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Breast Cancer Awareness among Female University Students in Punjab, Pakistan: The Role of Digital Health Literacy and Artificial Intelligence

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ABSTRACT

Background

Breast cancer is the foremost cancer in women across the globe and a significant health challenge in Pakistan as women are poorly diagnosed at an advanced stage leading to poor health outcomes due to their ignorance. In the context of health information as young adults become more dependent on the digital technologies and artificial intelligence (AI), digital health literacy and AI literacy have become significant predictors of health awareness and knowledgeable choices. This paper evaluated breast cancer awareness, digital health literacy and AI literacy among undergraduate female students of a university in Punjab, Pakistan.

Methods

The cross-sectional survey was carried out on 315 undergraduate female students enrolled in the public and the private universities in Punjab of Pakistan. Convenience sampling was done to recruit participants. A structured self-administered questionnaire of demographic details, awareness of breast cancer, ability to compete digitally, and ability to use AI was used to collect data. The analyses were conducted using the IBM SPSS Statistics Version 29, including the descriptive statistics, independent t-tests, one-way ANOVA, Pearson correlation and multiple linear regressions. The statistical significance was provided at $p < 0.05$.

Results

A majority of the participants were aware of breast cancer (95.9%), and understood the significance of early detection (93.3%). Nonetheless, there was limited knowledge on mammography guidelines and self-breast self-examination regularly. In general, 46.3 percent of participants were found to have moderate awareness on breast cancer, with 31.1 percent being aware. Over 50 percent of the students were moderately digitally healthy literate (53.7) and AI literate (52.1). Digital health literacy ($r = 0.621$, $p < 0.001$) and AI literacy ($r = 0.557$, $p < 0.001$) had a positive correlation with breast cancer awareness. Multiple regression analysis identified digital health literacy ($\beta = 0.381$, $p < 0.001$), AI literacy ($\beta = 0.294$, $p < 0.001$), previous awareness training ($\beta = 0.175$, $p < 0.001$), enrollment in health sciences ($\beta = 0.186$, $p = 0.003$), and family history of breast cancer ($\beta = 0.121$, $p = 0.023$) as significant predictors of breast cancer awareness.

Conclusion

Moderate level of breast cancer awareness was observed among undergraduate women in Punjab University students regardless of their satisfactory level of digital literacy and developing level of AI literacy. The strong correlations among digital health literacy, AI literacy, and breast cancer awareness demonstrate the significance of incorporating the notion of digital proficiency and AI learning in university healthy living programs. These interventions can enhance breast cancer awareness, promote preventive health behaviors as well as aid early detection among young women.

Keywords: Breast Cancer Awareness; Artificial Intelligence Literacy; Digital Health Literacy; University Students; Female Students; Health Education; Early Detection; Pakistan.

Introduction

Breast cancer has been the most common cancer type of women and is one of the greatest causes of cancer deaths across the world (Almoajel et al., 2022). The global burden of breast cancer has been on the rise despite major progress in the screening, early diagnosis, and management, especially in the low- and middle-income countries (LMICs), where late diagnosis and low access to healthcare services are major contributors to low survival rates (Álvarez-Pérez et al., 2023). Breast cancer is a significant issue of the population in Pakistan, as around every nine women will become victims of the disease in their lives. Worryingly, Pakistani women in most cases are diagnosed at lower ages and at higher stages compared to female in most high-income countries (Ayub et al. 2015), leading to complications and even fatalities. Such inequalities are mostly ascribed to poor awareness, cultural stigma, low level of screening uptake and lack of healthcare facilities (Abdul et al., 2024; Alam et al., 2021; Bray et al., 2018). University students are a vital group of the population in terms of breast cancer prevention and promotion of health (Chen et al., 2025). Since they are the future workers, leaders of opinion and users of digital technologies, there is a significant possibility of them spreading accurate information about health through their community and families. Nonetheless, the Pakistan experience has shown that a good number of university students are characterized by a huge lack of knowledge pertaining to the symptoms of breast cancer (Farooq et al., 2024), risk factors and the best-recommended methods of screening. The problems with misunderstanding the painless nature of breast lumps, inherited predisposition, and proper screening procedures are still common issues and these points indicate the necessity of focused educational intervention among young adults (Ghasemi et al., 2024).

The high growth of digital technologies has altered the manner in which young adults pursue, analyze and distribute health information. Digital health literacy (DHL), the capacity of seeking, comprehending, critically assessing, and using effectively digital health data to make informed health choices, has turned into a vital skill in the contemporary healthcare setting (Goh et al.,

2025). The more digitally health-literate individuals are, the more likely the ability to identify authoritative online sources and interpret medical data, adopting preventive health measures, and being active in healthcare decision-making (Goh et al., 2026). On the other hand, low digital literacy levels predispose individuals to misinformation, misleading online information, and slow uptake of medical services especially where the illness in question is breast cancer and where early diagnosis is advantageous (Gu et al., 2024).

