review article

Adoption of Information and Communication Technologies for Early Detection of Breast and Cervical Cancers in Low- and Middle-Income Countries

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abstract

Purpose **In response to the growing burden of breast and cervical cancers, low- and middle-income countries (LMICs) are beginning to implement national cancer prevention programs. We reviewed the literature on information and communication technology (ICT) applications in the prevention of breast and cervical cancers in LMICs to examine their potential to enhance cancer prevention efforts.**

Methods **Ten databases of peer-reviewed and gray literature were searched using an automated strategy for English-language articles on the use of mobile health (mHealth) and telemedicine in breast and cervical cancer prevention (screening and early detection) published between 2005 and 2015. Articles that described the rationale for using these ICTs and/or implementation experiences (successes, challenges, and outcomes) were reviewed. Bibliographies of articles that matched the eligibility criteria were reviewed to identify additional relevant references.**

Results **Of the initial 285 citations identified, eight met the inclusion criteria. Of these, four used primary data, two were overviews of ICT applications, and two were commentaries. Articles described the potential for mHealth and telemedicine to address both demand- and supply-side challenges to cancer prevention, such as awareness, access, and cost, in LMICs. However, there was a dearth of evidence to support these hypotheses.**

Conclusion **This review indicates that there are few publications that reflect specifically on the role of mHealth and telemedicine in cancer prevention and even fewer that describe or evaluate interventions. Although articles suggest that mHealth and telemedicine can enhance the implementation and use of cancer prevention interventions, more evidence is needed.**

INTRODUCTION

Globally, the annual number of new cases of cancer is expected to increase 70% by 2030 as a result of demographic changes alone.[1] Cancer mortality rates in low- and middle-income countries (LMICs) are well above those of high-income countries.[2] Ninety-five percent of patients with cancer in developing countries are diagnosed with late- to end-stage disease, when treatment options are few and prognosis is poor, which signals the need for concerted action for cancer prevention.[3,4]

This is especially true of breast and cervical cancers, which comprise a large proportion of all cancers in developing countries, where more than 50% of deaths resulting from breast cancer and 88% resulting from cervical cancer occur.[5] Nine of 10 cervical cancer deaths occur in less developed regions, which is roughly 445,000 cases and 230,000 deaths annually.[6] Breast cancer is the most frequent cause of cancer death in less developed regions, accounting for 324,000 deaths of the 883,000 cases.[6] Overburdened health systems, gender discrimination, stigma, and uneven access to care for women in developing countries create an equity issue, particularly as breast and cervical cancer burdens increase.[5]

Mortality rates of these cancers can be dramatically reduced via screening and early detection.[1] For population-level impact, prevention programs need to be effectively implemented at scale. In cases of screening and early detection, factors

such as awareness of signs and symptoms, screening coverage, screening test performance, triage, care linkages, cost and coverage, specialists, diagnostics and treatment availability and quality, and stigma can influence impact. Information and communication technologies (ICTs) have the potential to influence these factors, thereby helping to address female cancers from an equity perspective and enhance the scalability and effectiveness of prevention programs.

Motivated by the successes in using ICTs for women's cancer prevention in higher-income countries,[7-11] the goal of this article was to examine the extent to which this potential has been explored in low-resource settings, where there is great need and potential. We examined the peer-reviewed and gray literature on the use of ICTs for prevention (screening and early detection) of breast and cervical cancers in LMICs. We assessed the ways in which ICTs have been deployed for cancer prevention and implementation experiences, including outcomes and challenges.

ICTs are tools that facilitate communication, processing, transmission, and sharing of knowledge and information through electronic means[12] and can be used to gather, store, access, analyze, manipulate, and disseminate a diverse set of information electronically via communication formats and platforms.[13] For the purposes of this review, we focused on two prominent types of ICTs for health: mobile health (mHealth) and telemedicine. mHealth is the use of mobile devices, such as mobile telephones, patient monitoring devices, personal digital assistants, and other portable wireless devices, to support the practice of medicine and public health.[14] Telemedicine is the practice of medicine over telecommunication networks, including the specialty of teleoncology.[15] Teleoncology refers to the delivery of oncology services at a distance via ICTs that aid in clinical diagnosis, treatment, and follow-up through the transfer of video, images, and data, such as pathology and radiology images, graphics, and text.[16] We are focused on prevention, whereas teleoncology is more focused on postdiagnosis practice of medicine; thus, for the purpose of this article, we use the term telemedicine.

