

Cost-Effectiveness of mHealth Intervention (TeCHO+) for Improving Maternal and Child Health Indicators in Gujarat, India

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Abstract

Background: Gujarat has implemented an mHealth program, technology for community health operations-plus (TeCHO+) in 2019. TeCHO+ is a mobile and web-based application that essentially enables data entry by the frontline workers providing service at the time and place of service delivery to improve the coverage and data quality. It also facilitates early identification of morbid condition and timely treatment. This study assessed the cost-effectiveness of TeCHO+ program in Gujarat. **Materials and Methods:** The study compared key program outcome indicators before and after the launch of TeCHO+ program. As the program was launched across the State, eMamta, the previous version of mother and child tracking system was used for comparison. A decision tree was parameterized to estimate change in disability-adjusted life year (DALY) and cost as a result of implementing TeCHO+ from a health system perspective. **Results:** TeCHO+ incurred a cost of Rs. 2,624 per beneficiary against Rs. 1,075 per beneficiary under the previous eMamta program. TeCHO+ has resulted in significant DALY averted through early identification of high-risk cases both among pregnant women and children. Overall, cost-effectiveness analysis indicated that TeCHO+ incurred an incremental cost of Rs. 1802.84 per DALY averted, which is 1.19% of the GDP per capita of India (year 2020). **Conclusion:** This study concludes that TeCHO+ is cost-effective for mother and child care and can be considered for replicating.

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

INTRODUCTION

Mobile health or mHealth has been an approach used for service delivery, including communicable and non-communicable diseases and reproductive and child health. Reporting and low coverage of services were concern highlighted in the literature.^[1] The mother and child tracking system, e-Mamta, in Gujarat was inefficient because of the huge backlog in data entry. Quality of data, duplications, lack of data linking with facility, and service were areas of concerns. Female health workers had to fill 92 data columns every month, which had overburdened them as well as data entry operator at primary health centers (PHCs). The poor coverage of health services and inadequate data management pose itself as an obstacle to achieving sustainable development goals.^[2,3]

Systematic review of 14 studies conducted in 2017^[4] found mHealth interventions to be effective in improving antenatal care (ANC) and postnatal care services. The review suggested

that mHealth solutions can improve preventive maternal health care services and maternal outcomes. Innovative mobile-phone technology for community health operations (ImTeCHO) intervention – mHealth application piloted in Gujarat^[5] had reported several additional effects in terms of averting malnutrition and maternal health as well as improving coverage of essential maternal and newborn package of services. The increase in preventive service coverage led to a reduction in illness during pregnancy as well as after childbirth and during neonatal period. The implementation of ImTeCHO^[5] resulted

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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. Overall, ImTeCHO was proven to be cost-effective intervention from a program 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.^[5] Another mHealth application known as reducing maternal and newborn deaths (ReMiND)^[6] was implemented in 2012 through 259 Accredited Social Health Activist (ASHAs) in two blocks of Kaushambi District of Uttar Pradesh State of India. The incremental cost of ReMiND program was INR 12,993 (USD 205) per disability adjusted life year (DALY) averted and INR 371,577 (USD 5,865) per death averted.

Technology for Community Health Operations-Plus (TeCHO+) program in Gujarat

In response to the need for addressing above issues, the Health and Family Welfare Department, Gujarat introduced TeCHO+, a scaled-up version of ImTeCHO program across the State in 2019. TeCHO+ is a mobile and web-based application that essentially enables data entry by the front line workers providing service at the time and place of service delivery to improve the coverage and data quality. It also facilitates early identification of morbid condition and timely treatment.

The program encompassed unique features, such as real-time data entry, generates alerts for high-risk cases, tracks beneficiaries as well as health workers, web-based dashboard enables health officials at different levels to access progress reports, and extends supportive supervision to health workers.

An evaluation of the TeCHO+ program found that the program improves coverage of both maternal and child health services as well as data reporting quality of various maternal and child high-risk conditions.^[7] The current study was undertaken to assess cost-effectiveness of TeCHO+ for reducing maternal and child morbidity and mortality in Gujarat. The study assessed the incremental cost of delivering TeCHO+ solutions and estimated the incremental cost-effectiveness ratio of the program.

Materials and Method

The study compared key program outcome indicators before and after the launch of TeCHO+ program. As the program was launched across the State, eMamta, the previous version of mother and child tracking system was used for comparison.