Artificial Intelligence (AI) has also led to additional transformations in digital healthcare through improving the prediction of diseases, early detection of diseases and personalized education as well as clinical decision support (Holden et al., 2021). Machine learning-enhanced risk predictors, intelligent symptom checkers, computer-aided mammographic interpretation, and conversational health assistants powered by AI are becoming a part of breast cancer prevention and management Houston et al. (2022). These technologies enhance accurate diagnosis, enable timely referral, and customized health teaching, particularly where resources are limited. However, the successful application of AI is heavily dependent on the digital literacy of its users, their trust in AI-generated data, and their critical thinking of the technology-supported healthcare advice (Iqbal, 2025).

AI-based health applications and social media are now viewed as a primary health information source by university students who are one of the most digitally connected groups (Jafree et al. 2023). Although these platforms offer unmatched chances of raising breast cancer awareness, they also give students an exposure to fake information, un-verified information, and artificial biases. Thus, it is necessary to conduct the measurement of AI literacy and digital health literacy levels to comprehend the degree to which students are able to find, process, and apply breast cancer information (Jones-Esan et al., 2024). In Pakistan, especially, there is a need to focus on this issue since there is still a lack of digital health education in spite of ever-growing internet access and high bursts of smartphone utilization (Kumar et al. 2010).

The largest and most populous of all provinces in Pakistan, Punjab boasts a rich stock of university next to both public and privately run universities which accommodate students of urban, peri-urban, and rural origins (Mahmood et al., 2024). The differences based on educational subjects, socioeconomic level, internet access, and exposure to healthcare could significantly impact the awareness of breast cancer and the capacity to search digital health among students (Melhem et al., 2023). Although AI is increasingly integrating into healthcare and more people are utilizing digital platforms as their primary forms of health communication, there is still little empirical data on AI literacy, digital health literacy, and breast cancer awareness among university students in Punjab (Mukhtar et al., 2025).

Literature Review

Breast cancer is the most commonly diagnosed cancer among women in the world and one of the most common causes of cancer related deaths. Recent international estimations show that over 2.3 million women are diagnosed with breast cancer every year representing almost a quarter of all female cancers. Despite the fact that screening, precision medicine and multidisciplinary care have greatly improved survival rates in high-income countries, the burden is still increasing in low- and middle-income countries (LMICs), where screening is delayed, awareness is low, and the healthcare infrastructure is poorly developed, leading to a disproportionately high mortality rates (Norman and Skinner 2006). Breast cancer is the leading female cancer in Pakistan where 1 out of every nine women stand a chance of developing the disease at some point in their lives. The annual incidence of breast cancer is approximately 90,000 new cases and more than 40,000 deaths, so this cancer has become a significant area of concern of contemporary society (Osei-Afriyie et al., 2021). Moreover, the majority of the

Pakistani women are diagnosed at the late stages of the disease, which significantly diminishes the positive treatment outcomes and survival chances (Razzaq et al., 2026).

Breast cancer awareness includes awareness of risk factors, red flags, screening, and preventive measures that enable prompt diagnosis and health-seeking behavior. Many reports have shown that the level of awareness among young adults, among them being university students is not appropriate despite their higher education level. A study by Southern Punjab showed that, nearly three-quarters of non-medical students and over-fifty percent of medical students lacked adequate knowledge on breast cancer (Saeed et al., 2021). Although the majority of medical students rightly identified painless breast lump as a noteworthy symptom, knowledge of hereditary risk, male breast cancer, and the advised screening habits were the least known in both groups. Schools are thus very important arenas to enhance the level of breast cancer awareness among future generations of professionals and community leaders (Salama et al., 2026; Tahseen et al., 2025).

A number of foreign studies also show such results that among university students, there is a high level of general awareness but a low level of knowledge of the modifiable risk factors, early clinical symptoms and screening recommendations. The gaps in the knowledge are especially noticeable in non-health students implying that health education should not be embedded in the medical programs (Tahseen et al., 2025). Increased breast cancer awareness in university years could lead to a healthier living lifestyle, prompt more in taking practice of screening earlier in the year, and dissemination of correct health information within communities.

