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Economic Feasibility and Budget Impact of the OncoCare mHealth Application for Digital Cancer Care in Karnataka India

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Abstract

Background

Cancer represents a significant health and economic burden in India, and catastrophic health expenditure affects 70% of cancer patients. Mobile health interventions offer promising solutions for cancer care coordination; however, comprehensive economic evaluation data remain limited in resource-constrained settings.

Objective

To conduct a micro-costing analysis of the OncoCare mHealth application development and implementation in Karnataka, India, and assess its fiscal impact within existing cancer care program budgets.

Methods

A comprehensive micro-costing analysis was conducted using a top-down approach from the provider's perspective for the 2023-24 fiscal year. Cost data were systematically collected and categorised into direct development, stakeholder engagement, and training costs. The analysis included a sensitivity analysis and a fiscal impact assessment against Karnataka's National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke, with a budget allocation of ₹10.78 crores.

Results

The total development and implementation cost was ₹1,00,372 (US$1,205), distributed across direct development costs (53.8%, ₹54,000), stakeholder engagement costs (37.0%, ₹37,111), and training costs (9.2%, ₹9,261). Mobile application development represented the largest single component (₹40,000, 39.9%). The intervention's cost represents only 0.093% of Karnataka's NPCDCS budget, with estimated annual maintenance costs of ₹15,000 (0.014% of the state budget). Sensitivity analysis revealed a total cost variation of ± 8.0%, with app development as the primary cost driver.

Conclusion

The OncoCare application demonstrates exceptional economic feasibility with minimal budgetary impact and substantial scalability potential. These findings provide compelling evidence for integrating digital health interventions in cancer care programs within resource-constrained settings.

Introduction

Cancer represents one of the most pressing global health challenges of the 21st century, with an estimated 19.3 million new cases and 10.0 million deaths worldwide in 2020(1). India faces a particularly acute cancer burden, with approximately 1.39 million new cancer cases reported in 2020, representing 8.7% of global cancer incidence (2). The age-standardised incidence rate of cancer in India is 100.4 per 100,000 population, with significant variations across different states and regions.

The economic burden of cancer care in India is substantial and multifaceted, encompassing direct medical costs, indirect costs due to productivity losses, and intangible costs related to pain and suffering. Studies indicate that the average cost of cancer treatment in India ranges from ₹50,000 to ₹15,00,000, depending on the type, stage, and treatment modality, with chemotherapy cycles alone costing between ₹10,000 to ₹1,00,000 per cycle (3). Catastrophic health expenditure affects approximately 70% of cancer patients in India, pushing many families below the poverty line (4). The National Sample Survey Office reported that cancer treatment accounts for 25% of all hospitalisations in India, with an average per-episode cost of ₹58,763 for cancer care.

Cancer care complexity extends beyond direct treatment costs, encompassing significant challenges in care coordination, medication adherence, side effect management, and long-term follow-up. Studies demonstrate that 30–50% of cancer patients experience medication non-adherence, leading to suboptimal treatment outcomes and increased healthcare utilisation (5). Poor care coordination results in treatment delays, duplicated tests, and fragmented care delivery, contributing to increased morbidity and mortality. Side effects from chemotherapy affect 80–90% of patients, with inadequate monitoring and management leading to treatment discontinuation in 15–20% of cases. These challenges are particularly pronounced in resource-constrained settings where healthcare infrastructure is limited and patient-to-provider ratios are suboptimal.

The integration of mobile health (mHealth) technologies has emerged as a promising solution to address these challenges in cancer care delivery. Systematic reviews indicate that mHealth applications in oncology demonstrate effectiveness in symptom management, medication adherence, appointment scheduling, and patient-provider communication (6). Global evidence suggests that mHealth interventions can improve medication adherence by 15–25%, reduce hospital readmissions by 20–30%, and enhance patient-reported outcomes through real-time monitoring and support (7). In low- and middle-income countries, where smartphone penetration exceeds 70%, and healthcare access is often limited, mHealth interventions offer promise for scaling cancer care support services.

