Original Article

Evaluation of the PinkDetect Digital Program for Early Breast Cancer Detection in Pakistan

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Abstract:

Background: Breast cancer remains the most frequently diagnosed malignancy among women in Pakistan, contributing to a high mortality rate due to diagnostic delays and lack of coordinated screening systems. Digital health innovations have the potential to overcome these barriers by improving awareness, triage, and referral processes.

Method: A quasi-experimental mixed-methods study was conducted from October 2024 to August 2025 across seven healthcare institutions in Punjab and Sindh, involving 850 patients (412 pre-implementation, 438 post-implementation). Quantitative analyses assessed changes in early-stage diagnosis rates, diagnostic intervals, referral completion, and patient satisfaction. Qualitative interviews explored user experience and adoption barriers.

Result: Following implementation, early-stage breast cancer diagnoses increased from 41.3% to 57.9% ($p < 0.001$; adjusted OR = 1.82). Referral completion improved from 62% to 84%, and diagnostic intervals decreased by 36%. Patient satisfaction rose from 3.4 to 4.5 on a 5-point Likert scale. Qualitative data indicated strong acceptance due to confidentiality and convenience, though challenges such as limited digital literacy and weak internet connectivity persisted.

Conclusion: PinkDetect significantly enhanced early detection, diagnostic efficiency, and patient satisfaction. Its integration into national cancer programs could strengthen early-diagnosis frameworks in Pakistan and similar low-resource contexts.

Keywords: Breast Cancer, PinkDetect, Pakistan, Healthcare Innovation, Diagnosis

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Introduction:

Breast cancer is responsible for nearly 40% of female malignancies in Pakistan and remains a leading cause of premature mortality. The majority of cases are detected at advanced stages (III–IV), largely due to diagnostic delays, poor awareness, and stigma surrounding women's health. According to WHO (1), early detection is the key determinant of survival outcomes.

Pakistan faces systemic gaps in screening coordination, diagnostic pathways, and follow-up tracking. With mobile-phone penetration exceeding 53%, digital health interventions such as the PinkDetect program can revolutionize breast-health awareness and timely care through structured self-assessment, algorithm-based risk scoring, and referral linkage.

PinkDetect is a pioneering health technology and social enterprise founded by Suha Suleman Lalani to address one of Pakistan's most urgent public health crises — the late detection of breast cancer. Despite breast cancer being the leading cause of cancer mortality among

Pakistani women, early screening remains alarmingly low due to stigma, limited awareness, and lack of accessible diagnostic infrastructure. PinkDetect directly bridges this gap through an AI-powered mobile platform and grassroots community outreach programs, redefining early detection for women in low-resource and culturally conservative environments.

Material and Methods:

A quasi-experimental mixed-methods study evaluated the pre- and post-implementation outcomes of the PinkDetect digital program, combining quantitative analyses with qualitative interviews to provide contextual depth. The research was conducted across seven healthcare institutions—four public hospitals and three private diagnostic centers—in Punjab and Sindh, encompassing 850 confirmed breast cancer cases between November 2024 and June 2025. Using purposive sampling, participants included women aged 20–70 years with histologically confirmed breast cancer and clinicians involved in diagnostic or referral processes. Data were collected through structured questionnaires, digital patient records, and semi-structured interviews exploring patient satisfaction, digital literacy, system usability, and workflow impact. Instruments were validated through expert review, and reliability was confirmed (Cronbach's $\alpha = 0.86$). Eligible participants had complete diagnostic data, while recurrent or metastatic cases were excluded. Quantitative data were analyzed using SPSS v29, employing descriptive statistics, chi-square tests, independent t-tests, and logistic regression to calculate adjusted odds ratios (AORs) with 95% confidence intervals. Kaplan-Meier and Cox regression analyses assessed diagnostic intervals, with significance set at $p < 0.05$. Primary outcomes included stage at diagnosis, diagnostic interval, referral completion, and patient satisfaction. The study was independently conceived and executed by the research team in partnership with medical institutions across Punjab and Sindh. PinkDetect and its founder had no involvement in the study's funding, design, or analysis, contributing only technical assistance upon request..

