected in two rounds. March 2019 for measuring adherence and coverage of essential MNCH packages, March 2020 for measuring morbidity management.

METHOD

The study compared key programme outcome indicators before and after the launch of TeCHO+ programme. The ethics approval for the study has been obtained by the Institutional Ethics Committee on 19th March 2019 wide letter no., TRC-IEC No: 10/2018-19 and the protocol was approved by Technical Advisory Committee of Department of Health Research on 25 April, 2019.

Objective 1: Assess the incremental cost of delivering mHealth solutions

Cost data was collected from a health systems perspective. An incremental costing approach was adapted for the study. Financial record of *TeCHO+* project involved in delivering intervention activities remained a key source of information.

In addition, a time usage study was conducted to assess the true cost incurred by the State and assess any time saved as a result of the TeCHO plus programme through interviewing key stakeholders and programme staffs at every level. Cost of capital items were annualized across the project life, with discounting at an annual rate of 3%.

Orientation training cost was considered since the launch of the programme. Refresher training was assumed to be a recurrent activity. Cost of time spent by various technical partners of TeCHO+ programme towards capacity building, resource utilization was assessed through

interviews and financial records. Cost of service delivery (cost of ANC care, immunization, cost of PHC & CHC level care, cost of institutional delivery, cost of specialist care (Gynaecologist and Paediatrician) were inferred from secondary literature. The company waived off the software development cost; hence we could not consider software development cost. Other fixed costs include the costs of development of guidelines for implementation and training costs for both staff and supervisors' costs. All costs are presented in local currencies. Costs were converted to constant values and reported as annualized cost in 2019- 2020 price.

Objective 2: Assess key outcome indicators for measuring programme impact

Programme impact was planned to be measured over three years, however, due to COVID-19 pandemic, we could measure programme impact over 2018-2020, with two rounds of data collection each year during March – April. The objective was to assess whether TeCHO+ programme improved coverage and morbidity management over the study reference period.

At baseline, data from a sample of existing MCTS, known as e-Mamta in Gujarat was obtained and validated in five districts of Gujarat viz. Gandhinagar, Sabarkantha, Bharuch, Panchmahal and Devbhumi Dwarka. The study team planned a second round of data collection from selected five districts but could complete data collection from three districts due to COVID-19 pandemic. The selection of the district is explained in the sample selection and sample size section.

The first step of assessing any routine health information system such as e-Mamta is the registration of eligible beneficiaries; however, incomplete registration and duplications were major concerns. In India, registration of pregnant women in the MCTS is sub-optimal, and few authors argue it to be as low as 35%.[18] In order to address the limitation of the e-Mamta programme, data was gathered at two levels:

1. A line list of all eligible households was obtained from the respective auxiliary nurse midwives (ANM) for her sub-centre. A sample of those households was surveyed, as detailed below. This enabled an intent-to-treat analysis, and also covered households who have received services from ANM, but whose entries were missing in e-Mamta.

2. A list of all eligible households was obtained from e-Mamta. All details about their ANC, PNC, child health services and morbid conditions was obtained from e-Mamta for the selected sample. This enabled per-protocol analysis.

In the subsequent rounds, data from TeCHO+ programme was validated to assess the coverage and morbidity management. Table 3 presents indicators with a specified timeline for the reference.

Table 3. Indicators and timeline for measurement

Indicators	**March 2019**	**March 2020**
Maternal Care		
No. of Pregnancy Registrations	√	
Task completion rate by FHW	√	
Identification of Severe Maternal Anaemia		√
Mothers who received full antenatal care (%)		√
Mothers who received full postnatal care (%)		√
Institutional births (%)		√
Management of Severe Maternal Anaemia		√
Pregnancy Induced Hypertension and Management		√
Children Care and immunizations		
Identification of lbw (less than 2.5 kg) and its management		√
Identification of SAM (%)		√
Referral of Children to NRC/ CMTC/ CMAM (%)		√
Children age 12-23 months fully immunized (BCG, measles, and 3 doses each of polio and DPT) (%)		√
Feeding Practices		
Children under age 6 months exclusively breastfed (%)		√
Children age 6-8 months receiving complementary feeding (%)		√

Participants' Inclusion Criteria for Validation

Participants' Inclusion Criteria

The inclusion criteria were:

(1) Women who have delivered between 1st November 2018 to 31st January 2019 for baseline and between 1st October 2019 to 31st December 2019 for follow-up of survey.

(2) Children in the age group of 12-15 months for child-related indicators i.e. (1st November 2017 to 31st January 2018 for baseline and 1st October 2018 to 31st December 2018 for follow-up survey); and

(3) Pregnant women and children with specific high-risk conditions (2019).

Participants Exclusion Criteria for Validation

Population residing in urban talukas and municipal corporation areas were not included.

Sample Selection and Sample Size

The study participants were surveyed from 48 sub-centres spread across the three selected districts of Gujarat. The selection of the district was done based on the category of HDI ranking of Gujarat and maturity of TeCHO+ programme. The selection of Taluka was done purposively based on their distance to their respective headquarters. However, a simple random sampling method was adopted to select the PHC and Sub-Centre using a table of random numbers. A custom software was designed for the data collection. A correction factor on E-Mamta data was applied, and the validated data was utilized to establish the baseline score.

We surveyed 385 postpartum women and mothers of 230 children at baseline and 357 postpartum women and mothers of 157 children after one year of programme intervention in 2020. For morbidity and its management related indicators, all the high-risk women suffering from severe maternal anaemia and pregnancy-induced hypertension (PIH) and children suffering from severe acute malnutrition and low birth weight reported at the selected PHCs was surveyed. We analysed programme coverage and calculated concordance rate by compare data from e-Mamta for the same respondents at baseline and TeCHO+ after a year of implementation.

Objective 3: Estimate the incremental cost-effectiveness ratio of the programme

Cost-effectiveness analysis for TeCHO+ was done using decision analytic modelling for pregnant women and children. A decision tree was parameterized on MS-Excel spreadsheet to estimate the incremental cost-effectiveness ratio.

Cost-effectiveness ratios was estimated by dividing the incremental cost of the intervention with the number of deaths averted to estimate the cost per DALY averted. We have used online DALY calculator to derive DALY i.e. https://cevr.shinyapps.io/DALYcalculation.

Proximal outputs in terms of changes in service coverage was modelled to estimate key outcome variables and DALYs averted in Gujarat According to the most commonly cited cost-effectiveness thresholds, an intervention is considered cost-effective, if the incremental cost-

effectiveness ratio or ICER (cost per DALY averted) is equal to less than per capita GDP is considered very cost-effective.[5]

Objective 4: Assess pathways to the observed programme outcome

Several factors are expected to contribute to the observed effect. To understand the pathway to change is important for any health technology assessment study. This included in-depth understanding of the contribution of factors including supportive supervision, behaviour changes among female health workers and PHC medical officers and the contribution of the software application to the observed outcome. Hence, a mixed method approach incorporating in-depth interviews in a realist paradigm was undertaken to understand the contribution of each of the programme components. Programme managers from the health & family welfare department, important stakeholders such as SEWA Rural, EMRI officials, Argusoft – the software partner, PHC medical officers, female health workers, female health supervisors and Accredited Social Health Activists were interviewed to understand the programme pathways.

RESULTS

Objective 1: Assess the incremental cost of delivering mHealth solutions

Assessment of Incremental Cost

We analysed the costs from health system perspective. The health system cost comprised of three components – 1) start-up cost, 2) implementation cost and 3) service delivery cost. Costs were then inflated from the year of purchase to the current value of product in 2020 using online calculator https://scripbox.com/plan/inflation-calculator#calculator-section. Cost of delivering preventive and curative health services at PHC and CHC was used from secondary literature.

Programme cost: The table below details the cost incurred towards implementing this programme. The cost of TeCHO+ has been annualized in order to estimate the programmatic cost.