Despite growing evidence of mHealth effectiveness in cancer care, a significant gap remains in economic evaluation data, particularly regarding implementation costs and fiscal impact assessments. Studies from high-income countries report development costs ranging from US$10,000 to US$500,000 for comprehensive cancer care applications; however, these estimates may not apply to resource-constrained settings with different labour costs, infrastructure requirements, and regulatory environments (8). The lack of standardised costing methodologies and comprehensive economic

evaluations limits evidence-based decision-making for mHealth implementation in cancer care programs.

India's National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) represents a significant policy framework for addressing challenges in cancer care, with a total budget allocation of ₹3,000 crores for the period 2017–2020 (9). The program emphasises strengthening cancer screening, early detection, and treatment services while promoting innovative approaches to improve the efficiency of care delivery. However, the economic feasibility of integrating mHealth interventions into existing program budgets remains unclear, highlighting the need for comprehensive cost analyses.

Karnataka state, with a population of 67.5 million and a cancer incidence rate of 106.2 per 100,000 population, represents an important setting for evaluating mHealth interventions in cancer care. The state's NPCDCS allocation of ₹10.78 crores for FY 2023-24 provides a specific context for assessing the fiscal impact of digital health innovations. The relatively high smartphone penetration rate and existing digital health infrastructure make Karnataka an ideal setting for implementing and evaluating mHealth solutions for cancer care(10).

Understanding the economic implications of mHealth implementation is crucial for informing policy decisions, allocating resources effectively, and developing scaling strategies. Micro-costing analysis provides a detailed examination of all resources required for intervention development and implementation, enabling accurate cost estimation and comparative analysis with alternative approaches (11). This methodology has increasingly been recognised as the gold standard for the economic evaluation of digital health interventions, particularly in resource-constrained settings where precise cost information is essential for sustainability planning.

The present study addresses this critical knowledge gap by conducting a comprehensive micro-costing analysis of the OncoCare mHealth application, designed to provide comprehensive cancer care support for patients and healthcare providers in Karnataka, India(12). Through detailed cost categorisation, stakeholder engagement assessment, and fiscal impact analysis, this research aims to provide evidence-based insights for policymakers, healthcare administrators, and researchers considering similar digital health interventions for improving cancer care.

Methodology

Study Design and Setting

A micro-costing analysis using a top-down approach was conducted to determine the economic costs of developing and implementing the OncoCare mHealth application for comprehensive cancer care management and patient support. This approach was selected to capture all resources utilised in the development process, allowing for a detailed examination of cost components and their relative contributions to the total cost. The study was conducted in Karnataka, India, from 2023 to 2024.

Application Development and Features

The OncoCare mobile application was developed using the Flutter framework, with Firebase serving as the backend infrastructure, to provide comprehensive support for cancer care to patients and healthcare providers. OncoCare serves as “Your Comprehensive Cancer Care Companion”, designed to empower both patients and doctors throughout the cancer treatment journey. Key features included: (1) chemotherapy scheduling and management system with automated appointment reminders; (2) comprehensive treatment records and progress tracking with user-friendly record-keeping system; (3) side effects management and monitoring with personalised insights and coping strategies; (4) notification center with real-time updates about appointments, medication reminders, and important healthcare information; (5) doctor-patient collaboration platform enabling seamless communication and shared treatment monitoring; and (6) secure user authentication with robust privacy protection measures. The application architecture incorporated Firebase Authentication for secure login, Cloud Firestore for patient data storage, Firebase Real-time Database for treatment tracking and progress monitoring, and advanced security measures to ensure confidentiality of health information. The OncoCare application was designed for and deployed among cancer patients and healthcare providers in Karnataka, where the project was actively implemented. The app aimed to support patients in taking control of their cancer journey through accessible digital tools, enhanced care coordination, and comprehensive treatment management(13).

Costing Framework

The current study employed a provider perspective to assess the costs of developing and implementing the OncoCare application. The analysis time horizon encompassed the full development cycle and the initial one-year implementation period. All costs were calculated in Indian Rupees (INR) for the financial year 2023-24, during which the actual development and implementation took place. Cost data were systematically collected and categorised into direct development, stakeholder engagement, and training costs.

Data Collection

Cost data were collected using a microcosting tool, adapted from validated digital health costing instruments, to capture all direct and indirect costs systematically. Primary data sources included project financial records, meeting minutes, purchase receipts, salary information, and semi-structured interviews with key personnel involved in the development process. For shared resources, appropriate apportioning techniques were employed to allocate costs accurately to the OncoCare project.