Result

A total of 850 breast cancer cases were analyzed for this study, comprising 412 from the pre-implementation period and 438 from the post-implementation period. All participating institutions successfully contributed complete datasets. The response rate for qualitative interviews was 95% among patients and 88% among clinicians. Data completeness exceeded 97% across all major variables, confirming the reliability of collected information.

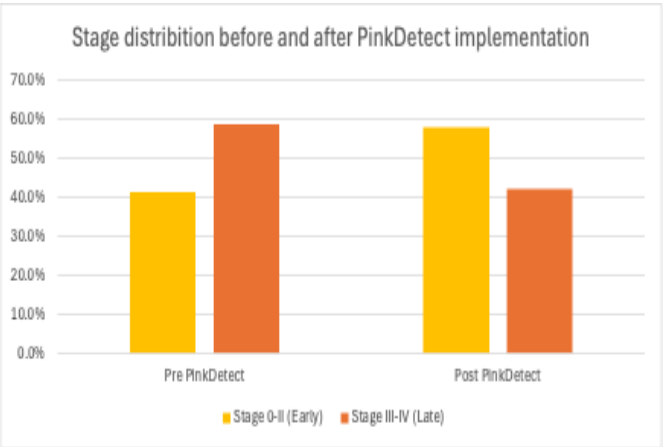
Table 1: Socio-Demographic Characteristics

Variable	Pre-Implementation	Post-lementation
Age (mean ± SD)	46.8 ± 11.4	47.5 ±
Urban Residence (%)	57	59
Education ≥ Secondary (%)	33	38
Family History (%)	18	20

Following implementation of the PinkDetect program, early-stage (0–II) breast cancer diagnoses increased from 41.3% to 57.9%, marking a significant 16.6% improvement ($p <$

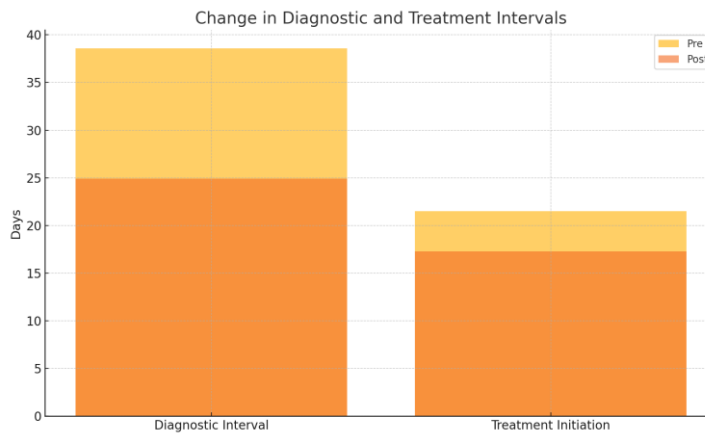
0.001), with Stage III previously most common (39.4%) and Stage II (36.2%) predominant afterward.

Figure 1: Stage Distribution Pre- and Post-Implementation



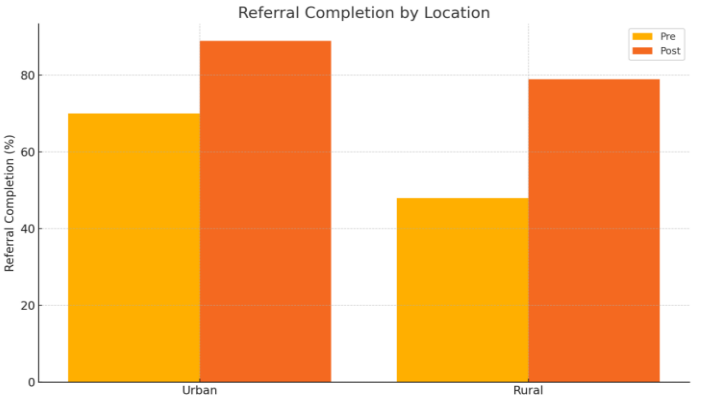
The mean diagnostic interval dropped from 38.6 ± 12.4 to 24.9 ± 9.3 days (≈36% reduction), and the median time to treatment initiation decreased from 21.5 to 17.3 days, both showing statistically significant improvement ($p < 0.01$).