METHODS

The goal of this review was to examine the ways in which ICTs, particularly mHealth and telemedicine, have been deployed for breast and cervical cancer prevention, as well as implementation outcomes and challenges. The review focused on LMICs, as classified by the World Bank definition of having gross national income per capita between $1,035 to $4,085.

Ten databases (PubMed, GoogleScholar, Cochrane Library, Scopus, IndMed, Popline, Global Health Library, WHOLIS, Taylor & Francis, and Open Gray) were searched using the following search terms: information and communication technology (using any of the following terms: ICT, information communication technology, mobile health, mHealth, telemedicine, telecommunications, smartphone, mobile phone, eHealth, and teleoncology) AND cancer prevention (using any of the following terms: cancer prevention, cancer screening, cancer literacy, cervical cancer, breast cancer, human papillomavirus, cancer education, visual screening, cancer awareness, cancer control, primary prevention, and secondary prevention) AND low- and middle-income countries (using any of the following terms: LMICs, India, Africa, Asia, South America, low-income country, middle-income country, and developing country). In addition, we searched the *Journal of mHealth* and the eHealth/mHealth theme of the Health and Social Care Arena Collection from Routledge and Taylor & Francis. The bibliographies of selected articles were also reviewed to identify any additional relevant references. Articles were restricted to those published between 2005 and 2015. Inclusion and exclusion criteria are listed in Table 1.

Results, including title, abstract, authors, and database, were exported to Excel (Microsoft, Redmond, WA). A preliminary review of the title and abstract was completed by the primary reviewers (J.M.D. and S.G.), and articles were marked as either meeting criteria, may meet criteria, or do not meet criteria. For articles identified as not relevant for inclusion, the reason for noninclusion was recorded on the spreadsheet. The full text of articles meeting or possibly meeting inclusion criteria was reviewed, and relevant information (including population and geographic focus, cancer site, type of ICT, cancer prevention activities targeted, intervention features, outcomes assessed, challenges identified, research gaps or limitations, and suggestions for improvement) was abstracted from those confirmed to be eligible. A qualitative content analysis of selected articles was then conducted.

RESULTS

The search yielded 285 citations, of which 61 were reviewed in full after applying exclusion criteria. Of these articles, eight met all inclusion criteria and were reviewed and abstracted (Table 2). Two common reasons for exclusion were lack of focus

Table 1 – Inclusion and Exclusion Criteria for Literature Review

Type	Criterion
Inclusion	Published between 2005 and 2015
	Original research, review, systematic review, or meta-analysis
	Search words as defined in Methods and in Table 2
	LMICs with World Bank classification
	English language
Exclusion	Articles/studies focused only on high-income countries
	Editorial discussion arguing case for field of research or course of action
	Newspaper article or other form of popular media
	Does not include primary or secondary prevention of cancer
	Lacks supporting evidence in main text (eg, details on databases searched or selection criteria)
	Does not use some form of ICT

Abbreviations: ICT, information or communication technology; LMIC, low- or middle-income country.

on LMICs or no use of an ICT. Of the articles analyzed, four reported original research, two were overviews of ICT applications, and two were commentaries. They were published between 2005 and 2015; five were published in cancer-focused journals and three in broader health care or medical journals. Articles focused either on a location-specific intervention (n = 5) or on LMICs more broadly (n = 3). One article focused exclusively on cervical cancer and three others exclusively on breast cancer. The remaining four articles addressed cancer prevention broadly and discussed specific sites peripherally. Full-text articles were excluded because they did not involve an ICT (n = 18), occur in an LMIC (n = 20), or focus on breast or cervical cancer (n = 16; Fig 1).

Table 2 – Search Terms for Inclusion

Search Term
Information and communication technology (ICT) AND
Using any of the following terms: information communication technology, mobile health, mHealth, telemedicine, telecommunications, smartphone, mobile phone, eHealth, and teleoncology
Cancer prevention AND
Using any of the following terms: cancer prevention, cancer screening, cancer literacy, cervical cancer, breast cancer, human papillomavirus, cancer education, visual screening, cancer awareness, cancer control, primary prevention, and secondary prevention
Low- and middle-income countries (LMICs)
Using any of the following terms: LMICs, India, Africa, Asia, South America, low-income country, middle-income country, and developing country