Program cost

Cost data were collected from a health systems perspective and time horizon of 2 years. The health system cost comprised three components – 1) start-up cost, 2) implementation cost, and 3) service delivery cost. Costs were then inflated from the year of incurring to its current value at 2020 price. Cost of delivering preventive and curative health services at PHC and community health centre (CHC) was used from secondary literature.^[6]

Expenditure incurred under TeCHO+ program was obtained from program records with permission from the Health and Family Welfare Department, Gujarat. In addition, a time

usage study was conducted to assess the true cost incurred by all personnel involved in service delivery and program management. Time saved as a result of the TeCHO+ program was assessed through interviewing key stakeholders and program staffs at every level. Cost of capital items was annualized across the project life, with discounting at an annual rate of 3%.

Orientation training cost was considered since the launch of the program. Refresher training was assumed to be a recurrent activity. Cost of time spent by various technical partners of TeCHO+ program towards capacity building and resource utilization was assessed through interviews and financial record. Cost of service delivery (cost of ANC, immunization, cost of PHC and CHC level care, cost of institutional delivery, and cost of specialist care, such as gynecologist and pediatrician) was inferred from secondary literature.^[6]

Software development cost was waived off by the technology partner; hence, we could not obtain actual software development cost. To overcome this, two scenarios considered were as follows: cost analysis without software development cost and cost analysis with software cost derived from pilot project ImTeCHO.^[5]

All costs were presented in local currencies. Costs were converted to constant values and reported as annualized cost in 2019–2020 price.

Cost-effectiveness analysis

Based on observed impact of the TeCHO+ program – reported elsewhere – cost-effectiveness analysis for TeCHO+ was done using decision analytic modeling for pregnant women and children.^[6] A decision tree was parameterized to estimate change in DALYs and cost as a result of implementation of TeCHO+ compared to E-Mamta from health system perspective [Figure 1].

Evaluation based on primary survey reported that TeCHO+ program has resulted in identifying high-risk women suffering from pregnancy-induced hypertension, severe maternal anemia or gestational diabetes, and the identification of high-risk children with low birth weight and severe acute malnutrition.^[7] Based on incidence of high-risk cases reported in the primary survey and using disability weights from global burden of disease study DALY were calculated.^[8]

Transition probabilities were derived from primary as well as secondary literature. Transition probabilities estimated the risk of progression from a diseased state to survival or death, subject to effective case management. Details of transition probabilities and other data used for populating the decision tree are presented in Table 1.

According to the most commonly cited cost-effectiveness thresholds, an intervention is considered cost-effective if the incremental cost-effectiveness ratio (ICER) (cost per DALY averted) is equal to or less than per capita GDP.^[9] India's GDP per capita in 2020 was Rs. 1,45,679.

Ethic statement

Table 1: Input parameters used for cost-effectiveness analysis of TeCHO+ program

Parameters	Transition Probabilities	Source	Lower Bounds	Upper Bounds
Antenatal Care				
Full ANC under TeCHO+	0.801	Primary	0.6409	0.9613
Full ANC under eMamta	0.763	Primary	0.6104	0.9156
Full ANC not received under TeCHO+	0.012	Assumed as eMamta	0.0099	0.0149
Full ANC not received under eMamta	0.237	Primary	0.1896	0.2844
Probability of high-risk ANC TeCHO+	0.220	Primary	0.1762	0.2644
Probability of high-risk ANC eMamta	0.02670	Primary	0.0214	0.0320
Probability of SMA TeCHO+	0.778	Primary	0.6222	0.9334
Probability of SMA eMamta	0.37500	Primary	0.3000	0.4500
Probability of PIH TeCHO+	0.222	Primary	0.1778	0.2666
Probability of PIH eMamta	0.62500	Primary	0.5000	0.7500
High risk case management				
Probability of SMA management TeCHO+	1.000	Primary	0.8000	1.2000
Probability of SMA management eMamta	0.67000	Primary	0.5360	0.8040
Probability of PIH management TeCHO+	0.550	Primary	0.4400	0.6600
Probability of PIH management eMamta	0.20000	Primary	0.1600	0.2400
Probability of survival among SMA managed	0.999	Derived from mortality	0.7992	1.1988
Probability of survival among PIH managed	1.000	Derived from mortality	0.7998	1.1996
Probability of survival among missed high-risk cases	0.361	Derived from mortality	0.2891	0.4337
Children				
Probability of high-risk TeCHO+	0.828	Primary	0.6624	0.9936
Probability of high-risk eMamta	0.20090			0.2411
Probability of LBW TeCHO+	0.608	Primary	0.4862	0.0073
Probability of LBW eMamta	0.88333	Primary	0.1843	1.0600
Probability of SAM TeCHO+	0.392	Primary	0.3138	0.0047
Probability of SAM eMamta	0.11667	Primary	0.0243	0.1400
High-risk children management				
Probability of SAM managed TeCHO+	0.922	Primary	0.7373	1.1059
Probability of SAM managed eMamta	0.20000	Primary	0.1600	0.2400
Probability of LBW survived	0.996	Derived from mortality	0.7970	1.1955
Probability of survival among managed SAM	1.000	Derived from mortality	0.7998	1.1997