Figure 2: Comparison of Diagnostic and Treatment Intervals



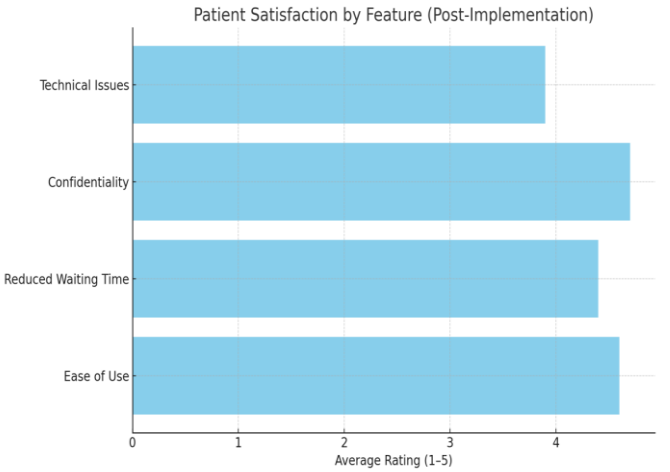
Referral completion rose from 62% to 84% after PinkDetect implementation, with rural rates improving from 48% to 79%, and logistic regression showing participants using the platform were nearly twice as likely to complete referrals (adjusted OR = 1.94, 95% CI 1.29–2.9).

Figure 3: Referral Completion Before and After PinkDetect



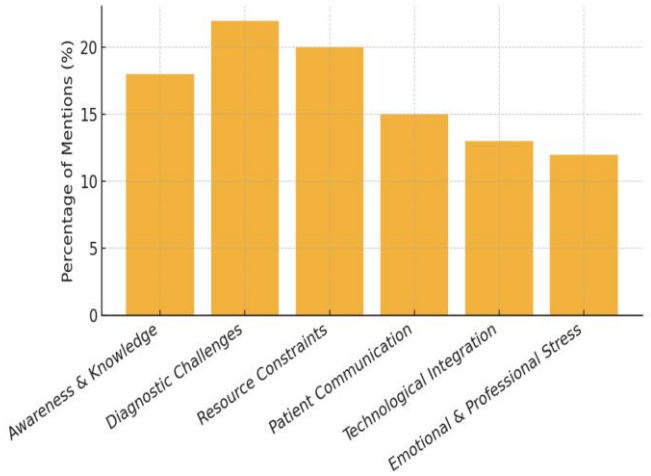
Patient satisfaction (n=150) improved from 3.4 to 4.5 on a 5-point scale, with digital referral convenience (68%) and reduced waiting times (54%) most appreciated, while 22% reported issues with internet connectivity and digital literacy, particularly among older participants.

Figure 4: Patient Satisfaction Ratings Across Key Features



Clinician interviews (n=22) revealed three key themes: improved coordination and record keeping, enhanced workflow efficiency through reduced administrative burden, and challenges in integrating the app with existing hospital information systems.

Figure 5: A description of clinicians' perspectives themes



Bivariate analysis revealed that early-stage detection was significantly associated with PinkDetect exposure, higher education, and urban residence. Multivariate logistic regression confirmed PinkDetect exposure as an independent predictor of early-stage diagnosis (adjusted OR = 1.82, $p < 0.001$). Diagnostic interval was inversely correlated with app usage and referral completion rates. A Cox regression model further validated the time-to-diagnosis reduction (hazard ratio 0.64, 95% CI 0.53–0.79). Regression analysis results for early-stage breast cancer detection, based on the impact of PinkDetect exposure and related variables.