Cost Categorisation and Measurement

Direct development costs encompassed mobile application development by the technical team, gap assessment activities, and implementation materials (including printing, information, education, and communication materials). Stakeholder engagement costs included three key project meetings: project initiation and requirements gathering, progress review and feedback incorporation, and final validation and implementation planning. At each meeting, costs were further categorised into human resources, equipment, furniture, and space. Training costs comprised human resources, furniture and equipment, space, and computer equipment for comprehensive training sessions across urban and rural healthcare settings.

For capital items and durable goods with a lifespan exceeding 1 year, costs were annualised using a linear depreciation method with a 3% discount rate, in line with standard health economic evaluation practices.

Fiscal Impact Analysis

The fiscal impact of implementing the OncoCare application within the existing National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) was assessed by comparing the development and maintenance costs to the Karnataka state budget allocation for NPCDCS (₹10.78 crores for FY 2023-24). This analysis helped determine the budgetary feasibility of integrating the application into the state's cancer care program and assessed the potential for scaling within existing resource allocations(10).

Sensitivity Analysis

A one-way sensitivity analysis was conducted to assess the robustness of the costing results to variations in key cost parameters. Each cost component (app development, stakeholder engagement costs, implementation materials, training costs, and gap assessment) was independently varied by ± 20% while holding all other parameters constant. Results were presented in a tornado diagram to visually illustrate the relative impact of each parameter on the total cost. This analysis helped identify the most influential cost drivers and assess the stability of the cost estimates under different assumptions.

Data Analysis

All costs were calculated in Indian Rupees (INR) for the 2023-24 fiscal year, during which the actual development and implementation took place. Data were analysed using Microsoft Excel 2019 for cost calculations and Python 3.8 (matplotlib 3.5.1, pandas 1.4.2) for visualisations of sensitivity analysis. Results were reported as total costs and percentages by category, with detailed breakdowns of each cost component to ensure transparency and reproducibility.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of JSS Medical College, JSS Academy of Higher Education & Research, Mysuru (IEC reference number: JSSMC/IEC/05012022/36NCT/2021-22). All stakeholders involved in providing cost information gave informed consent for their participation. Written informed consent to participate was obtained from all participants involved in the study before data collection. The privacy and confidentiality of all cost-related data were maintained throughout the study period, and the data were stored securely in accordance with institutional guidelines.

Results

The micro-costing analysis of the Oncocare mHealth cancer care application development and implementation revealed a total cost of ₹1,00,372 (US$1,205). As shown in Table 1, this total was distributed across three primary cost categories: direct development costs (53.8%), stakeholder engagement costs (37.0%), and training costs (9.2%).

Table 1
Total costs of Oncocare mHealth application development and implementation

Cost Category	Resource Description	Unit	Quantity	Unit Cost (INR)	Total Cost (INR)
Development Phase					
Software Development	Mobile application development by the technical team	Fixed cost	1	40,000	40,000
Pre-Implementation Phase					
Human Resources	Data collectors for gap assessment (2 persons)	Person-trips	2	2,000	4,000
Implementation Phase					
Materials & Communication	IEC materials, forms, printing, and dissemination	Fixed cost	1	10,000	10,000
Total Setup Costs					**54,000**

Direct Development Costs

Direct development costs accounted for the largest share of the total budget, at ₹54,000 (53.8%). As detailed in Table 2, these costs primarily comprised mobile application development (₹40,000), implementation materials and communication (₹10,000), and gap assessment activities (₹4,000).

Table 2
Breakdown of direct development costs

Item	Cost (INR)	Percentage	Description
App Development	40,000	74.1%	One-time mobile application development by the technical team
Gap Assessment	4,000	7.4%	Data collectors for gap assessment (2 persons, travel + work)
Implementation Materials	10,000	18.5%	IEC materials, forms, printing, and dissemination
Total	**54,000**	**100%**	

Mobile application development accounted for the largest single cost component, reflecting the technology-intensive nature of the intervention. The relatively modest cost compared to commercial app development can be attributed to the academic setting and the utilisation of open-source frameworks. Implementation costs for information, education, and communication materials demonstrated a balanced approach between technology development and user education components.