Table 4: Incremental cost (2019-20 Prices)

Cost Parameters	TeCHO+ (Average annualized cost 2019-20) Registered beneficiaries PW: 1204590 Children: 1238430	eMamta (Average annualized cost 2019-20) Registered beneficiaries PW: 1406252 Children: 1159292	Remarks/Source
A. Start-up Cost	**48711015**	**2844713.75**	
RCH register printing	0	2844714	Primary
Mobile phones	33308735	0	Primary
Training	11536209	0	Primary
Data transfer	3866071	0	Primary
B. Implementation Cost	**47607348**	**89528553**	
Monitoring	2651128	0	Primary
Human Resource	34106688	89528553	For eMamta, 1049 (PHCs)*6300 (50% salary) *12 (months) and adjusted for 2020 price.
GVK EMRI Helpline	10849533	0	Divided by total beneficiaries registered
C. Service Delivery Cost_Pregnant Women	**2823650740**	**3247733364**	
Antenatal Care	506623446	575121908	For TeCHO+, 80.11% of total high-risk cases identified; 77.90% of total high-risk cases identified. Unit cost is taken from Prinja et al 2014
Immunization	93604709	119082825	Same as above. Unit cost is taken from Prinja et al 2014
Institutional delivery	2223422585	2553528632	For TeCHO+ 98.60%; 97% for eMamta. Unit cost is taken from Prinja et al 2016
C1. Service Delivery Cost for high-risk case management_Pregnant Women	**1195170552**	**25653918**	
Community Health Centre	1082595434	17473392	For TeCHO+, 193760.97 (90.04% of high-risk cases were managed); For eMamta, 37.5% of High-risk cases managed (14080.09). Unit cost is taken from Prinja et al 2016
Specialist care/Gynecologist/	112575118	8180526	Prinja et al 2017 (50% of total high risk)

D. Service Delivery Cost_Children	**744539348**	**291139026**	
Cost of Immunization	90321362.79	98170005.27	For TeCHO+, 77.3% (931148.07) fully immunized; For eMamta, 87.3%
Primary Health Centre (IPD/OPD)	654217986	192969021	50% of high risk (302459.28 for eMamta; 1025420.04 for TeCHO+)
D1. Service Delivery Cost for high-risk case management_Children	**1809777359**	**146837500**	
Cost for management _Community Health Centre	**1233351841**	**100068829**	For TeCHO+, 96.92% of high-risk cases identified managed; For eMamta, 26.6% of total high-risk cases identified managed.
Cost of Specialist Healthcare	576425518	46768671	50% of LBW babies
Total cost for PW_A+B+C	**2919969103**	**3340106631**	
Total cost for Children_A+B+D	**840857711**	**383512293**	
Per beneficiary Cost_Pregnant Women	**2424**	**2375**	Total start-up+ implementation+ service delivery PW divided by total beneficiaries in TeCHO+ & eMamta respectively
Per beneficiary cost_Children	**679**	**330.81**	Total start-up+ implementation+ service delivery for children divided by total beneficiaries in TeCHO+ & eMamta respectively

The annualized cost incurred for the TeCHO+ was estimated to be INR 291,99,69,103. With this investment, around 12,04,590 beneficiaries, the calculated cost per beneficiary amounted to (INR) 2424. Similarly, for eMamta, the programme cost was estimated to be INR 334,01,06,631. With this investment, around 14,06,252 beneficiaries, the calculated cost per beneficiary amounted to (INR) 2375. For the management of high-risk cases, the total calculated cost per beneficiary for high-risk management in TeCHO+ programme was (INR) 4827 and (INR) 4778 for eMamta based on secondary literature.

Service delivery cost: For management of high-risk cases, we added cost of receiving services at Community Health Centre and cost of specialist care (Gynaecologist) proposed by Prinja et al 2016 & 2017. The total calculated cost per beneficiary for high-risk management was (INR)

4827. Similarly, cost per beneficiary for high-risk management in eMamta was calculated as (INR) 4778. For children, calculated cost per beneficiary for high risk management was (INR) 3080 and (INR) 2732 for TeCHO+ and eMamta respectively. Table 5 provides detailed calculation of the same.

Table 5. Details of the cost for high-risk management (2019-20 Prices)

Parameter	**TeCHO+ (Average annualized cost @2019-20)**	**eMamta (Average annualized cost @2019-20)**	Remarks/Source
Per beneficiary cost for management of SMA/PIH	4827	4778	Per beneficiary cost added with high-risk management cost Unit cost for CHC taken from Prinja et al 2016. Unit cost for Specialist care taken from Prinja et al 2017.
Per beneficiary cost for management of LBW/SAM children	3080	2732	

Scenario analysis

We have two scenarios 1) Cost analysis without software development cost and 2) cost analysis with software cost derived from pilot project ImTeCHO.

TeCHO+ is based on success of ImTeCHO pilot. ImTeCHO software development cost was INR 46,00,000 at 2016-17 price. Annual maintenance cost was INR 36, 74, 375/-. The project was piloted in 11 PHCs. Thus for 1100 PHCs, one-time cost of software development was calculated as INR 46,00,00,000 at 2016-17. The annualized cost for software development is calculated as INR 36,74,37,500 and INR 53,22,35,151 for software maintenance at 2019-20 price. Total software cost (including maintenance cost) calculated is INR 95,73,72,441.

Table 6. Scenario analysis of total cost of TeCHO+ and eMamta

Cost Parameters	Scenario 1 Without Software cost		Scenario 2 With assumed software cost	
	TeCHO+ (Average annualized cost 2019-20)	eMamta (Average annualized cost 2019-20)	TeCHO+ (Average annualized cost 2019-20)	eMamta (Average annualized cost 2019-20)
Non-discounted				
Total cost for PW & Children	376,08,26,815	372,36,18,924	471,81,99,256	372,36,18,924
Per beneficiary Cost	1,539	1,451	1,931	1,451
Discounted (3%)				
Total cost for PW & Children	364,80,02,011	361,19,10,356	457,66,53,278	361,19,10,356
Per beneficiary Cost	**1,493**	**1,407**	**1,873**	**1,407**

Objective 2: Assess key outcome indicators for measuring programme impact

In Gujarat, eMamta was replaced by TeCHO+ which means eMamta was stopped after introduction of TeCHO+. For the study, validated eMamta data in 2018-19 yielded pre-intervention data while TeCHO+ data of 2019-20 (after one year of its introduction) was considered as post-intervention data. We have used similar indicators in both eMamta and TeCHO+ for comparability.

Pre-intervention (eMamta) data comprised of 385 women and 230 children below 2 years whereas post-intervention (TeCHO+) data comprised of 357 women and 157 children below 2 years.

Sociodemographic characteristics: The overall demographic data were similar in terms of average age, religion, caste, and socio-economic status. However, statistically significant differences were observed in all indicators.

Table 7. Sociodemographic characteristics of women

Indicators	Category	Pre-intervention (385)	Post-intervention (357)	*P* value
Age	<25	172 (44.7)	189 (52.9)	0.0243
	>25	213 (55.3)	168 (47.1)	
Religion	Hindu	178 (46.2)	123 (34.5)	
	Muslim	149 (38.7)	148 (41.5)	0.0007
	Others	58 (15.1)	86 (24.1)	
Region	Rural	123 (31.9)	98 (27.5)	0.0004
	Tribal	89 (23.1)	113 (31.7)	
	Coastal	38 (9.9)	57 (16.0)	
	Urban	135 (35.1)	89 (24.9)	
Caste	SC/ST	95 (24.7)	143(40.1)	< 0.000
	OBC	133 (34.5)	118(33.1)	
	General	157 (40.8)	96(26.9)	
	BPL	167 (43.4)	237(66.4)	
SES	APL	218 (56.6)	120(33.6)	< .0000

Quality and Coverage of routine Maternal Health Indicators

We compared changes in coverage of services in the intervention and control arm from 2018 to 2020 using difference-in-difference analysis (DID). Quality of data reporting in follow-up survey improved as compared to baseline for all the indicators except for full ANC and reporting of delivery in trust hospitals. Improvements are noted in the case of consumption of iron-folic acid (IFA) tablets, delivery reported in government hospitals, medical termination of pregnancy and early initiation of breastfeeding. The concordance rate for routine maternal health indicators (a measure of data accuracy) improved from 69.1% to 80.5%. The below Table provides coverage details of various maternal health indicators.