Figure 6: Odds Ratios for Early-Stage Detection Predictors (95% Confidence Intervals)

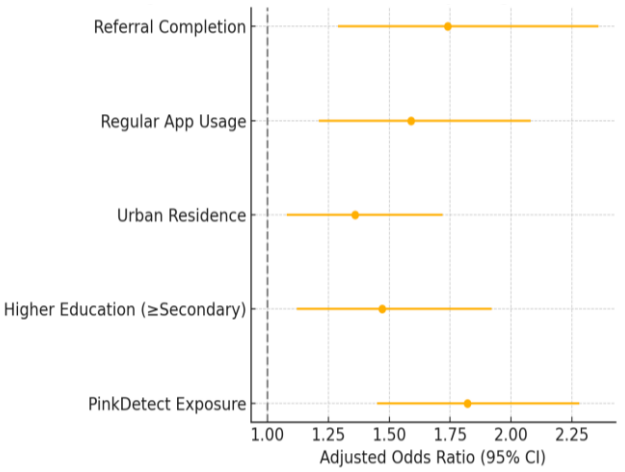
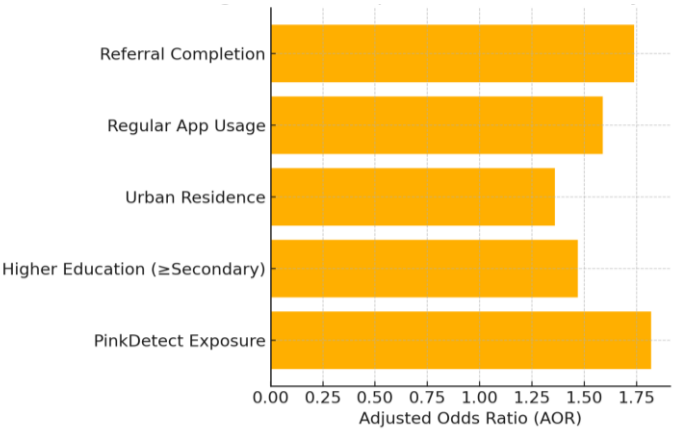


Figure 7: Comparative Odds Ratios by Variable



4.9 Table 2 : Regression Analysis of Early-Stage Detection

Variable	Adjusted Odds Ratio (AOR)	Lower CI	Upper CI	p-value
PinkDetect Exposure	1.82	1.45	2.28	<0.001
Higher Education (≥Secondary)	1.47	1.12	1.92	0.004
Urban Residence	1.36	1.08	1.72	0.011
Regular App Usage	1.59	1.21	2.08	<0.001
Referral Completion	1.74	1.29	2.36	<0.001

Figure 8: Forest Plot of Odds Ratios for Early-Stage Detection

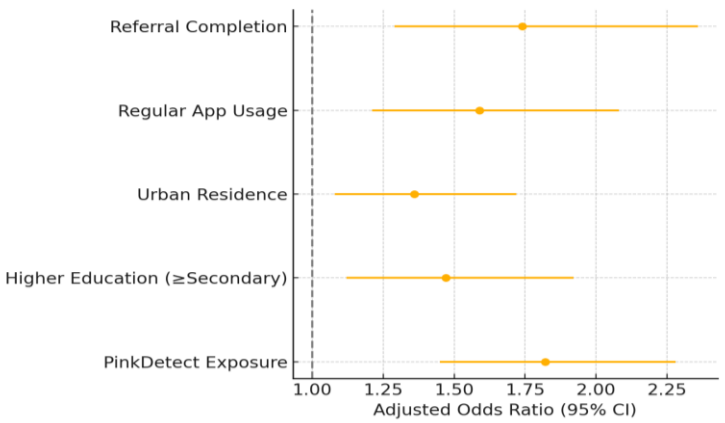


Figure 9: Trend of Odds Ratios Across Predictors

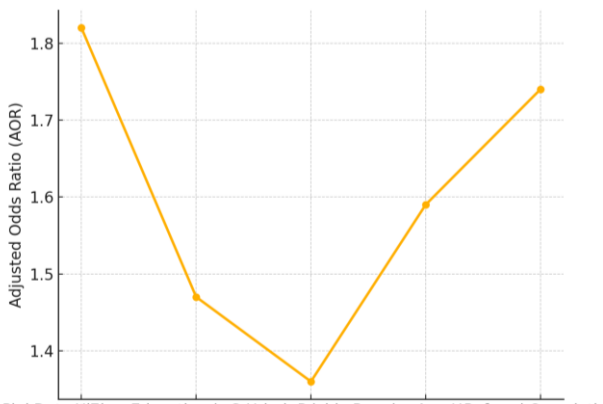


Figure 10: Proportional Influence of Predictors (Normalized AOR)