Both mHealth and telemedicine applications for cancer prevention were described in the articles identified. In Bangladesh, community health workers (CHWs) used smartphones to strengthen breast health promotion, including uptake of clinical breast examinations and follow-up clinic visits.[17] In Cambodia, a telemedicine framework facilitated remote diagnosis and the provision of care in remote rural areas.[18] In India, Khokar[19] explored the use of short message service (SMS) reminders to promote monthly breast self-examinations. Finally, in Zambia, telemedicine using digital images and distance consultation enabled the provision of cervical cancer screening, diagnosis, and treatment in areas with limited access to physicians and laboratory infrastructure.[20] Articles advocated for the broad use of ICTs in overcoming barriers to cancer prevention, such as access to information, health care providers and specialists, quality care, and cost of services, especially in rural or resource-limited settings.[3,21-23]

ICT Applications for Cancer Prevention

Within the reviewed articles, mHealth, telemedicine, and ICTs were identified. Articles highlighted both demand- and supply-side barriers that could be addressed by these ICTs. Demand-side barriers included timely health care seeking for breast and cervical cancers, stigma,[3] lack of information,[21] and cost of care to the individual.[17] They noted that health seeking was also impeded by fear associated with a cancer diagnosis because of the high mortality rate in LMICs. Cancer myths, stigma, and gender inequities were also identified as barriers to timely care seeking faced by women.[17] These, along with the complexity of medical information and ambiguities of the nature of chronic disease, posed challenges in communicating to patients.[21] One article indicated that women lacked information on cancer because they may be apathetic in seeking it.[3] Another article noted that women's access to information might be minimal or inaccurate.[21] Even if there was some understanding of cancer prevention and screening, the perceived cost of care and lack of trust in the quality of care could prevent care seeking.[3] These demand-side factors led to late-stage diagnosis and poorer health outcomes.[23]

In a few cases, mobile telephones were used to facilitate the dissemination of prevention