Stakeholder Engagement Costs

Stakeholder engagement costs totalled ₹37,111 (37.0% of total costs) and were distributed across three strategic project meetings, as shown in Table 3. Project initiation (Meeting 1) and final validation (Meeting 3) accounted for the highest investments at 40.2% and 40.0%, respectively, while the progress review meeting (Meeting 2) accounted for 19.8%.

Table 3
Breakdown of stakeholder engagement meeting costs

Meeting	Purpose	Cost (INR)	Percentage
Meeting 1	Project Initiation & Requirements Gathering	14,900	40.2%
Meeting 2	Progress Review and Feedback Incorporation	7,340	19.8%
Meeting 3	Final Validation and Implementation Planning	14,870	40.0%
Total		**37,111**	**100%**

Each meeting's costs included multiple components, with human resources accounting for the largest share. For Meeting 1 (Project Initiation & Requirements Gathering), human resources accounted for 92.3% (₹13,750) of the total meeting cost, comprising contributions from an IT Professor, a Professor of Community Medicine, and a Medical Oncologist. The remaining costs were distributed among furniture (3.9%, ₹587), equipment (2.8%, ₹413), and space (1.0%, ₹150), with all capital items appropriately annualised using a 3% discount rate. This cost structure was representative of all three project meetings, highlighting the knowledge-intensive nature of mHealth application development for cancer care.

Table 4
Detailed cost analysis - Primary stakeholder meeting (Meeting 1)

Cost Component	Amount (INR)	Percentage (%)	Description	Annualization Method
Human Resources	13,750	92.3%	IT Professor, Community Medicine Professor, Medical Oncologist	N/A
Furniture	587	3.9%	AC, computer, chairs, table, fan, LED lights	Annual depreciation
Space	150	1.0%	Meeting room facility costs	Annual rental equivalent
Equipment	413	2.8%	Laptop and presentation equipment	Annual depreciation
Total Meeting 1	**14,900**	**100.0%**	**Comprehensive stakeholder engagement**	**-**

Training Costs

Training costs comprised ₹9,261 (9.2% of total costs), as detailed in Table 5. These costs primarily consisted of human resources (₹7,950), representing 85.9% of training expenses, with smaller allocations for furniture and equipment (₹650), space (₹360), and computer equipment (₹301).

Table 5
Training program cost analysis

Cost Component	Amount (INR)	Percentage (%)	Description
Human Resources	7,950	85.9%	Six trainers (oncologists, nurses, and medical social workers) across urban and rural locations
Furniture & Equipment	650	7.0%	Annualised costs for LED TV, chairs, tables, fans, and lights
Space	360	3.9%	Annualised cost for the training room
Equipment	301	3.2%	Annualised cost of computer systems
Total Training Costs	**9,261**	**100.0%**	**Comprehensive training program**

The training program demonstrated cost-effectiveness for comprehensive staff training across urban and rural healthcare settings. Human resources accounted for the majority of costs, reflecting the specialised nature of cancer care technology training and the need for qualified clinical instructors with expertise in both oncology and digital health platforms. The geographic distribution strategy, which employs trainers across both urban and rural locations, ensures equitable access to training while maintaining cost efficiency.

Fiscal Impact Analysis

Implementing the Oncocare mHealth cancer care application aligns with the objectives of the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS). It could be efficiently integrated within its existing budgetary framework. Based on the Karnataka state budget allocation for NPCDCS (₹10.78 crores for FY 2023-24), the total development cost of Oncocare (₹1,00,372) would represent merely **0.093% of the annual budget**.

Table 6
Fiscal Impact Analysis - Karnataka NPCDCS Program

Parameter	Value
Karnataka NPCDCS Budget (FY 2023-24)	₹10.78 crores (₹107,800,000)
Oncocare Development Cost	₹100,372
Budget Impact (%)	0.093%
Annual Maintenance Cost (estimated)*	₹15,000
Maintenance as % of NPCDCS Budget	0.014%
Cost per 1,000 beneficiaries**	₹1,004
*Estimated based on 15% of development cost for annual maintenance and updates. **Based on an estimated 100 direct beneficiaries in the pilot implementation	

The exceptionally low budget impact demonstrates that the Oncocare intervention represents a minimal financial burden while potentially achieving significant improvements in cancer care coordination and patient outcomes. If implemented through the State-specific Initiatives and Innovation component of NPCDCS, the application could enhance program effectiveness while requiring negligible additional financial resources.