Table 8. Coverage of various Maternal Health Indicators

Maternal Health Indicators				
Variable	**Follow-up Survey % (N=357)**	**Baseline Field Survey %(N=385)**	**% change in Coverage between Follow-up and Baseline Field Survey**	***p*-value**
Full ANC visits	80.1	77.9	2.2	0.024
Full PNC	36.2	27.9	8.3	0.058
180 IFA Tablets	93.5	77.2	16.3	<0.0001
Delivery Place				
Government Hospitals	34.1	26	8.1	0.045
Private Hospital	60.2	66.5	-6.3	
Trust Hospital	0.8	3.7	-2.9	
Home	4.9	3.7	1.2	
Type of Delivery				
Normal	83.7	80.9	2.8	0.084
C- Section	14.6	19.1	-4.5	
Delivery Outcome				
Live Birth	98.8	98.6	0.2	0.219
Still Birth	0	0.9	-0.9	
MTP	1.2	0.5	0.7	
Breast Feeding Initiated within a 1Hour	42.7	24.2	18.5	<0.0001

Coverage of all the maternal health indicators have improved in the follow-up survey (Table 8). There is marked improvement specifically of the consumption of 180 IFA tablets (16.3 % increase in coverage) and initiation of breast feeding within an hour of birth (18.5% increase in coverage). Between the two surveys, decline was observed in delivery in private as well as trust hospitals, caesarean section deliveries and still birth.

Pearson Chi-square tests was applied to assess the association between the change in coverage of various maternal health services. The improvement in coverage of important health indicators such as full ANC examination (80.1% vs 77.9%, p-value=<0.0001), consumption of at least 180 iron-folic acid tablets (93.5 % vs 77.2 %, p-value<0.0001), and early initiation of breast feeding (42.7% vs 24.2%, p-value<0.001) were found to be statistically significant at 5% level of significant and 95% Confidence Interval.

Quality and Coverage of routine Child Health Indicators

For assessment of child health indicators our sample constituted of 12-15 months of children (Table 9). At the baseline we surveyed 230 children while during follow-up survey 157 children were interviewed.

Improvement in quality of data reporting were observed for almost all the child health indicators during the follow-up survey. However, a marginal decline of quality of reporting was found for BCG vaccination at birth (change in concordance from 96.7 to 95.2 at follow-up) and full immunization (change in concordance from 89.6 to 87.5 at follow-up). The concordance rate for routine child health indicators improved from 86.6% to 92.1%.

Table 9. Coverage of Child Health Indicators

Child Health Indicators				
Variable	**Follow-up Survey (N=157)**	**Baseline Field Survey (N=230)**	**% change in Coverage between Follow-up and Baseline Field Survey**	***p*-value**
Immunization Status				
At Birth				
BCG	95	96.1	-1.1	0.69
OPV 0	79	70.6	8.4	0.15
HBV 0	67.2	35.3	31.9	<0.0001
At 1.5 months				
OPV 1	97.5	96.1	1.4	0.553
Pentavalent 1	98.3	96.1	2.2	0.307
At 2.5 months				
OPV 2	98.3	94.1	4.2	0.095
Pentavalent 2	100	95.1	4.9	0.015
At 3.5 months				
OPV 3	95	94.1	0.9	0.783
Pentavalent 3	96.6	94.1	2.5	0.369
9 months				
MR/ Measles	85.7	93.1	-7.4	0.77
Vitamin A	84.9	91.2	-6.3	0.154
Fully immunized	77.3	87.3	-10	0.056

Coverage of immunization has increased significantly in providing HBV0 vaccine and OPV0 vaccine. However, the coverage of full immunization in children of 12-15 months of age shows a non-significant decline of 10% when compared to the findings of baseline survey.

Pearson Chi-square tests were used to assess the association between the change in coverage of various child immunization services with the launch of TeCHO+ programme. The improvement in coverage of HBV0 vaccination (67.2% vs 35.3%, p-value<0.0001) and Pentavalent 2 (100% vs 95.1%, p-value=0.015) were found to be statistically significant at 5% level of significance and 95% Confidence Interval.

Matched case analysis

Since the eMamta data is considered as control, it could have resulted in bias in the analysis. To minimize this, propensity score method (PSM) was used to control demand side characteristics among women in intervention and control groups which could influence utilization of various MCH services. Thus, each woman in the intervention arm was matched on the basis of socio-demographic characteristics (such as religion, caste, region, socio-economic status).

After matching, the women from intervention and control arms (n=250 each) were similar in terms of all socio-demographic characteristics, except the distribution of religion. However, the difference was very small – 41.5% and 38.5% were Muslims in both intervention and control arm.

We found a statistically significant change in ANC/PNC visits, IFA consumption, high risk identification, referral, and breastfeeding within an hour between intervention and control arm. However, there was statistically insignificant change in institutional delivery, 2 TT received, and child immunization (Table 10).

Table 10. Impact of mHealth intervention on various health indicators in Gujarat from 2018-19 to 2019-20 (Matched cases)

Indicators	Difference-in difference parameters for various maternal and child health indicators					
	Estimate	Std. Error	*t* value	*P* value	Lower Limit	Upper Limit
Full ANC visits received	0.1154	0.0212	5.987	<0.0001	0.09232	0.13848
180 IFA consumption	0.0322	0.0403	0.743	<0.0001	0.02576	0.03864
2 Immunization (TT) received	0.1348	0.0237	2.961	0.3734	0.10784	0.16176
High risk (SMA) identified	0.1312	0.0274	5.823	<0.0001	0.10496	0.15744
High risk (PIH) identified	0.1211	0.0563	2.013	<0.0001	0.09688	0.14532
Referred	0.0402	0.0422	2.112	<0.0001	0.03216	0.04824
Institutional delivery	0.0206	0.0546	2.013	0.3734	0.01648	0.02472
Breastfed child within an hour	0.0120	0.0201	5.143	<0.0001	0.0096	0.0144
Immunization of child	-0.05432	0.06387	0.785	0.3734	-0.043456	-0.065184

4 PNC visits	0.1030	0.0672	1.886	<0.0001	0.0824	0.1236
High risk child (SAM) identified	0.2301	0.0726	4.844	<0.0001	0.18408	0.27612
High risk child (LBW) identified	0.2102	0.0712	4.060	<0.0001	0.16816	0.25224
Referred to specialist	0.0310	0.0301	1.636	<0.0001	0.0248	0.0372

Quality of morbidity indicators among high risk pregnant women and children

Quality and coverage of health services among high risk women was evaluated. TeCHO+ programme has resulted in identification of high-risk women suffering from pregnancy induced hypertension, severe maternal anaemia or gestational diabetes as well as identification of high-risk children with low birth weight and severe acute malnutrition. During field validation all these high-risk mothers and children were found and these led us to believe that quality of reporting has improved, although without baseline estimates available we have limited confidence to report on the improvement.

Objective 3: Estimate the incremental cost-effectiveness ratio of the programme

A decision tree was parameterized on MS Excel spreadsheet to estimate change in DALYs and cost as a result of implementation of TeCHO+ compared to E-Mamta from health system perspective. Proximal outputs in terms of changes in service coverage, high-risk identification and management were modelled to estimate years of life lost (YLL) to premature maternal and child mortality and reduction of disability adjusted life years (DALY).