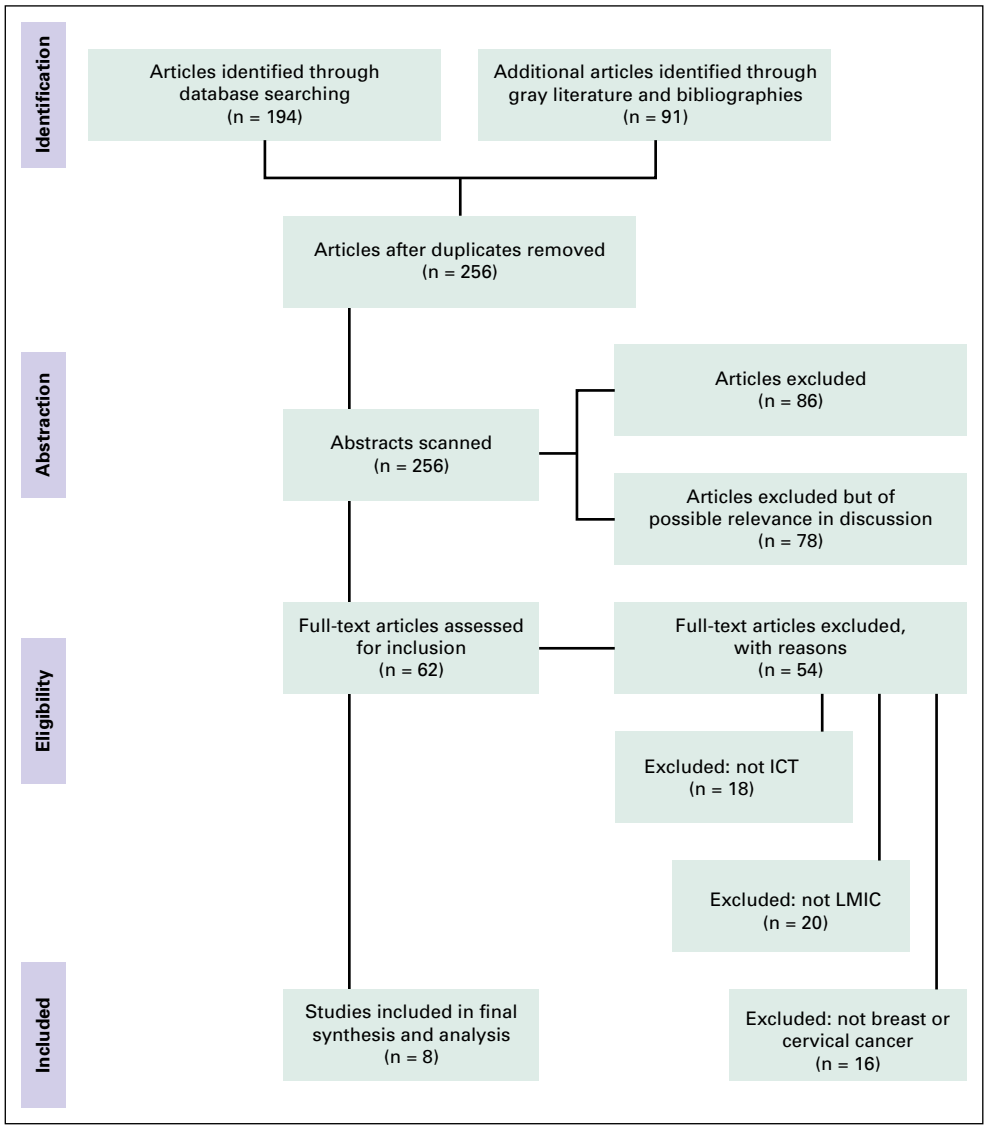

Fig 1 –
Process of article selection. ICT, information or communication technology; LMIC, low- or middle-income country.

messages and/or seen as an important component to addressing demand-side barriers. For example, a study in Delhi, India, explored the effectiveness of SMS reminders for a monthly self-breast examination among 106 women who were employed in the organization and possessed a mobile telephone. After 2 months of sending reminders, there was a statistically significant increase in the practice of breast self-examination from 42% at the end of the first month to nearly 73% at the end of 6 months ($P < .05$).[19] Another article presented a 10-layer health model focused exclusively on messaging and education that was developed from an overview of potential ICTs for breast cancer prevention.[21] It explored how prevention, diagnosis, and treatment messages could be disseminated for breast cancer, highlighting SMS, voice calls, social media, the Internet, e-mail, and Web sites. Mobile technology was considered the primary agent of communication and the Internet as secondary. This was the only article to specify message content.

Telemedicine and mHealth were advocated as potential solutions to supply-side barriers, such as health system deficiencies and challenges of access and cost. Nearly all studies hypothesized a reduction of costs as a primary benefit of using ICTs. Reductions resulted from removing unnecessary referrals, reducing travel and waiting times, and eliminating the need for a physician to be present on site. The time saved resulted in quicker medical attention, hence improving patient outcomes. Provision of cancer prevention and treatment services was especially lacking for the poor and in rural areas, where there were few opportunities for affordable or quality care.[17,18] Thus, the broad binding constraints noted in the literature

were delivery and coordination of care, rather than biomedical knowledge.[22] This was supported by evidence that highlighted limited human and technical resources, such as low physician density or physician-to-patient ratio, limited funding for prevention programs, undercapacitated laboratory infrastructure, and distance to clinics.[20,23] Overall, delivery of care was inhibited by cost, access to health services, organizational constraints on access to specialized care, and a weak, fragmented health system.[18,22] ICTs were proposed as part of the solution to these challenges.

Telemedicine was viewed as a means of both reducing cost and increasing access to comprehensive care specifically for remote locations, because it facilitated access to experts and transfers of laboratory data for earlier detection and better diagnosis.[23] In Cambodia, medical information, including photographs, were sent via e-mail to a distant center of expertise to facilitate remote diagnosis and recommend treatment options.[18] Over time, the number of offsite referrals and the duration of the primary complaint decreased. However, in this case, specific data on cervical and breast cancer screening and diagnosis were not presented.

An initiative in Zambia used a telemedicine platform specifically for cervical cancer screening, diagnosis, and treatment.[20] Using digital cervicography, photographs of the cervix were obtained and sent to a specialist at a distant center for rapid consultation or for quality control and continuing education. The introduction of mobile technologies in Zambia facilitated task shifting, allowing nonphysician health care workers to provide services. They used widely available and affordable communication technologies to sustainably deliver cervical cancer screening and treatment services. Holeman et al[22] illustrated the ability of mHealth to strengthen health systems through a case in Malawi where CHWs were provided a mobile telephone to connect with a nurse at the district hospital. Benefits included improved primary health care via referrals, reporting of symptoms, and requesting of supplies and advice.

Uniquely, a case in Bangladesh used a randomized controlled trial (RCT) to evaluate an mHealth application wielded by CHWs that addressed both demand- and supply-side issues.[17] CHWs used smartphones to improve breast health outreach (participation in an interview, disclosure of a breast symptom, and uptake of a clinical breast examination) through a motivational video. The study also looked at the added benefit of a patient navigation tool and found that women who received this additional intervention were significantly more likely to attend a clinic visit after an abnormal clinical breast examination than women in comparison groups. Parham et al[20] also advocated for the use of ICTs to improve both demand for and supply of cancer prevention services, such as ongoing capacity building for health care providers, program monitoring and evaluation, and patient education.