The annual maintenance costs (estimated at ₹15,000, representing 0.014% of the state NPCDCS budget) compare favourably with traditional cancer care coordination systems. This minimal ongoing cost structure, combined with the preventive and supportive focus on cancer care management, suggests potential for substantial long-term cost savings through improved treatment adherence, reduced hospital readmissions, and enhanced care coordination.

Cost Structure Analysis

The cost distribution reveals several important characteristics of digital health intervention economics in cancer care:

1. **Technology-Development Focus (53.8%)**: The predominance of direct development costs reflects the one-time nature of application creation, with subsequent implementations requiring minimal additional development investment.

2. **Stakeholder-Centred Approach (37.0%)**: The substantial investment in stakeholder engagement demonstrates the importance of participatory design in healthcare technology development, ensuring user acceptance and clinical relevance.
3. **Efficient Training Model (9.2%)**: The relatively low training costs suggest an efficient knowledge transfer model, with potential to cascade training effects to additional healthcare workers.
4. **Scalability Potential**: The fixed-cost structure (90.8% of total costs) indicates substantial economies of scale, enabling additional users to be accommodated at minimal incremental cost.

The Oncocare cost structure compares favourably with traditional cancer care support systems while offering enhanced functionality, including patient monitoring, medication adherence tracking, and care coordination. The comprehensive digital platform provides 24/7 accessibility, standardised care protocols, and real-time data collection capabilities at a fraction of the cost of conventional support systems.

Sensitivity Analysis

A one-way sensitivity analysis was conducted using a tornado diagram (Fig. 1) to assess the robustness of the cost estimates and identify cost drivers with the highest potential impact. A uniform variation of ± 20% was applied to each key cost component. This range was chosen based on standard practice in economic evaluations when empirical uncertainty bounds are unavailable, and it represents a conservative estimate commonly used in public health cost studies and micro-costing analyses.

Table 7
One-way sensitivity analysis results for the Oncocare mHealth application

Cost Component	Low (-20%) (INR)	High (+ 20%) (INR)	Impact Range (INR)	Contribution to Variance (%)
App Development	92,371	108,371	16,000	39.9%
Meeting 1 (Project Initiation)	97,391	103,351	5,960	14.8%
Meeting 3 (Final Validation)	97,397	103,345	5,948	14.8%
Implementation Materials	98,371	102,371	4,000	10.0%
Training - Human Resources	98,781	101,961	3,180	7.9%
Meeting 2 (Progress Review)	98,903	101,839	2,936	7.3%
Gap Assessment	99,571	101,171	1,600	4.0%
Training - Furniture & Equipment	100,241	100,501	260	0.6%
Training - Space	100,299	100,443	144	0.4%
Training - Equipment	100,311	100,431	120	0.3%

Base Case Total: ₹100,371

The sensitivity analysis reveals that the total cost of the Oncocare mHealth application shows varying degrees of sensitivity across its cost components, with the overall cost ranging from ₹92,371 to ₹108,371, representing a ± 8.0% variation from the base case estimate. App development costs emerged as the dominant cost driver, accounting for 39.9% of the total cost variance and causing a fluctuation of ₹16,000 (±₹8,000) from the base case. This finding highlights the crucial importance of effective development methodologies, precise technical specifications, and robust project management practices in controlling overall intervention costs.

Stakeholder engagement activities, particularly the initial project initiation meeting (Meeting 1) and the final validation meeting (Meeting 3), ranked second and third among the most influential cost drivers, contributing 14.8% each to the total variance, with impact ranges of ₹5,960 and ₹5,948, respectively. The substantial impact of these meetings underscores the value of thorough planning, comprehensive requirements gathering, and effective stakeholder coordination to minimise costly revisions in later development phases. The moderate impact of Meeting 2 (Progress Review) at 7.3% of total variance suggests that mid-project adjustments, while important for quality assurance, have a more contained effect on overall costs.