Transition probabilities were derived from primary as well as secondary literature. Details of transition probabilities and other data used for populating the decision tree is presented below. The Table 11 shows data considered for purpose of decision analytic modelling in intervention and control arm.

Table 11. Calculation of transition probabilities for intervention and control arm (Pregnant Women)

Transition from and to		**Intervention: TeCHO+**		
Transition from	**Transition To**	**Transition Probabilities**	**%**	**Source**
Intervention Arm				
Antenatal Care	Full ANC	0.801	80.110	Primary
Antenatal Care	Not received ANC	0.199	19.890	Primary

Full ANC	High risk	0.220	22.030	Primary
Full ANC	No High risk identified	0.780	77.970	Primary
High risk	SMA	0.778	77.780	Primary
High risk	PIH	0.222	22.220	Primary
High risk- SMA	Managed	1.000	100.000	Primary
High risk - SMA	Not managed	0.000	0.000	Primary
High risk- PIH	Managed	0.550	55.000	Primary
High risk- PIH	Not managed	0.450	45.000	Primary
Managed SMA	Survived	0.999	99.902	Derived from mortality
Managed SMA	Died	0.001	0.098	Derived from Prinja at al 2018 (0.2% mortality among pregnant women received ANC care)
Not managed-SMA	Survived	0.000	0.000	Zero cases were unmanaged
Not managed-SMA	Died	0.000	0.000	Zero cases were unmanaged
Managed PIH	Survived	1.000	99.970	Derived from mortality
Managed PIH	Died	0.000	0.025	Derived from Prinja at al 2018 (18% mortality among pregnant women received ANC care)
Not managed-PIH	Survived	0.998	99.820	Zero cases were unmanaged
Not managed-PIH	Died	0.002	0.180	0.4 The Magpie Trial 2007
High Risk Not Indentified	Survived	0.361	36.143	Derived from mortality
High Risk Not Indentified	Died	0.639	63.857	Proportional [TeCHO+ data (63.86% (562/880 death of non-high risk mother)]
Full ANC not received	High risk	0.012	1.243	Assumed as eMamta
Full ANC not received	No High risk identified	0.988	98.758	Primary
High risk	SMA	0.778	77.780	Same prevalence (of Full ANC in TeCHO+) considered
High risk	PIH	0.222	22.220	Same prevalence (of Full ANC in TeCHO+) considered
High risk- SMA	Managed	0.000	0.004	Assumed as eMamta (67%)
High risk - SMA	Not managed	1.000	99.996	Derived
High risk- PIH	Managed	0.000	0.000	Assumed as eMamta (20%)
High risk- PIH	Not managed	1.000	100.000	Derived
Managed SMA	Survived	1.000	100.000	Derived from mortality
Managed SMA	Died	0.000	0.000	Derived from Prinja at al 2018 (0.2% mortality among pregnant women received ANC care)
Not managed-SMA	Survived	0.910	91.001	Derived from mortality

Not managed-SMA	Died	0.090	8.999	Derived from Maternal death review-Gujarat (9% maternal mortality)
Managed PIH	Survived	0.99975	99.975	Derived from mortality
Managed PIH	Died	0.00025	0.025	18% mortality The Magpie Trial 2007
Not managed-PIH	Survived	0.600	60.000	Derived
Not managed-PIH	Died	0.400	40.000	40% mortality The Magpie Trial 2007
High Risk Not Indentified	Survived	0.361	36.143	Derived from mortality
High Risk Not Indentified	Died	0.639	63.857	Proportional [TeCHO+ data (63.86% (562/880 death of non-high risk mother)]
Children	High risk	0.828	82.803	Primary
Children	Not high risk	0.172	17.197	Primary
High risk children	LBW	0.608	60.769	Primary
High risk children	SAM	0.392	39.231	Primary
Identified LBW	Managed	1.000	100.000	Primary
Identified LBW	Not managed	0.000	0.000	Primary
Identified SAM	Managed	0.922	92.157	Primary
Identified SAM	Not managed	0.078	7.843	Primary
LBW managed	Survived	0.996	99.629	Derived from mortality
LBW managed	Died	0.004	0.371	Derived from Prinja at al 2018 (0.47% neonatal mortality with treatment)
LBW not managed	Survived	0.000	0.000	Zero cases were unmanaged
LBW not managed	Died	0.000	0.000	Derived from Prinja at al 2018 (11.3% mortality)
SAM managed	Survived	1.000	99.978	Derived from mortality
SAMmanaged	Died	0.000	0.022	Derived from Prinja at al 2018 (0.047% neonatal mortality with treatment)
SAM not managed	Survived	0.998	99.792	Derived from mortality
SAM not managed	Died	0.002	0.208	5.2% mortality (Burza et al 2016)
High Risk Not Indentified	Survived	0.995	99.541	Derived from mortality
DALYs_Died		1		
DALYS_SMA_Survived		0.147		
DALYs_PIH_Survived		0.049		
DALYs_Died		1.000		
DALYS_LBW_Survived		0.060		
DALYS_SAM_Survived		1.331		
DALYS_High risk not identified		0.000		
Cost_Programmatic		2351.3		
Cost_SMA		4682.23		
Cost_PIH		4682.23		
Cost_Programmatic		658.60		
COST_LBW		2987.57		
COST_SAM		2987.57		
Avg age of Cohort		23.20		

Avg age of death		23.90		
Transition from and To		**Control: EMamta**		
Transition from	**Transition To**	**Transition Probabilities**	**%**	**Source**
Control Arm: EMAMTA				
Antenatal Care	Full ANC	0.763	76.3	Primary
Antenatal Care	Not received ANC	0.237	23.7	Primary
Full ANC	High risk	0.02670	2.67	Primary
Full ANC	No High risk identified	0.97330	97.33	Primary
High risk	SMA	0.37500	37.50	Primary
High risk	PIH	0.62500	62.50	Primary
High risk- SMA	Managed	0.67000	67.00	Primary
High risk - SMA	Not managed	0.33000	33.00	Primary
High risk- PIH	Managed	0.20000	20.00	Primary
High risk- PIH	Not managed	0.80000	80.00	Primary
Managed SMA	Survived	0.99730	99.73	Derived from mortality
Managed SMA	Died	0.00270	0.27	Derived from Prinja at al 2018 (0.2% mortality among pregnant women received ANC care)
Not managed-SMA	Survived	0.99910	99.91	Derived from mortality
Not managed-SMA	Died	0.00090	0.09	Derived from Maternal death review-Gujarat (9% maternal mortality)
Managed PIH	Survived	0.99820	99.82	Derived from mortality
Managed PIH	Died	0.00180	0.18	Derived from Prinja at al 2018 (18%)
Not managed-PIH	Survived	0.98400	98.40	Derived from mortality
Not managed-PIH	Died	0.01600	1.60	40% Magpie Trial 2007
High Risk Not Indentified	Survived	0.36143	36.14	Derived from mortality
High Risk Not Indentified	Died	0.63857	63.86	Proportional [TeCHO+ data (63.86% (562/880 death of non-high risk mother)]
Full ANC not received	High risk	0.01750	1.75000	Primary
Full ANC not received	No High risk identified	0.98250	98.2500	Primary
High risk	SMA	0.37500	37.50	Same prevalence (of Full ANC in eMamta) considered
High risk	PIH	0.62500	62.50	Same prevalence (of Full ANC in eMamta) considered