Implementation Experiences and Outcomes

The articles we reviewed provided limited evidence in support of the use of ICTs in cancer prevention and also revealed the limitations and challenges of implementing ICT-based interventions. The Bangladesh study was the only large-scale RCT of an ICT-based cancer prevention intervention.[17] It found that CHWs equipped with a smartphone were able to interview more women and identify more patients with an abnormal clinical breast examination. In addition, those with an abnormal clinical breast examination who were offered a clinic appointment by a CHW armed with the smartphone application were more likely to adhere to advice regarding a clinic visit. However, this study underscored difficulties in tracking the final diagnoses of women with abnormal breast examinations and the importance of linking the ICT application across the care continuum, from screening to diagnosis to treatment. Moreover, the trial was conducted in an area where community trust had been established, which could have contributed to the high acceptability of the intervention.

Several technical challenges unique to mHealth-supported screening applications were noted in the literature. Image clarity affected remote diagnosis, because devices ranged in quality. Moreover, the skill of the operator was critical in capturing features such as lesion depth.[20] Devices were also found to malfunction or need repairs, which can take a long time in low-resource settings. The quality of training for the users of the mHealth application and their ability to translate information into practice were also important influences on outcomes. Connectivity to the Internet and/or mobile telephone network also determined the effectiveness of ICT-based interventions, as was the case in Cambodia. Beyond limited connectivity, the availability of smartphones also required consideration. In both Bangladesh and Malawi, researchers equipped CHWs with smartphones and provided them with training on smartphone use.[17,22] Recognizing this challenge, Holeman et al[22] argued for building on existing technology and adapting current interventions.

Beyond this, evidence pointed to the need for continued research on how innovations can explicitly address and promote sustained behavior change. The SMS-based intervention assessed the practice of breast self-examinations at 6 months; however, it is unclear how long the practice was continued.[19] It may be useful for mHealth interventions to be sustained over long periods of time for evaluation and improved effectiveness. Holeman et al[22] called for human-centered design to promote behavior change, that is, design that explicitly aligns and adapts technology for cancer care provision in local contexts.

Few articles unpacked cultural barriers to ICT-supported interventions. ICTs were not designed specifically to address barriers such as stigma, gender inequity, or lack of knowledge of cancer. Moreover, users may not be familiar with the technologies used and may require in-depth training. Lack of familiarity could affect ease of adoption and effectiveness of ICT-based interventions. One article noted that in an intervention implemented by Medic Mobile in Malawi, CHWs had never used laptops or mobile telephones, but they were successful in exchanging information using these devices over the first 6 months.[22] Variations in exposure to and experience with ICTs, particularly in rural areas, were not highlighted in the literature. Table 3 summarizes selected articles.

Review Limitations

Our review has several limitations. Although we ultimately focused on telemedicine and mHealth, preliminary searches included a broader set of ICT-related terms, such as radio, tablet, and Internet. Because we found no articles satisfying those terms, they were excluded from the final search strategy. We were also limited by the number of search terms that certain search engines could process. Given the focus on women's cancers—breast and cervical cancers—tobacco-related cancers were excluded, although there is likely to be a more robust literature on ICT applications in that context.[24,25]

All the articles we identified focused on LMICs in Africa or Asia. The lack of low-income countries or countries in Latin America or central Asia may be a limitation of our search strategy. The dearth of ICT applications for cancer prevention in low-income countries might be a result of the availability of ICT infrastructure, differing health priorities, and affordability of devices.[26,27] Latin America and central Asia may be absent because some countries in these regions are categorized as low income and others as upper middle–income countries, which were not part of our inclusion criteria.

A number of publications were relevant to our overall goal but did not fit our inclusion criteria. Most often, articles were excluded because they did not focus on an LMIC. That said, studies in high- and upper middle–income countries might provide relevant insights, such as the use of telemedicine to address human resource limitations[28] or analyses of Internet use by patients with cervical cancer to increase access to information.[29] We also excluded articles that focused on ICT applications for the prevention of cancers other than breast or cervical (eg, lung, colorectal, and stomach [n = 7] in low-resource settings outside of LMICs). Because ICT-supported interventions are a relatively new phenomenon, there may be interventions that have not yet been published. Given this, we attempted to cast a wide net by using broad search terms.