Implementation materials demonstrated moderate cost sensitivity, accounting for 10.0% of total variance and an impact range of ₹4,000. This component's influence emphasises the importance of strategic procurement planning and efficient resource utilisation for educational materials, printing, and dissemination activities. Training-related human resources, although representing a high absolute cost, exhibited relatively contained cost sensitivity, accounting for 7.9% of total variance, suggesting that variations in trainer compensation or training duration have manageable impacts on overall project costs.

Notably, infrastructure-related training components demonstrated exceptional cost stability, with furniture, equipment, space, and computer equipment collectively accounting for only 1.3% of the total cost variance. The minimal impact ranges of ₹260, ₹144, and ₹120, respectively, indicate that these components exhibit remarkable price stability, suggesting that financial planning can accommodate reasonable variations in training infrastructure without substantially affecting overall project budgets.

The gap assessment component, which accounts for 4.0% of the total variance and has an impact range of ₹1,600, represents a moderate but manageable source of cost variation. This finding suggests that while pre-implementation assessment activities are important for intervention design, their cost impact remains within acceptable bounds for project planning.

These sensitivity analysis results provide several strategic insights for implementation planning and scale-up considerations. First, the predominance of app development costs as the primary cost driver suggests that investments in front-end development planning, technical architecture design, and quality assurance processes yield disproportionate returns in cost control. Organisations considering similar interventions should prioritise robust development partnerships, clear technical specifications, and agile development methodologies to optimise this critical cost component.

Second, the substantial impact of stakeholder engagement meetings indicates that comprehensive upfront planning and stakeholder alignment can significantly influence overall project costs. The relatively greater impact of initial and final meetings compared to progress reviews suggests that strategic investment in thorough requirement-gathering and validation processes can prevent costly mid-project modifications and scope changes.

Third, the remarkable stability of training infrastructure costs provides confidence for budget planning and scale-up scenarios. The minimal variation in these components suggests that training programs can be reliably costed and scaled across different implementation sites without significant uncertainty in infrastructure requirements.

Overall, the sensitivity analysis demonstrates that while the Oncocare intervention exhibits some cost sensitivity to key development and engagement activities, the total cost variation of ± 8.0% falls within acceptable bounds for health intervention planning. Identifying app development and stakeholder engagement as primary cost drivers provides clear targets for cost-optimisation efforts and supports

evidence-based resource-allocation decisions for similar digital health implementations in resource-constrained settings.

Discussion

This comprehensive micro-costing analysis of the OncoCare mHealth application provides valuable insights into the economic feasibility of implementing digital cancer care interventions in resource-constrained settings. The total development and implementation cost of ₹1,00,372 (approximately US$1,205) represents a remarkably cost-effective approach to enhancing cancer care delivery, with significant implications for policymakers and healthcare administrators considering similar digital health investments.

The cost distribution observed in this study demonstrates a well-balanced approach to mHealth development, with direct development costs accounting for 53.8% of the total budget. This finding aligns closely with previous mHealth microcosting studies from India, including the landmark ReMiND program evaluation by Prinja et al., which reported that development and technology costs accounted for approximately 60% of total implementation expenses. (14). Our results are notably lower than international benchmarks; Kumar et al. reported mHealth development costs ranging from US$10,000 to US$500,000 in high-income countries, highlighting the cost advantages achievable in resource-constrained settings through strategic use of local expertise and open-source technologies (8).

The predominance of stakeholder engagement costs (37.0%) reflects best practices in participatory design, emphasising the critical importance of user-centred development in healthcare technology. This investment pattern mirrors findings from Prinja et al.'s microcosting analysis of healthcare delivery systems, which identified stakeholder engagement as a key determinant of intervention sustainability and user adoption (15). The relatively modest training costs (9.2%) suggest an efficient knowledge transfer model, comparable to the 8–12% training allocation reported in other Indian mHealth implementations (16).

The fiscal impact analysis reveals exceptional affordability within existing healthcare budgets. The OncoCare implementation cost represents merely 0.093% of Karnataka's NPCDCS budget allocation, demonstrating substantial scope for scaling without significant budgetary strain. This finding is particularly significant when compared to traditional cancer care interventions; Chauhan et al. reported that comprehensive cancer screening programs in India require 2–5% of state health budgets, making OncoCare a highly attractive complementary intervention (3).