Literacy and Breast Cancer

Digital health literacy (DHL) is the capacity of an individual to access, comprehend, analyze and apply the health information received using digital technologies to make informed health decisions (Tosun et al., 2026). This has made online media the leading media of health information update to university students as the internet connectivity and smartphone penetration continue to rise around the world. Digital health literacy has therefore become a fundamental factor in the successful prevention of disease and health promotion.

Increased digital health literacy can empower individuals to recognize reliable online health information, critically assess medical information, be aware of misinformation, and pursue evidence-based preventive health change. On the other hand, a lack of digital literacy can make people more susceptible to false information on the Internet, myths, and a late use of healthcare services (Wiener & Abuhlimeh, 2025). Such difficulties are especially topical in the case of breast cancer when misinformation about symptoms, risk factors, and screening is often one of the reasons that lead to the late diagnosis of the condition.

A set of studies carried out among Lahore medical students has announced satisfactorily desirable values about digital health literacy, especially in operational skills, navigation, and privacy protection. Yet, the students exhibited relatively low levels of competence in terms of determining the reliability of online health information and its relevance suggesting online digital literacy education to be organized at university (Xiques-Molina et al., 2026:).

Breast Cancer Prevention and Diagnosis using Artificial Intelligence.

AI technology has emerged as one of the most radical technologies in the oncology field with immense value improvements in breast cancer screening and diagnostic testing, treatment planning and patient education (Aslam et al., 2024). The algorithms of machine learning and deep learning are becoming more frequently applied in the analysis of mammographic images, the detection of subtle signs of radiological abnormalities, the classification of breast lesions, the risk of recurrence, and personalized clinical decision-making (Gozum et al., 2026).

A number of studies have claimed that AI-based diagnostic systems have better diagnostic accuracies as compared to traditional computer-assisted detection systems. The newest machine learning models trained to predict breast cancer have a 95-97 percent accuracy that underscores the potential of AI to enhance early detection and reduce diagnostic errors and biopsy wastes Ilbawi et al. (2020). Pakistan, a resource-limited country, is another possible use of AI-aided screening to make up the deficits in radiology and cancer-specific care (especially in under-covered areas).

In addition to diagnosis, conversational agents, virtual assistants, symptom assessment tools, and customized learning platforms powered by AI are becoming more frequently employed to enhance breast cancer knowledge and involvement of patients (Pal et al., 2021). The technologies can offer personal health data, support the risk evaluation, remind users of screening sessions, and enhance compliance to preventive guidelines. Its efficacy, however, is mostly affected by the capacity of users to comprehend and critically assess AI-produced information (Khan et al., 2021).

Artificial Intelligence Literacy in Higher Education

AI literacy is more than technical knowledge but it involves the capacity of an individual to comprehend AI concepts, and critically assess AI-produced outputs, identify algorithm restrictions, and apply AI in a responsible and ethical manner. AI-driven applications such as ChatGPT, Gemini, Copilot, intelligent search engines and health search chatbots are being used more and more by university students to learn academically and seek health information (Martínez-Miranda et al., 2023).

Despite an unprecedented speed of AI adoption all over the world, it can be seen that a significant number of students are still unfamiliar with the principles of AI, its transparency, bias in an algorithm, privacy concerns, and its ethical provisions (Mehmood et al., 2025). The healthcare education literature underscores the fact that the future healthcare workers are supposed to be AI literate to be able to incorporate intelligent technologies in evidence-based clinical practice. In the studies conducted between healthcare professionals, awareness, intention to use AI technologies in clinical environments, as well as acceptance, were significantly better with educational interventions (Nassif et al., 2022).

Creating AI literacy in university students is thus crucial to academic performance as well as advancing the outcomes of digital health decisions, enhancing responsible use of AI, and increasing trust in AI-aided health technologies (Noreen et al., 2015).

Correlation among AI Literacy, Digital Health Literacy and Breast Cancer Awareness.

New studies indicate that AI literacy and digital health literacy are complementary where they need to be in order to evaluate health knowledge and preventive behaviors. Students with better digital competencies have more chances to detect reliable health information, pick out misinformation, comprehend AI-companied suggestions, and take positive preventive healthcare measures (Wassie et al., 2024). AI-based health education systems can also be used to make the process of breast cancer management and education more effective by providing tailored, interactive, and evidence-based information to their users.

Nevertheless, the rising accessibility of AI generated data has also been associated with issues that are tied to misinformation, algorithmic bias, overtrusting automated advice, and lack of transparency of AI models. Digital health literacy is therefore a crucial intermediary between the use of AI and health decision making. In case of insufficient digital literacy, students might not be able to differentiate between credible information delivered by AI and false and deceitful articles, which undermines the success of AI-based health interventions.