DISCUSSION

Our review indicates that there are few publications that reflect specifically on the role of mHealth and telemedicine in breast and cervical cancer prevention or that describe ICT-based interventions. Only two articles provided quantitative measures of intervention outcomes, and evidence on long-term implementation outcomes and challenges of ICT-supported programs has not been gathered. Only four studies collected primary data: two used quasi-experimental designs, one was a community-based observational study, and another used an RCT design. The RCT, in Bangladesh, identified a significant increase in participant follow-up—43% with a CHW compared with 63% when the CHW was guided by a smartphone.[17] However, studies such as this were conducted over a relatively short duration (< 6 months) and based on small sample sizes. Although the RCT, for example, indicated a statistically significant increase in breast self-examination from SMS reminders, the data were collected over the initial 2 months, and reminder effectiveness may decrease over time.[17] Thus, issues such as scalability, replicability, sustainability, and long-term effectiveness have not yet been examined in LMICs. There is an especially sizeable gap in the literature around scale-up and sustainability of ICT-based cancer prevention interventions. Engagements with stakeholders such as the government, nongovernmental organizations, and communities were not explicitly described, integrated, or targeted in any article, showing the nascent stages of research and

Table 3 – Overview of Selected Articles

Study Title	First Author	Study Population or Focus	Location	Type of Article	ICT Type	Cancer Site and Points in Cancer Care Continuum Deployed or Examined	Objective/Focus	Finding
Harnessing Information and Communication Technologies to Leverage Scarce Resources for Cancer Education, Research and Practice in Developing Countries (2006)	Andela[3]	ICTs	LMICs	Commentary	General/ overview	All; 1°, 2°	To highlight importance of ICTs in organizing and leveraging scarce resources for cancer education, research, and practice in developing countries	Transferring appropriate knowledge and technology from developed countries is desirable but should not undermine opportunities available in developing countries that could be transformed for improved cancer care
Cancer Diagnosis and Telemedicine: A Case Study From Cambodia (2006)	Kvedar[18]	Patients and/or CHWs in remote communities with e-mail access	Cambodia	Primary data: pilot project	Telemedicine	All; 2°	To assess whether accurate diagnosis and treatment can be provided by e-mail to patients in remote locales in developing world	Telemedicine can have positive impact on public health of remote communities in developing world; however, although it may overcome obstacle of access to expert consultation, poor infrastructure and other logistic challenges can greatly limit treatment options; cancer remains particularly challenging because of scarcity and cost of treatment everywhere in Cambodia
Information and Communication Technology: New Approach for Rural Cancer Care Improvement (2008)	Maserat[23]	Remote communities	LMICs	Commentary	Telemedicine	All; 1°, 2°	To address oncological challenges in rural areas and the potential of ICT solutions for prevention, early diagnosis, treatment, and palliative care, by describing a frameworks for implementation of telemedicine.	Teleoncology can have key impact on public health and cancer care in remote communities by providing comprehensive care; it can overcome obstacle of access to expert consultation and transfer pathology and laboratory data to aim for best cancer diagnosis and early detection in remote locations

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Table 3 – Overview of Selected Articles (Continued)

Study Title	First Author	Study Population or Focus	Location	Type of Article	ICT Type	Cancer Site and Points in Cancer Care Continuum Deployed or Examined	Objective/Focus	Finding
A New Ten-Layer ICT Model For Health Communication in Fatal Disease Management (2014)	Bexci[21]	Literature on empiric studies of ICT tools for fatal diseases	LMICs	Analysis of ICT communication methods	mHealth and Internet	Breast cancer and other NCDs; 1°	To speak to need for improved use of ICT resources that are direct, cost effective, timesaving, and highly persuasive in pursuit of quality health care delivery by proposing 10-layer ICT model to disseminate health messages for patients with fatal diseases, using breast cancer as example	Health communication for chronic diseases, as exemplified in breast cancer, can be formulated based on 10-layer ICT model; this strategic communication model provides exhaustive set of tools with unique, supplementary, and complementary characteristics that can be adapted for application in developed or developing nations irrespective of socioeconomic or cultural barriers
Mobile Health for Cancer in Low to Middle Income Countries: Priorities for Research and Development (2014)	Holeman[22]	Literature on ICTs and cancer	LMICs	Commentary	mHealth	All; 1°, 2°	To provide evidence of ability of mobile technology to reduce costs for and improve access to health services, as well as strengthen health systems to meet interrelated challenges of cancer and other NCDs	mHealth technologies for cancer that have successfully targeted other health conditions must be leveraged, as we focus on coordination and delivery of care rather than new biomedical knowledge; adapting existing interventions to support cancer care and control requires well-funded and concerted interdisciplinary efforts, which if harnessed show potential to address interrelated challenges of cancer and NCDs