TeCHO+ = technology for community health operations-plus, LBW=low birth weight, ANC=antenatal care, SMA=severe maternal anaemia, PIH=pregnancy-induced hypertension, SAM=severe acute malnutrition

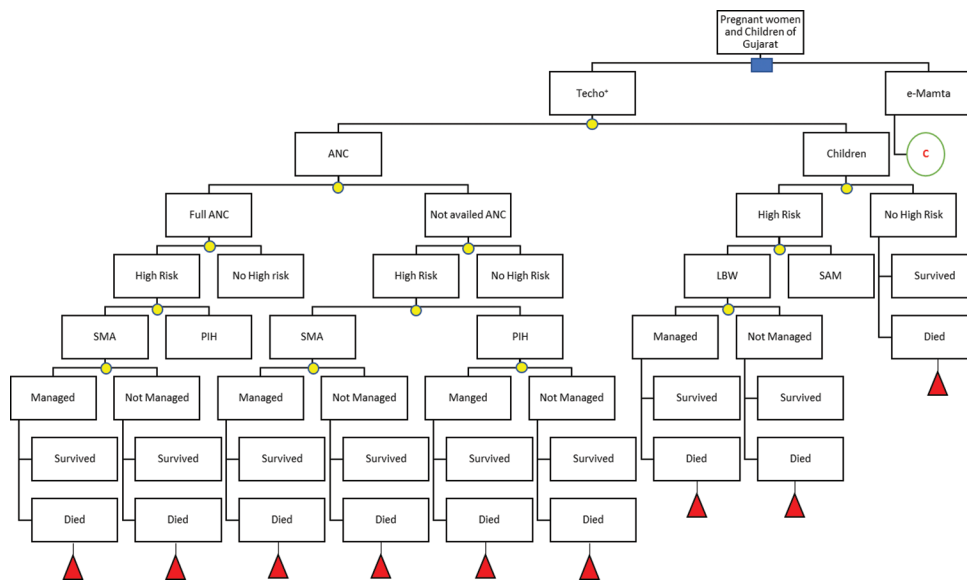


Figure 1: Decision model for TeCHO+ study. Note: ANC- Antenatal Care, SMA-Severe Maternal Anaemia, PIH-Pregnancy induced hypertension, LBW-low birth Weight, SAM-Severe Acute malnutrition

The study was approved by the Institutional Ethics Committee of Indian Institute of Public Health, Gandhinagar wide letter no. TRC-IEC No: 10/2018-19 dated 19th March 2019.

RESULTS

Assessment of program cost

Table 2 details the cost incurred towards implementing TeCHO+ program. The annualized program cost incurred for the TeCHO+ was estimated to be Rs. 3,76,08,26,815, whereas it was 3,72,36,18,924. Unit program cost per beneficiary worked out to Rs. 1,539 and Rs. 1,451 for TeCHO+ and eMamta program, respectively. The total calculated cost per beneficiary for high-risk pregnant women management was Rs. 4,827 and Rs. 4,778 for TeCHO+ and eMamta program, respectively. For high-risk children, the cost worked out to Rs. 3,080 and Rs. 2,731, respectively, for the two programs. Unit program

cost should be inferred along with the cost of high-risk case management and overall incidence, as reported in Table 3, to derive the overall unit cost reported in Table 4.

DALY for morbidities among pregnant women and children

DALY for severe maternal anemia, pregnancy-induced hypertension, severe wasting, and moderate motor impairment because of the pre-term birth was calculated both for TeCHO+ and eMamta program [Table 3]. This clearly shows TeCHO+ has resulted in significant DALY averted through early identification of high-risk cases both among pregnant women and children.