The estimated annual maintenance cost of ₹15,000 (0.014% of the state budget) compares favourably with international digital health sustainability models. Systematic reviews of mHealth cost-effectiveness in developing countries report maintenance costs typically ranging from 10–25% of initial development investments, positioning OncoCare within optimal sustainability parameters (17). This cost structure suggests potential for significant return on investment through improved treatment adherence, reduced hospital readmissions, and enhanced care coordination.

While this study focused on implementation costs rather than full cost-effectiveness analysis, the results can be contextualised within broader mHealth economic evaluation literature. Prinja et al.'s cost-effectiveness analysis of the ReMiND mHealth intervention demonstrated an incremental cost-effectiveness ratio of ₹12,993 (US$205) per DALY averted (18). Extrapolating from similar digital health interventions, OncoCare's cost structure suggests potential for highly favourable cost-effectiveness ratios, particularly given cancer's substantial burden of disease and the intervention's comprehensive approach to care coordination.

International evidence supports the economic value proposition of cancer-focused mobile health (mHealth) interventions. A systematic review by Gentili et al. identified mobile health applications for chronic disease management, including cancer, as consistently cost-effective with cost per QALY ratios well below established thresholds (19). The OncoCare application's multifunctional approach, encompassing appointment scheduling, medication adherence, side effect monitoring, and care coordination, positions it favourably within this evidence base.

The cost structure analysis reveals substantial scalability potential through economies of scale. With 90.8% of costs classified as fixed development expenses, marginal costs for additional users remain minimal. This finding aligns with the economic theory of digital goods and mirrors patterns observed in other successful mHealth scale-up initiatives. The ImTeCHO program in Gujarat, India, demonstrated similar scalability advantages, with per-beneficiary costs declining by 60–70% as implementation expanded from pilot to state-wide deployment (20).

The geographic distribution of training costs across urban and rural settings provides important insights for equitable implementation. The balanced approach adopted in OncoCare training (₹9,261 total with rural components) reflects recognition of India's diverse healthcare landscape. This strategy aligns with recommendations from Prinja et al.'s analysis of primary healthcare delivery costs, which emphasised the importance of tailored approaches for different healthcare settings (21).

Policy Implications and Future Directions

The findings have significant implications for health policy and resource allocation decisions. The minimal budgetary impact (0.093% of the NPCDCS allocation) suggests that mHealth interventions, such as OncoCare, can be implemented without crowding out other essential health services. This finding supports the National Digital Health Mission's emphasis on technology-enabled healthcare delivery and provides concrete evidence for decision-makers considering digital health investments.

Future research should focus on comprehensive cost-effectiveness analyses that incorporate clinical outcomes, patient-reported outcome measures, and long-term healthcare utilisation patterns. Additionally, multi-state implementation studies would strengthen the generalizability of economic findings and provide insights into regional cost variations.

Methodological Strengths and Limitations

The micro-costing methodology employed in this study follows established health economic evaluation standards, ensuring transparency and reproducibility. The use of a provider perspective with detailed cost categorisation aligns with international guidelines for digital health economic evaluation (22). The incorporation of sensitivity analysis strengthens the robustness of findings, with the ± 8.0% cost variation falling within acceptable bounds for health intervention planning.

However, several limitations warrant acknowledgement. The study was conducted in a single state context, which may limit its generalizability to other Indian states with different healthcare infrastructures and cost structures. The one-year implementation timeframe may not capture long-term maintenance and sustainability costs, though international evidence suggests that annual maintenance typically remains within the 15% range estimated in this study. Additionally, the analysis did not include effectiveness outcomes, precluding a full cost-effectiveness assessment.

Conclusion

This micro-costing analysis demonstrates that comprehensive mHealth applications for cancer care can be developed and implemented at remarkably low cost in resource-constrained settings. The OncoCare intervention's cost structure, characterised by modest total investment, minimal budgetary impact, and substantial scalability potential, provides a compelling economic case for digital health integration in cancer care programs. These findings provide valuable evidence to the growing literature on mHealth economics in developing countries and support policy initiatives that promote technology-enabled healthcare delivery.

The study's results, when viewed alongside international evidence on mHealth cost-effectiveness, suggest that well-designed digital health interventions offer a promising pathway to improve cancer care accessibility and quality while maintaining fiscal sustainability. As healthcare systems worldwide grapple with rising cancer burdens and resource constraints, the OncoCare model provides a replicable framework for leveraging technology to enhance care delivery efficiency and effectiveness.