(Continued on following page)

Table 3 – Overview of Selected Articles (Continued)

Study Title	First Author	Study Population or Focus	Location	Type of Article	ICT Type	Cancer Site and Points in Cancer Care Continuum Deployed or Examined	Objective/Focus	Finding
An mHealth Model to Increase Clinic Attendance for Breast Symptoms in Rural Bangladesh: Can Bridging the Digital Divide Help Close the Cancer Divide? (2014)	Ginsburg[17]	22,337 women age ⩾ 25 years living in Khulna Division	Bangladesh	Primary data: RCT	mHealth	Breast; 1°, 2°	To demonstrate benefit of equipping CHWs with smartphone to improve model of care for breast health promotion, clinical breast examination, and patient navigation in rural Bangladesh	CHWs guided by smartphone applications and patient navigation models were more effective in breast health promotion and in encouraging clinic attendance; despite minimal cancer control infrastructure, locally based, multidisciplinary project team can address barriers to care seeking for breast symptoms, which also highlights need to address gap in cancer services in rural areas
Short Text Messages (SMS) As a Reminder System for Making Working Women From Delhi Breast Aware (2009)	Khokhar[19]	106 female employees, age 22 to 54 years, from private company	Delhi, India	Primary data: Community-based survey	mHealth	Breast; 1°, 2°	To measure, via community-based study, effectiveness of SMS reminders to perform monthly breast self-examination	The practice of breast self-examination increased significantly (χ^2 $P < .05$) within 2 months after initiating SMS reminders
eC_3: A Modern Telecommunications Matrix for Cervical Cancer Prevention in Zambia (2011)	Parham[20]	Nurses	Zambia	Primary information: Overview of pilot program	Telemedicine	Cervix; 2°	To overcome limitations (eg, low physician density, undercapacitated laboratory infrastructure, and limited resources) to development and implementation of widely accessible cervical cancer programs in sub-Saharan Africa	eC_3 system (electronic cervical cancer control) facilitates monitoring, evaluation, and continued education of primary health care providers, patient education, and medical records documentation; it is contextually focused telemedicine framework that sends digital images and facilitates distance consultation for cervical cancer screening, diagnosis, and treatment in area that faces limits in physicians and laboratory infrastructure

Abbreviations: CHW, community health worker; ICT, information or communication technology; LMIC, low- or middle-income country; mHealth, mobile health; NCD, noncommunicable disease; RCT, randomized controlled trial.

evidence generation in this field. Articles fell short on policy and legal integration and lacked data on the costs of ICT-supported interventions. Not surprising given the limited amount of original research in this field, insights garnered from studies and commentaries were not necessarily supported by quantitative evidence.

Lessons may be drawn from noncancer ICT-supported interventions as well as cancer-focused ICT interventions in upper middle– and high-income countries. For example, a systematic review of ICTs for chronic disease management and control showed that ICTs improved health education and hypertension detection.[30] Another looked to mHealth to address noncommunicable diseases in sub-Saharan Africa and concluded (as we have) that there is insufficient evidence in support of mHealth for noncommunicable disease prevention and control in that setting.[31] It is also worth noting that the literature suggests that ICT-supported chronic disease interventions have not been rigorously evaluated or documented in LMICs. However, there are some promising ICT-supported breast and cervical cancer prevention interventions in upper middle– and high-income countries. A feasibility study of breast self-examination reminders via a smartphone application in Korea reported an increase in breast self-examination screening.[7] In New Mexico in the United States, a study on cancer prevention knowledge, health seeking behavior, and desire for mobile messaging among Hispanic and non-Hispanic rural women concluded that mobile technology may fill an important gap in educational needs on cancer prevention.[8] A study in Botswana showed improved access to see-and-treat cervical cancer screening via mobile telemedicine for women in remote regions.[9] Another pilot program in Botswana using telemedicine to reach regions with few medical specialists demonstrated the need for both strong management and local partnerships to achieve sustainability. It identified benefits of reduced referral costs and improved patient outcome; however, significant limitations concerning device function and cultural alignment existed.[10] These experiences indicate that ICTs can help overcome barriers such as access, reach, and awareness in LMICs.