Cost-effectiveness analysis

As depicted in Table 4, TeCHO+ incurred an incremental cost-effectiveness ratio of 1,802.84 per DALY averted of pregnant women and children that is 1.19% of the 2020 GDP per capita of India. It means that the program is highly cost-effective.

One-way sensitivity analysis was applied. Figure 1 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. As illustrated in the Figure 2, minor variation is noted except cost of high-risk managed children. This is less than 1.19% of India's per capita GDP of Rs. 1,45,678 in 2020; the TeCHO+ program is very cost-effective for reducing maternal and child mortality from India health system perspective.

DISCUSSION

Cost-effectiveness analysis clearly shows that TeCHO+ is very cost-effective for mother and child care with incremental cost of Rs. 1,802.84 per DALY averted. Similar results were reported by the cost-effectiveness of the ReMiND program^[6] 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 Rs. 12,933 per DALY averted and Rs. 3,71,577 per death averted.

TeCHO+ primarily serves to increase the capacity of front line health workers to deliver services to pregnant women and children. 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 high-risk conditions after the introduction of TeCHO+ program compared to the eMamta program. TeCHO+ has resulted in significant DALY averted through early identification of high-risk cases both among pregnant women and children.

A study done by Balakrishnan *et al.*^[10] 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

Table 2: Incremental annualized cost at 2019-20 Prices (In Indian Rupees)

Cost Parameters	TeCHO+	eMamta
A. Start-up Cost	4,87,11,015	28,44,714
RCH register printing	0	28,44,714
Mobile phones	3,33,08,735	0
Training	1,15,36,209	0
Data transfer	38,66,071	0
B. Implementation Cost	4,76,07,348	8,95,28,553
Monitoring	26,51,128	0
Human Resource	3,41,06,688	8,95,28,553
Helpline	1,08,49,533	0
C. Service Delivery Cost for Pregnant Women	2,82,36,50,740	3,24,77,33,364
Antenatal Care	50,66,23,446	57,51,21,908
Immunization	9,36,04,709	11,90,82,825
Institutional delivery	2,22,34,22,585	2,55,35,28,632
C1. Service Delivery Cost for high-risk Pregnant Women management	1,19,51,70,552	2,56,53,918
Community Health Centre	1,08,25,95,434	1,74,73,392
Specialist care/Gynaecologist/	11,25,75,118	81,80,526
D. Service Delivery Cost for Children	74,45,39,348	29,11,39,026
Cost of Immunization	9,03,21,363	9,81,70,005
Primary Health Centre (IPD/OPD)	65,42,17,986	19,29,69,021
D1. Service Delivery Cost for high-risk Children management	1,80,97,77,359	14,68,37,500
Cost for management at Community Health Centre	1,23,33,51,841	10,00,68,829
Cost of Specialist Healthcare	57,64,25,518	4,67,68,671
Total cost for Pregnant Women	2,91,99,69,103	3,34,01,06,631
Total cost for Children	84,08,57,711	38,35,12,293
Registered pregnant women	12,04,590	14,06,252
Registered children	12,38,430	11,59,292
Programmatic cost per beneficiary	1,539	1,451
Unit cost for high-risk pregnant women management	4,827	4,778
Unit cost for high-risk children management	3,080	2,731