High risk- SMA	Managed	0.02251	2.25	Assumed same as Full ANC care in eMamta
High risk - SMA	Not managed	0.97749	97.75	Assumed same as Full ANC care in eMamta
High risk- PIH	Managed	0.00063	0.06	Assumed same as Full ANC care in eMamta
High risk- PIH	Not managed	0.99937	99.94	Assumed same as Full ANC care in eMamta
Managed SMA	Survived	0.99996	100.00	Derived from mortality
Managed SMA	Died	0.00005	0.00	Derived from Prinja at al 2018 (0.2% mortality among pregnant women received ANC care)
Not managed-SMA	Survived	0.91203	91.20	Derived from mortality
Not managed-SMA	Died	0.08798	8.80	Derived from Maternal death review-Gujarat (9% maternal mortality)
Managed PIH	Survived	0.99989	99.99	Derived from mortality
Managed PIH	Died	0.00011	0.01	18% mortality The Magpie Trial 2007
Not managed-PIH	Survived	0.60024	60.02	Derived
Not managed-PIH	Died	0.39976	39.98	40% mortality The Magpie Trial 2007
High Risk Not Indentified	Survived	0.92700	36.14	Derived from mortality
High Risk Not Indentified	Died	0.07300	73.00	Proportional [eMamta data (73% (death of high risk mother)]
Children	High risk	0.20090	20.09	
Children	No High risk identified	0.79910	79.91	
Children Identified	LBW	0.88333	88.33	Primary
Children Identified	SAM	0.11667	11.67	Primary
Identified LBW	Sought care	0.27900	27.90	Primary
Identified LBW	Did not seek care	0.72100	72.10	Primary
Identified SAM	Sought care	0.20000	20.00	Primary
Identified SAM	Did not seek care	0.80000	80.00	Primary
LBW managed	Survived	0.99993	99.99	Derived from mortality
LBW managed	Died	0.00007	0.01	Derived from Prinja at al 2018 (0.47% neonatal mortality with treatment)
LBW not managed	Survived	0.95706	95.71	Derived from mortality
LBW not managed	Died	0.04294	4.29	Derived from Prinja at al 2018 (11.3% mortality)
SAM managed	Survived	0.99959	99.95900	Derived from mortality
SAM managed	Died	0.00041	0.04100	Derived from Prinja at al 2018 (0.047% neonatal mortality with treatment)
SAM not managed	Survived	0.99688	99.68800	Derived from mortality
SAM not managed	Died	0.00312	0.31200	5.2% mortality (Burza et al 2016)
High Risk Not Indentified	Survived	0.97200	97.20	Derived from mortality

High Risk Not Indentified	Died	0.02800	2.80	SRS Bulletin of Infant Mortality 2018 (28 death per 1000)
DALYs_Died		1.0000		
DALYS_SMA_Survived		2.3566		
DALYs_PIH_Survived		3.1386		
DALYs_Died		1.0000		
DALYS_LBW		1.7337		
DALYS_SAM		1.8000		
DALYS_Healthy		0.0000		
Cost_Programmatic		2303.92		Discounted (3%)
Cost_SMA		4634.83		Discounted (3%)
Cost_PIH		4634.83		Discounted (3%)
Cost_Programmatic		320.89		Discounted (3%)
COST_LBW		2649.87		Discounted (3%)
COST_SAM		2649.87		Discounted (3%)
SAM managed	Died	0.00041	0.04100	Derived from Prinja at al 2018 (0.047% neonatal mortality with treatment)
SAM not managed	Survived	0.99688	99.68800	Derived from mortality

DALY for respective disease condition are presented in below Tables

Table 12. DALY calculation for Severe Maternal Anemia

DALY: Severe Maternal Anemia			
Severe Maternal Anemia	**TeCHO+**	**E-Mamta**	**Source**
Average age of onset	23.2	23.2	Primary
Average age of maternal death	23.9	23.9	Prinja et al 2018
Incidents	49	57	Primary
Deaths	0.098	4.41	For E-Mamta, 9% maternal death as per Maternal Death Review – Gujarat 2018-19 0.2% maternal death who availed full ANC reported by Prinja et al 2018
Disability Weight	0.149	0.149	GDB -2019
Life Expectancy at the age of premature death	50.29	50.29	WHO Standard Life Expectancy (71 is the LE as per https://niti.gov.in/content/life-expectancy)
YLL	0	125.96	
YLD	7.19	8.37	
DALY (Population level)	**7.19**	**134.33**	
DALY per beneficiary	**0.147**	**2.357**	

Table 13. DALY calculation for Pregnancy Induced Hypertension

DALY: Pregnancy Induced Hypertension			
Pregnancy Induced Hypertension	**TeCHO+**	**E-Mamta**	**Source**
Average age of onset	23.2	23.2	Primary
Average age of death	23.9	23.9	Prinja et al 2018
Incidents	14	16.3	Primary data
Deaths	0.0252	1.63	For E-Mamta, 10% maternal death based on Maternal Death Review – Gujarat 2018-19 0.18% maternal death who availed treatment of PIH reported by Prinja et al 2018
Disability Weight	0.049	0.049	GDB -2019
Life Expectancy	50.29	50.29	WHO Standard Life Expectancy (71 is the LE as per https://niti.gov.in/content/life-expectancy)
YLL	0	50.39	
YLD	0.68	0.77	
DALY (Population level)	**0.68**	**51.16**	
DALY per beneficiary	**0.049**	**3.139**	

Table 14. DALY for Severe Acute Malnutrition

DALY: Severe Wasting			
Severe Wasting	**TeCHO+**	**E-Mamta**	**Source**
Average age of onset	1.2	1.2	Primary
Average age of death	2.8	2.8	Primary
Incidents	51	51	E Mamta had identified only 7 incidents. We assumed that incidents would be at-least 51 but could not be captured by EMamta
Deaths	2.091	2.652	For E- Mamta, 5.2% mortality without treatment as per Burza et al 2016 4.1% infant death who availed treatment as per Collins et al 2006
Disability Weight	0.128	0.128	GDB -2019
Life Expectancy	70.54	70.54	WHO Standard Life Expectancy
YLL	55.22	82.83	
YLD	12.67	12.67	
DALY	**67.89**	**95.5**	
DALY per beneficiary	**1.331**	**1.873**	

Table 15. DALY calculation for moderate motor impairment due to pre-term birth

DALY: Moderate motor impairment due to pre-term birth			
	TeCHO+	**E-Mamta**	**Source**
Average age of onset	1	1	Primary
Average age of death	2	2	Primary
Incidents	79	51	E Mamta had identified only 7 incidents. We assumed that incidents would be at-least 51 but could not be captured by EMamta
Deaths	0.371	2.652	For E- Mamta, 5.2% mortality without treatment as per Burza et al 2016
			4.1% infant death who availed treatment as per Collins et al 2006
Disability Weight	0.0061	0.128	GDB -2019
Life Expectancy	70.54	70.54	WHO Standard Life Expectancy
YLL	0	85.35	
YLD	4.75	3.06	
DALY	**4.75**	**88.42**	
DALY per beneficiary	0.060	1.734	