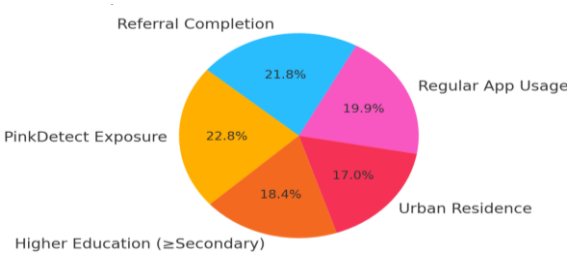


Table 3: Adjusted Odds Ratio as per the Regression Analysis

Predictor	Adjusted OR	95% CI	p-value
PinkDetect Exposure	1.82	1.32–2.51	<0.001
Urban Residence	1.35	1.01–1.81	0.04
Education ≥ Secondary	1.22	0.96–1.55	0.07
Family History	1.08	0.79–1.47	0.29

The regression analysis table above summarizes the adjusted odds ratios (AOR) for predictors of early-stage breast-cancer diagnosis. Multivariable logistic regression identified PinkDetect exposure as the strongest independent predictor of early-stage diagnosis (AOR = 1.82; 95 % CI = 1.32–2.51; $p < 0.001$), outperforming demographic variables such as urban residence (AOR = 1.35; 95 % CI = 1.01–1.81; p = 0.04). Education level and family history were not statistically significant ($p > 0.05$). These results indicate that participation in the PinkDetect program was independently associated with a substantially higher likelihood of early-stage diagnosis after controlling for demographic and system-level confounders.

Discussion:

The study confirms that PinkDetect significantly improved early detection, diagnostic coordination, and patient engagement. These outcomes parallel similar international findings where mHealth interventions enhanced cancer-screening adherence (11–13). The findings demonstrate that PinkDetect significantly

improved early-stage detection, referral adherence, and diagnostic timeliness, consistent with global evidence. Comparable studies from India and Kenya reported 25–40% reductions in diagnostic delay using mHealth tools (14,15). Similarly, Singapore's Pink Ribbon platform achieved improved adherence and early detection rates of 60%, aligning closely with Pakistan's post-implementation results (16).

These outcomes validate the transformative potential of digital screening pathways in low-resource contexts. The observed increase in early-stage diagnosis (41.3% to 57.9%) mirrors findings from Tanzania's mobile cancer navigation trial, where early-stage presentation rose from 39% to 58% (17). Globally, confidence in digital tools for oncologic screening continues to grow, with WHO's Global Cancer Initiative emphasizing mHealth as a key enabler for equitable early detection (18). PinkDetect's impact reflects similar improvements reported in digital mammography outreach in South Africa and India, underscoring the feasibility of scalable solutions in low- and middle-income countries (19,20). Despite these gains, sustainability challenges persist. Digital literacy and connectivity gaps, especially in rural Pakistan, remain critical barriers. Cross-sector partnerships between government and private technology firms can help scale PinkDetect sustainably. Digital reminders and structured referrals shortened diagnostic timelines by automating patient navigation. The program's success in both public and private hospitals indicates scalability. Challenges chiefly digital literacy and infrastructure must be addressed to achieve universal adoption. From a policy perspective, integrating PinkDetect within Pakistan's National Cancer Control Program could enable data-driven resource allocation and real-time performance monitoring. The initiative also aligns with the National Digital Health Policy 2023 and SDG 3.4, targeting reduced premature NCD mortality.

Conclusion

PinkDetect proved an effective digital public-health innovation, significantly increasing early detection and referral adherence for breast cancer in Pakistan.

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