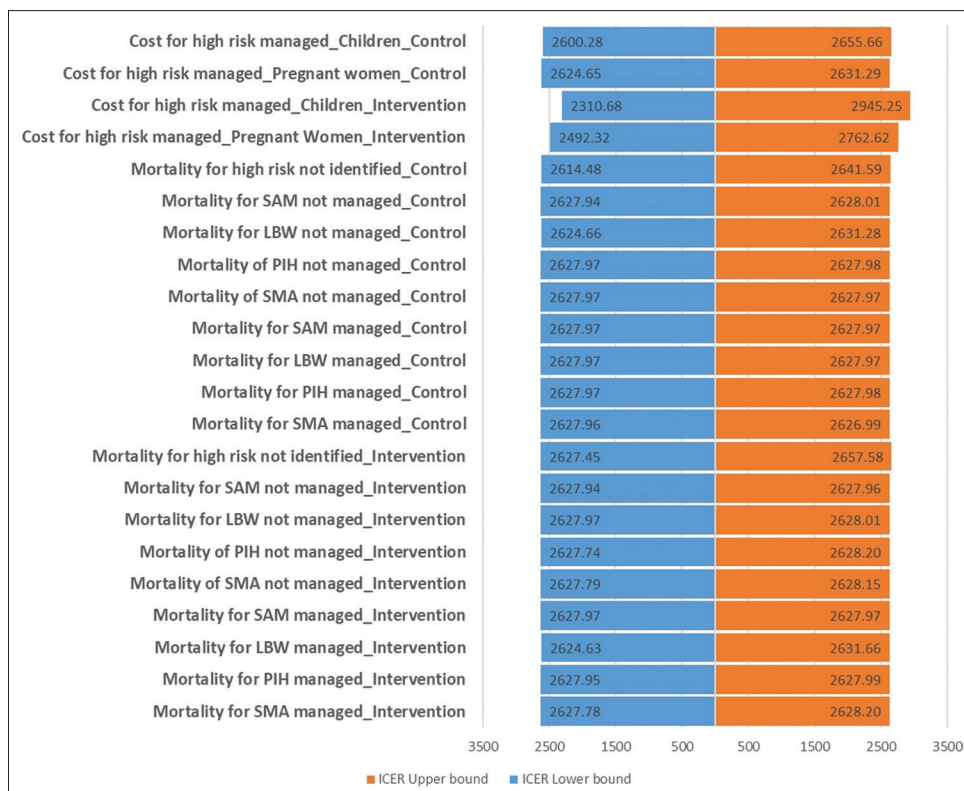


Figure 2: One-way sensitive analysis

Table 3: DALY for morbidities of pregnant women and children

	SMA		PIH		Severe Wasting		Moderate motor impairment due to pre-term birth	
	TeCHO+	eMamta	TeCHO+	eMamta	TeCHO+	eMamta	TeCHO+	eMamta
Average age of onset	23.2	23.2	23.2	23.2	1.2	1.2	1	1
Average age of death	23.9	23.9	23.9	23.9	2.8	2.8	2	2
Incidents	49	57	14	16.3	51	51	79	51
Deaths	0.098	4.41	0.0252	1.63	2.091	2.652	0.371	2.652
Disability weight	0.149	0.149	0.049	0.049	0.128	0.128	0.0061	0.128
Life expectancy at the age of premature death	50.29	50.29	50.29	50.29	70.54	70.54	70.54	70.54
Years of life lived	0	125.96	0	50.39	55.22	82.83	0	85.35
Years of life with disability	7.19	8.37	0.68	0.77	12.67	12.67	4.75	3.06
DALY per beneficiary	0.147	2.357	0.049	3.139	1.331	1.873	0.060	1.734

TeCHO+ = Technology for Community Health Operations-Plus, SMA=severe maternal anemia, PIH=pregnancy-induced hypertension, DALY=disability-adjusted life year

visits, and early initiation of breastfeeding in the intervention areas compared to entire Bihar.

TeCHO+ has reduced hours of documentation as data were collected by the service provider Auxiliary Nurse Midwife (ANMs) at the time of providing the service in real time.^[7] This has improved the data quality. As the government replaced the eMamta with TeCHO+, it becomes single source of data on mother and child health. The data generated by TeCHO+ were extensively used by program managers for monitoring and planning at every levels.

We acknowledge certain limitations of the study. Primary survey did not capture service cost for morbidity management; hence, we obtained such information from the published literature. Complications of the disease were not used in the model because of the unavailability of the data. A cost-effectiveness analysis was performed using DALY as an outcome measure as disorder-specific Quality Adjusted Life Year (QALY) is not available in the Indian context. For low birth weight, DALY was calculated using moderate motor impairment because of the pre-term birth as a disease condition.

Table 4: Cost-effectiveness ratio

Parameters	Value
Cost per beneficiary - TeCHO+	2,624.63
Cost per beneficiary - e-Mamta	1,075.30
Difference in cost	1,549.33
DALY for pregnant women and children - TeCHO+	0.642
DALY for pregnant women and children - eMamta	1.500
Difference in DALY	0.859
ICER	1,802.84

TeCHO+ = Technology for community health operations-plus, DALY=disability-adjusted life year, ICER=incremental cost-effectiveness ratio

Despite these limitations, through a robust mix of both primary and secondary data analysis, this study concludes that TeCHO+ is cost-effective for mother and child care and can be considered for replicating.

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Conflicts of interest

There are no conflicts of interest.

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