Future efforts should examine how ICTs can be used to address cultural barriers to the prevention of women's cancers. Programs will also need to take into account factors such as the gender digital divide—the gender disparities in both access to and use of ICTs[32]—and the role of families, religious leaders, and social networks more broadly in shaping women's access to and control over resources. Ideas about how ICTs can be used to address cultural issues may be derived from deployments of ICTs to advance women's empowerment in other domains in LMICs. Such empowerment outcomes through ICTs have been observed across individual and collective levels.[32] In Bangladesh, ICTs have been used by women's microcredit groups to increase efficient access to funds and decision making.[33] ICTs also broke down barriers to learning English, specifically faced by women, by bringing information to the domestic sphere and increasing women's confidence in interacting with technology.[34] Such ICT-enabled platforms used by women may offer opportunities to promote cancer prevention and provide insights into the optimal ways in which ICTs can be applied to address barriers related to access and decision making faced by women.

Experiences such as in Bangladesh suggest that ICTs may open new avenues of access to information and services for women and thus help overcome gender-based barriers. That said, it is important that programs also carefully monitor ways in which the use of ICTs may unwittingly exacerbate or reinforce underlying gender inequalities[32,34] or result in other adverse unintended consequences. For example, ICTs may be used to promote women's awareness of breast and cervical cancers and the importance of screening and early detection. However, if prevention services are unavailable or unaffordable, awareness-raising efforts may increase feelings of helplessness and result in anxiety or distress. Similarly, if ICT-enabled interventions improve screening follow-up, but screening test performance is poor, overall intervention outcomes will be suboptimal. Thus, ICT-supported efforts must be seen as part of a broader effort to improve the care continuum of prevention and designed and monitored to minimize unintended harms.

More research is needed to better understand which of the demand- and supply-side challenges to breast and cervical cancer prevention in LMICs can be effectively addressed by the application of ICTs. Overall, few attempts have been made to deploy ICTs to address issues such as lack of awareness and stigma related to breast and cervical cancers, although the importance of addressing sociocultural barriers, including awareness gaps and stigma, are well recognized.[17] As Andela et al noted, "the future of cancer medicine in developing countries hinges on the demystification of cancer through positive information, coupled to an effective organization that allows for optimal use of available resources,

Table 4 – Illustrative Benefits of ICT Applications for Cancer Prevention

Benefit
Primary prevention
Increasing awareness levels
Promoting behavior change regarding risk factors
Reducing stigma
Secondary prevention
Promoting behavior change to seek early detection
Improving referral pathway linkages to diagnosis and care
Reducing stigma
Disease management
Coordinating services and delivery of care (eg, patient navigation)
Improving management
Treatment adherence
Survival
Symptoms and sequelae
Survivor-related counseling (eg, nutrition)
Improving quality of life
Palliative care
Navigation of health system
Referral pathways to diagnosis and treatment
Access to information on financial assistance
Access to information on facilities for diagnosis, treatment, and care
Access to information on palliative care

Abbreviation: ICT, information or communication technology.

facilitates access and promotes flow of knowledge and technology through stakeholders."[3(p1)] Future research should take a more comprehensive approach to assessing the role of ICTs. There is also a need to examine the use of ICTs to support integration and/or coordination of interventions spanning primary, secondary, and tertiary cancer prevention (Table 4).

Given the state of the current literature, immediate priorities for research on ICTs and breast and cervical cancer prevention include more rigorous investigation, including the use of quasiexperimental and experimental study designs, to generate quantitative objective measures; studies that include longer-term follow-up and evaluation; research on the costs, cost savings, and cost effectiveness of ICT-supported interventions; development of an implementation and evaluation framework that synthesizes prevention priorities, challenges to cancer prevention, and ICT applications within the health system; and integration of cultural context, taking into account gender norms, community priorities, and stigma associated with cancer.

In conclusion, ICT-supported interventions for prevention of breast and cervical cancers seem feasible and indeed promising. The literature suggests that there is an opportunity and a need for the creative use of ICTs to address both demand- and supply-side barriers to prevention of breast and cervical cancers in LMICs. Future efforts to design ICT-supported interventions for the prevention of women's cancers should consider lessons learned from using ICT-based women's empowerment programs in LMICs. However, there is insufficient evidence on the most feasible and effective ways in which ICTs can be used to support long-term cancer prevention efforts. Future efforts to examine ICT applications for cancer prevention for women should build on the available information in LMICs, experiences of implementing ICT-based cancer prevention interventions in high-income countries (especially those targeting hard-to-reach, disadvantaged populations) and consider possible lessons from the applications of ICTs in non–cancer-related health promotion initiatives.

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