Declarations

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Figures

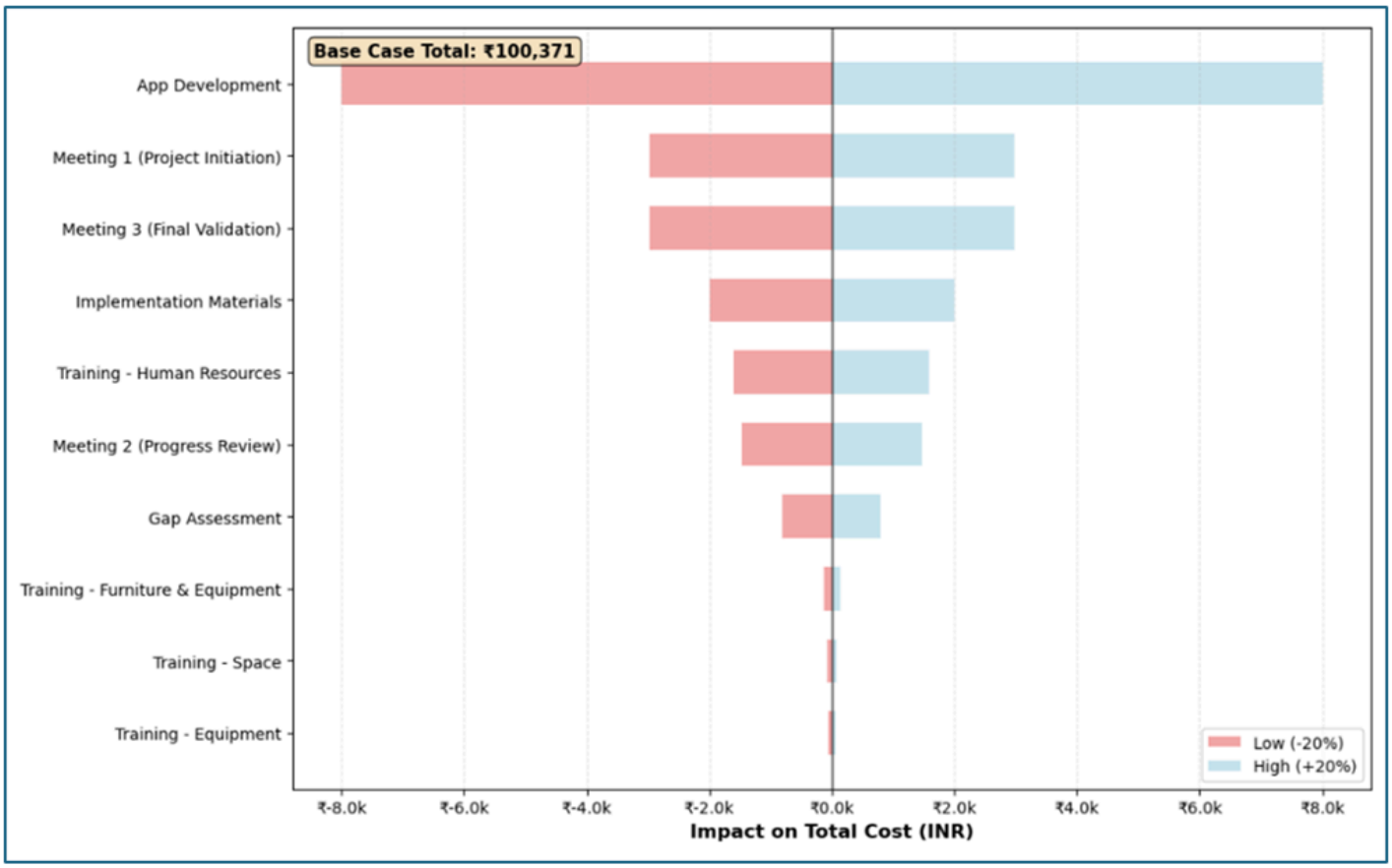


Figure 1

Tornado diagram showing the results of a one-way sensitivity analysis for the cost components of the Oncocare mHealth application.