Cost-effectiveness analysis

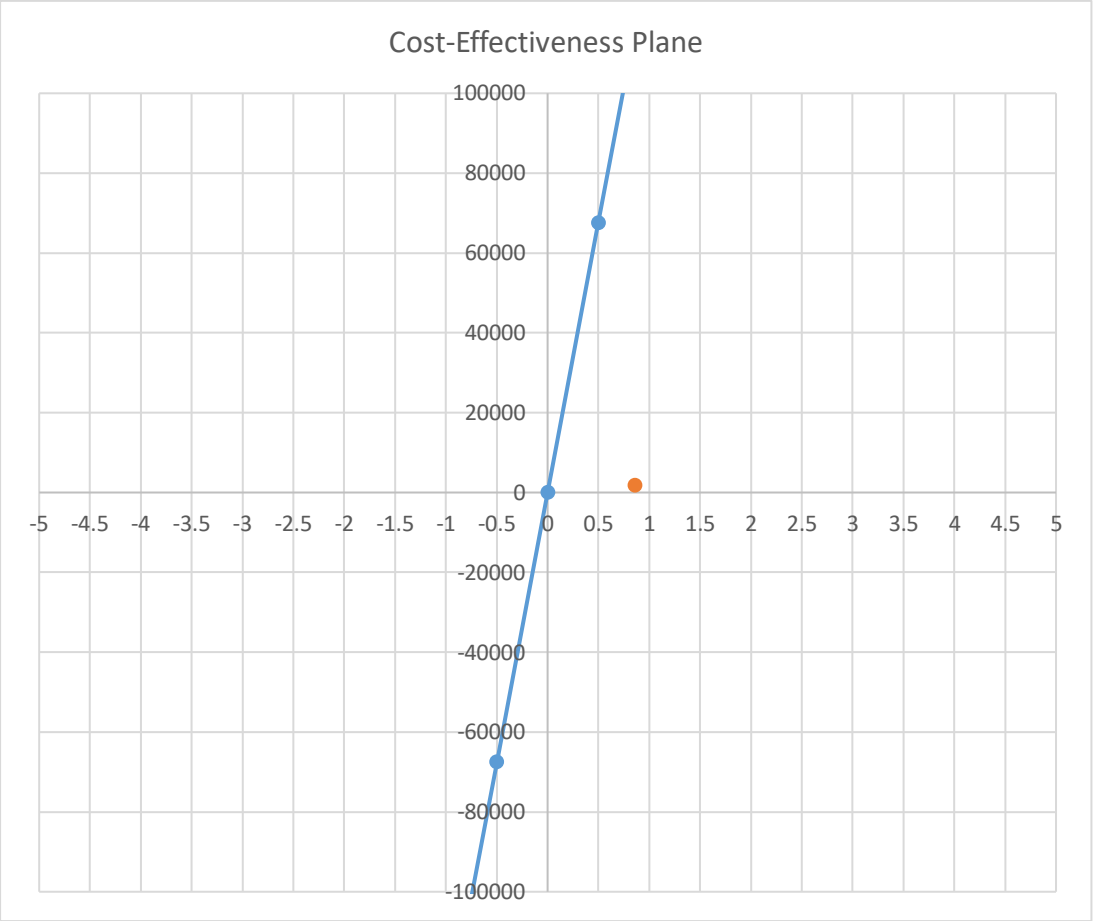
Cost-effective analysis for the TeCHO+ was done based using the decision tree model. From health system perspective, TeCHO+ incurs an incremental cost of INR 1802.84 per DALY averted of pregnant women and children which is 1.19% of the GDP per capita of India.

Table 16: Incremental Cost-Effectiveness Ratio (ICER) for TeCHO+

Difference in Cost	1549.33
Difference in DALY	0.859
ICER	1,802.84

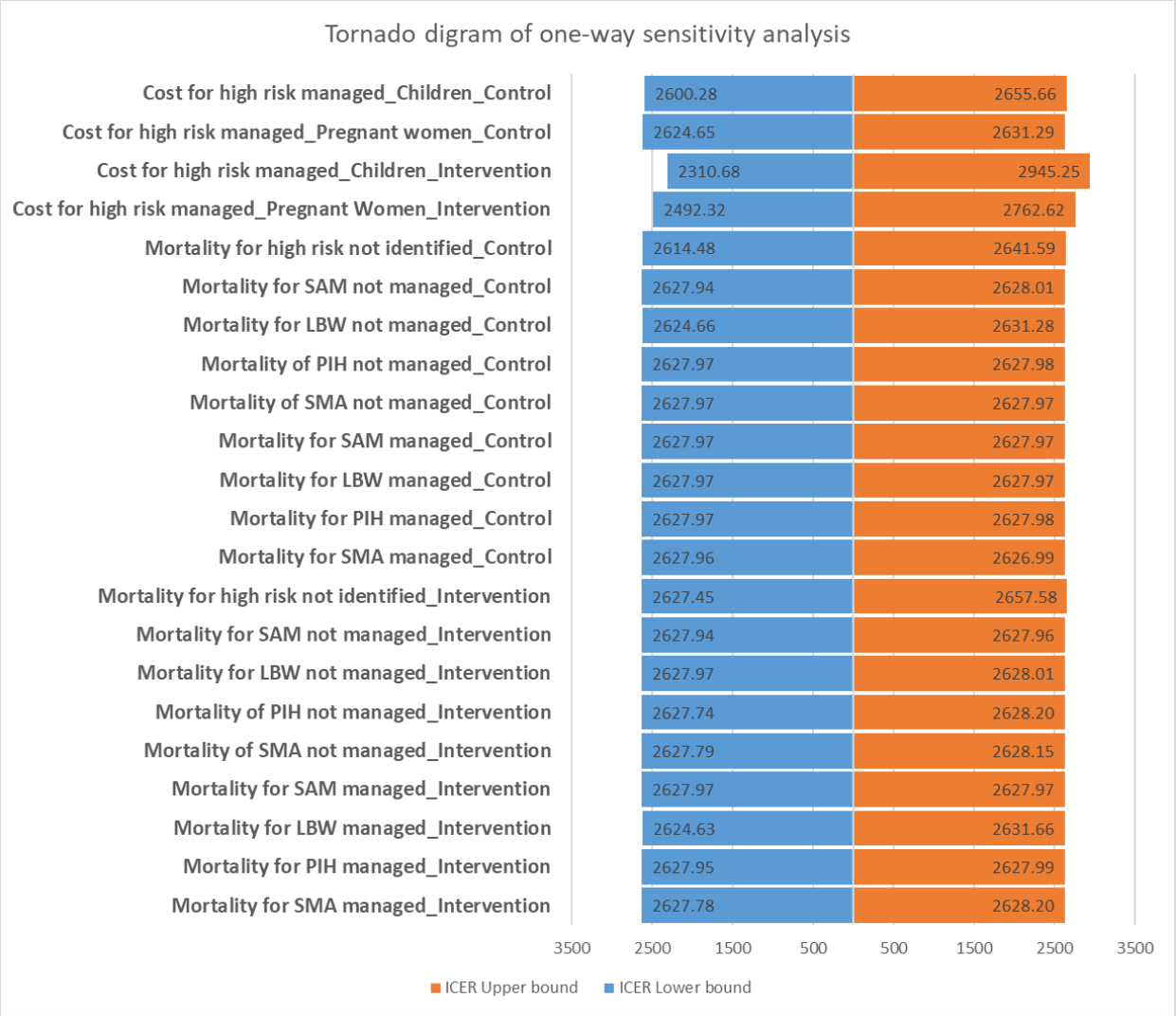
Figure 4 illustrates cost-effectiveness plane.

Figure 4. Cost-Effectiveness Plane with incremental effectiveness ratios, for Pregnant Women



One-way sensitivity analysis was applied. Figure 5 presents results from simulations done as part of one-way sensitivity analysis. The tornado diagram of one-way sensitivity analysis shows that ICER remains largely unchanged even if the input parameter is changed in multiple indicators.

Figure 5. Tornado diagram of one-way sensitivity analysis for pregnant women

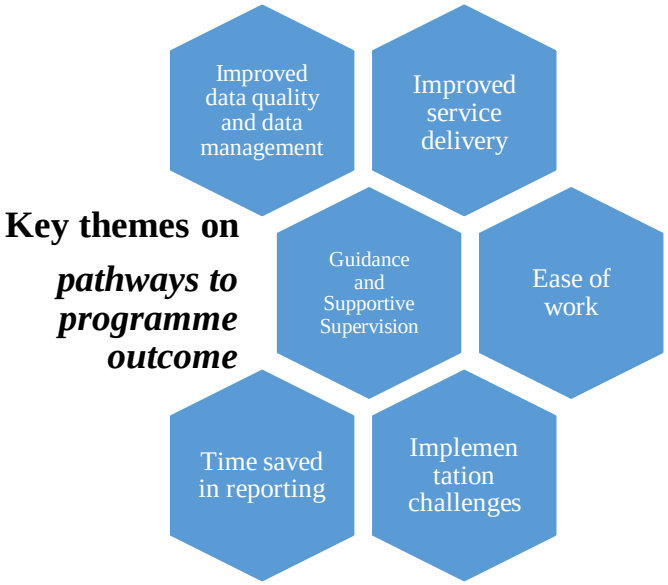


As illustrated in above figure, minor variation is noted except cost of high-risk managed children. With GDP per capita of nearly INR 1,51,760 (2019-20), the TeCHO+ program is very cost-effective for reducing maternal and child mortality from India health system perspective. Accounting for all the uncertainties in the analysis, there is 90% probability of TeCHO+ program to be cost-effective at willingness to pay threshold of INR 18, 500, which is only 12.19% of per capita GDP of India in 2019 (Figure 6).

Objective 4: Assess pathways to the observed programme outcome

We have assessed pathways for observed programme outcomes based on the feedback from key stakeholders. Feedback from stakeholders, primarily ANM, Medical Officers (MO), and

Data Entry Operators (DEO) on TeCHO+ were gathered. Using thematic content analysis, following six themes were emerged from the data.



Improved data quality and data management

Approximately 41 per cent participants (ANM & MO) believed that TeCHO+ has improved data quality due to improved monitoring by real-time data entry, auto-generation of micro-plan for each ANM, and auto-generation of report. Users have perceived TeCHO+ as a more reliable source of the beneficiary data.

> "Every day during log-in, we receive our work plan." - ANM
>
> "Report is auto-generated for ANM, for us [Medical Officer] as well as District, and State level officials." - A Medical Officer
>
> "The data of TeCHO+ is more reliable due to close supervision and software mechanism." - A Medical Officer

Improved service delivery

TeCHO+ programme has in-turn improved service delivery. Seventy per cent participants have affirmed that TeCHO+ programme has increased registration of early ANC, prevented duplication and false entry, improved coverage and enabled timely service delivery through the high-risk alert system.

> "Alerts for vaccination, high risk case helps us identify risk-cases early and enable us to provide timely services including referral" - ANM

Guidance and Supportive Supervision

The programme has strong guidance and supportive supervision mechanism in terms of the use of WhatsApp group, helpline, and timely instructions from supervisors. WhatsApp group of ANMs, Taluka and District TeCHO+ Coordinators was created for continuously communicating field level operational problems as well as solutions.

> "…receiving immediate solution for field problems over WhatsApp and voice calls is very helpful." An ANM

> "we check WhatsApp frequently in a day for updates. We all put query if confused at any level and our problems are immediately resolved by superiors."- A Medical Officer

Medical Officers expressed that the WhatsApp group helped them motivate and share necessary instructions to ANMs. Urgent issues were sorted out using voice calls. ANMs were also provided with the Helpline number (operated by Emergency Management Research Institute) for any field-level problems.

In addition to this mechanism, good works by ANMs were appreciated through WhatsApp which not only built confidence and promoted peer-mentoring but also encouraged many poor-performing ANMs to enhance their work.

Flexible and prompt solution-focused decisions from the state programme team prevented hindrances in implementation. Dang district had cellular network problems which were aptly addressed by providing flexibility to such district officials in choosing an available cellular service provider. Furthermore, the programme has decentralized actions at the district level to address field level challenges locally.

Ease of work

Generally, TeCHO+ is perceived to be easier and effective by both ANM and MO. Seventy-three per cent users reported that TeCHO+ has improved their work. Users have perceived responsive TeCHO+ application as the reason for easing their work. ANM stated user-friendly application, use of regional language in the application, timely software update, and self-assessment of work are key strengths of the programme.

"Identifying beneficiary from line list and locating beneficiary's house is easy through TeCHO+" - ANM

"…with TeCHO+, I don't need to carry register." - ANM

In addition, MO reported that having the supervisor's check in-built has added value to the programme.

"Prior to TeCHO+, I had to manually prepare my field visit report after I return and it was difficult to monitor action taken by the supervisee. Now, I can immediately record my observation and can track. – A Medical Officer

Time saved in reporting

ANM reported saving their data entry and reporting time. About 94% of participants felt no need to spare extra time for micro-planning and preparing monthly reports. An important innovation under the TeCHO+ programme is an auto-generated work micro-plan.

On an average, an ANM saved 1.7 hrs per day after the implementation of the TeCHO+ programme. DEO reported saving 1.5 hrs per day after introducing TeCHO+. This value can be true if manual data reporting is entirely eliminated, as in few instances, ANM have reported maintaining manual reporting.

TeCHO+ was found to be saving an average of 1.7 hrs per day for ANM. DEO reported saving 1.5 hrs per day after introducing TeCHO+. This value is considered based on the condition of the elimination of manual reporting.

Implementation challenges

The state-wide rollout of the TeCHO+ programme was accompanied by various challenges. Engaging the cadre of ANM and training them, fast scaling up, sequencing, technical human resources for monitoring the progress were crucial challenges. The programme was approved and started in the middle of the financial year 2017-18. Initially, there were issues in the timely procurement of the needed quantities of mobile phones and staff recruitment. This had repercussions in terms of limited in-person training and commencing Family Health Survey across the State. However, over time the State managed to tide over these challenges.

Apart from administrative programmatic challenges, software and operational related issues were also observed. Slow internet speed, frequent software hangs, unavailability of editing or deleting options, difficulties in understanding medical terminology in English, issues in data entry (such as software asks for repeated entry on full-name of a beneficiary, date of birth, height, blood group, LMP, Tubal Ligation, date of CU-T insertion while updating any information about beneficiary) came out as issues faced at the initial stage.

ANMs, mostly those in their fifties, were first-time smartphone users. They were enthusiastic and readily accepted the new technology but reported facing difficulties in learning the use of mobile. Participants (especially ANM) demanded more in-person training as training through satellite system (SATCOM) were deemed inadequate to clarify doubts. ANMs have also reported difficulties in coordinating with other ANMs regarding in/out migration of beneficiaries. Few ANMs (11%) reported a high work burden as they were also maintaining a manual register with a fear of losing mobile data.

Indeed, positive experiences encourage the grassroots team to continue using TeCHO+; implementation bottlenecks need to be addressed. It is essential to mention that many of the challenges have been addressed by the State Government. For example, the Government has introduced a better mechanism to address the migration issue, added medical terminologies in vernacular language - Gujarati.

Budget Impact Analysis

Budget Impact Analysis (BIA) has been performed to estimate the cost for the roll-out of TeCHO+ at the National level. The BIA has been performed at 2020 Prices. The Budget Impact Analysis depicts budget allocation for the five years. The state-wide scale-up for other states would cost INR 283,21,74,314 for the first year, with lower costs in subsequent years. This cost is exclusive of software cost as software cost is highly variable. The estimated cost for the software derived from the "IamTeCHO" trial is INR 95,73,72,441 for the first year and INR 53,22,35,151/- maintenance cost subsequent years.

The nationwide scale cost covering 1,52,326 sub-centres in the country is projected. The budget for 1st year is INR 7804,66,95,803/-. The budget of subsequent years is on the lower side except for the fifth-year budget, which is higher (INR 8608,94,49,343) considering 90% of service coverage, mobile replacement and the need for short orientation trainings.

Table16. Budget impact analysis of TeCHO+ program

National Level (2020 Proces)											
Sr. No.	**Budget Head**	**Items**	**Unit Definition**	**Units**	**Unit price**	**Annualized cost (INR)**					**Assumptions and Sources**
						Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
A	Start-up cost	Mobile phones	Sub Centre	1,52,326	4,579	69,75,23,602.90	2,09,25,708.09	2,09,25,708.09	2,79,00,944.12	4,18,51,416.17	Sub Centre as per Rural Health Statistics Bulletin (RHS) 2014. Assumed 30% of the phones will be damaged or require service in year 2 & 3. Year 4, 40% mobile phones may require to be replaced and in year 5, 60% mobile phones may require replacement.
		Data transfer	Sub Centre	1,52,326	531.49	8,09,59,745.74	-	-	-	-	Health and Family Welfare Statistics in India 2019. Software was provided by the company on probono basis. Hence, we have not included software cost. Data transfer cost is calculated based on the cost incurred by the State divided by number of ANC registration at Mother and Child Tracking software.
		Training	Sub Centre	1,52,326	1,586	24,15,81,607	-	-	-	24,17,02,398	50% of training cost is planned in fifth year.
Total (A)						**1,02,00,64,956**	**2,09,25,708**	**2,09,25,708**	**2,79,00,944**	**28,35,53,814**	
B	Recurrent Cost	Monitoring/review	Sub Centre	1,52,326	375.51	5,71,99,936	8,17,78,568	8,17,78,568	8,17,78,568	8,17,78,568	
		Human Resource Cost	Individuals	7,341	1,07,592	78,98,33,459	79,02,28,376	79,06,23,490	79,10,18,802	79,14,14,311	718 district coordinator/6,612 blocks-part time and 11 at National level. 5% annual increment
		Helpline (for monitoring and troubleshooting)	ANC registered	2,87,87,946	9	25,90,91,514					
		Service Delivery Cost_Full ANC & immunization coverage	Full ANC coverage/immunization	2,30,30,356	622	14,32,48,81,432	14,32,48,81,432	14,32,48,81,432	14,32,48,81,432	14,33,77,73,825	Assume that full ANC coverage will be steady at 80% and at fifth year it will reach to 90%.
		Service Delivery Cost_Institutional delivery	Institutional delivery	2,83,84,915	1,872	53,13,65,60,412	53,16,84,42,348	53,17,37,56,004	53,17,90,69,660	53,18,43,83,316	Assumed that institutional delivery will remain steady at 98.6%
		Service Delivery Cost_ high risk management	CHC	46,42,736	1,241	5,76,16,34,768	5,76,50,91,749	5,76,56,67,912	5,76,62,44,076	5,76,68,20,239	High risk (22.3% of total coverage i.e. 5135769.38 and out of HR identified, 90.4% of cases managed at CHC level.
		Service Delivery Cost_High Risk Case Management	Specialist care	23,21,368	1,162	2,69,74,29,326	2,69,90,47,783	2,69,93,17,526	2,69,95,87,269	11,90,49,02,454	50.3% of the high-risk cases may require specialist care
Total(B)						**77,02,66,30,847**	**76,82,94,70,256**	**76,83,60,24,933**	**76,84,25,79,807**	**86,06,70,72,714**	
						78,04,66,95,803	**76,85,03,95,964**	**76,85,69,50,641**	**76,87,04,80,751**	**86,35,06,26,528**	
Grand Total						Inflation rate (2.0%)	**78,38,74,03,883**	**78,39,40,89,653**	**78,40,78,90,366**	**88,07,76,39,058**	Average of last four years inflation (2.8+ 2.37+2.45+ 0.39/4=2)

The budget for 2nd, 3rd and 4th year depicts the annual implementation cost that will be incurred. Table 16 shows budget impact analysis and assumptions used. Additionally, we have also calculated the average inflation rate (2%) and added the cost for the second year onwards, which can be found in the last row of table 16.

DISCUSSION

Overall findings suggest that out of 13 services targeted for improvement, the TeCHO+ program has demonstrated significant improvement in 10 services namely, full ANC / PNC visits, IFA consumption, high-risk identification (Severe Maternal Anemia, Pregnancy Induced Hypertension, Low Birth Weight babies, and Severe Acute Malnutrition), referral for specialized healthcare, breastfeeding within an hour. We did not find any change in institutional delivery, two doses of TT, and child immunization despite the services being targeted as part of the TeCHO+ program. This could be the result of demand-side and supply-side interventions being implemented in Gujarat, which might have contributed to an overall improvement in institutional delivery and immunization.

Present study was found to be cost-effective. Similar results were reported by the cost-effectiveness of the 'Reducing Maternal and Newborn Deaths (ReMiND)' programmeme[7] piloted in one of the districts in Uttar Pradesh. The ReMIND was found to be a cost-saving intervention from a societal and health system perspective. ReMIND incurred an incremental cost of INR 12,933 per DALY averted and INR 3,71,577 per death averted.

The TeCHO+ primarily serves to increase the capacity of community health workers (female health workers /auxiliary nurse-midwifery) to deliver MCH services to pregnant and lactating women. The effect of better service delivery reflects in generating demand for the ANC services and uptake of these services thereof. The present study shows significant improvement in coverage of health services, the accuracy of data and reporting of various maternal and child high-risk conditions after the introduction of TeCHO+ software compared to the previous MCTS software. As per our knowledge, this is first evaluation conducted by an independent agency of a mHealth programme that is implemented at scale in India showing promising results. Similar results were observed in mHealth projects implemented in controlled setting. The ReMiND study team reported increased coverage of iron folic acid supplementation, full ANC, > 2 tetanus toxoid vaccination and ambulance usage in Kaushambi of Uttar Pradesh.

A study done by Balakrishnan et al[28] highlights the use of mobile health applications to maintain a continuum of care for maternal and child health services in Bihar and reported improvement in eight major service delivery components viz. early registration of pregnant women, three antenatal visits, tetanus toxoid immunization of the mother, iron and folic acid tablet supply, institutional delivery, postnatal home visits and early initiation of breastfeeding in the intervention areas when compared to entire Bihar. Unfortunately, there is no published evidence regarding the evaluation of large mHealth programmes at scale in India.

There are several probable reasons that might explain the results of the study. Earlier, data were maintained on paper registers by ANMs, which was later carried to data entry operators at PHC who would enter data in the e-Mamta portal, usually after few days of service provision. In contrast, data capture at the point and time of service by the service providers in the TeCHO+ software might have improved data quality. The state government decided to remove paper registers and e-Mamta software because all ANMs started using TeCHO+ within a year; this decision reduced time spent on data management. Subsequently, reports generated from the TeCHO+ software based on good quality data became a single source of truth and were extensively used by administrators for programme monitoring at every level. The TeCHO+ generated value for ANMs as well as administrators.

Limitations

There were several data gaps in the Indian context for assessing the cost-effectiveness, which we highlight here. We have used Primary Health Centre, Community Health Centre, and Specialist service delivery cost from secondary literature to represent TeCHO+ cost. Further, the TeCHO+ programme has no provision of the treatment cost; hence we have not considered treatment cost separately for each disease for the modelling.

We acknowledge the limitation of primary data on treatment outcomes and mortality as data collection was ceased due to the COVID-19 pandemic, and hence treatment outcomes and mortality data were not captured. Considering the unavailability of the data, we have not considered complications of the disease in the model. Due to the unavailability of data on mortality of healthy children, we considered infant mortality rate from the SRS bulletin 2018.

A cost-effectiveness analysis was performed using DALY as an outcome measure as disorder-specific QALY is not available in the Indian context. For Low Birth Weight, DALY was calculated using Moderate Motor Impairment due to pre-term birth as a disease condition, while for Healthy Children, 0.0 DALY was considered. More research is recommended for addressing these limitations in the future.

CONCLUSION

Cost-effectiveness analysis clearly shows that TeCHO+ is cost-effective for Mother and Child Care. It incurs an incremental cost of INR **1802.84** per DALY averted, which is below the GDP per capita of India. Overall, this study's findings indicate that the TeCHO+ programme is cost-effective and can be considered for replicating in other states or nationwide scale-up.

Despite some gaps in the available evidence, the findings indicate that TeCHO+ solutions can significantly improve health service delivery through increased data management accuracy, high-risk identification, quality and accessibility of care.

Acknowledgment

We thank Dr. Bhavesh Modi, State Nodal Officer – HTA; Dr. Chintan Patel and Dr. Goldie Sorathia from the Department of Health and Family Welfare, Government of Gujarat; and Dr. Shrey Desai from SEWA Rural for their support for the study.

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