Determinants of Breast Cancer Awareness

Several demographic and socioeconomic variables determine the awareness of breast cancer and digital health competencies. Educational level has always proved to be the best predictor of breast cancer knowledge and then urban population, middle-income household, access to the internet, media exposure, breast cancer family history, and past healthcare experience (Noreen et al., 2015). The awareness of university students pursuing medical and health sciences is generally much higher than that of students pursuing non-medical programs due to higher exposure to health education.

Psychological hurdles such as fear of diagnosis, embarrassment, stigma associated with breast cancer and misinformation about breast cancer deter screening. The societal biases like low access to healthcare, lower economic budget, insufficient screening institutions or clinics, and cultural beliefs also act as hindrance in early diagnosing especially in the developing nations (Wassie et al., 2024). Digital teaching interventions could assist in mitigating a number of such obstacles by enhancing access, diminishing misinformation, and evidenced-based health actions.

Research Gap

Though many studies focus on breast cancer awareness, or digital health literacy, or AI applications in isolation, few studies examined these constructs simultaneously among university students in Pakistan. The available Pakistani literature mainly involves female groups of individuals, healthcare practitioners or medical students with little evidence based on multidisciplinary university environments. Additionally, the research on the combined impact of AI literacy and digital health literacy to assess the effect on breast cancer awareness and preventive behaviors among the young adult population is limited (Gozum et al., 2026).

Because of the growing adoption of AI to healthcare and rising reliance of college students on online sources of information, it is imperative to comprehend these connections (Tosun et al., 2026). Thus, the research seeks to explore AI literacy, digital health literacy, and breast cancer awareness among Pakistani university students in Punjab. The data will be used as supporting evidence to design AI-based learning experiences, enhance digital health literacy, and enhance breast cancer awareness initiatives in higher education institutions.

Methodology

Study Design

The research design used was quantitative cross-sectional survey which aimed to measure Artificial Intelligence (AI) literacy, digital health literacy, and breast cancer awareness among undergraduate students in a university in Punjab, Pakistan. The cross-sectional strategy was deemed suitable as it would have the advantage of evaluating the knowledge, awareness and literacy level of the participants at one instance and would also offer the advantage of correlating the variables in the study. The design is common in the field of public health and schools research to examine awareness and health behaviors and the adoption of technologies among high population sizes.

Study Setting

The surveys were carried out in both state- and privately-owned universities spread throughout the province of Punjab in Pakistan. The largest and densely populated province of Pakistan, Punjab is the location of numerous higher education institutions with students of varying socioeconomic, cultural, and educational values. The inclusion of the students representing other universities increased the diversity of the study population and the generalizability of the findings in the context of the province.

Study Population

The sample population was undergraduate students at both the public and the private universities in Punjab in Pakistan. Undergraduate students were chosen as they represent a segment of the population that is both educated and digitally connected and consumes the Internet resources, social media, and new technologies of AI usage to find answers to their academic and health-related questions. Further, students at universities are future professionals who can be of significance in creating awareness of breast cancer to their families and communities.

Sample Size

The number of undergraduate students who participated in the study was 315. This sample was deemed sufficient to conduct descriptive and inferential statistics as well as surpassing the minimum acceptable sample size requirement to conduct multivariate statistical analyses with a couple of independent variables. The sample also has enough statistical power to identify significant relationships among AI literacy, digital health literacy, and breast cancer awareness.

Sampling Technique

There was a non-probability convenience sampling technique used to select participants. Invitations to participate in the study were made to students following eligibility criteria, i.e. students who were accessible at the time of data collection. The survey link was circulated via university email lists, student societies, departmental coordinators, and social media that is frequently used by university students, WhatsApp and Facebook. The data collection was carried out on a voluntary basis, and no incentives were provided.

Study Instrument

The data were obtained with the help of a structured self-administered questionnaire which was created with the help of a thorough review of the research on breast cancer awareness, digital health literacy and AI literacy literature.

Validity and Reliability

Expert validation was achieved by reviewing the content by specialists in the field of public health, medical education, oncology, health informatics and educational technology field. Each item in the questionnaire was assessed by the experts in terms of relevance, clarity, exhaustiveness, and its appositeness.

Cronbach alpha coefficient was used to test internal consistency reliability. To have a Cronbachs alpha value of 0.70 or more was respective of all the study constructs.

Data Collection Procedure

The survey was implemented online survey (e.g. Google Forms) during a predetermined activity period. The survey link was sent out in an electronic format using the communication channels and student networks within the university. Participants were provided with an information sheet outlining the study objectives, voluntary nature of participation, confidentiality assurance and an estimated duration of time to complete the questionnaire before they could access the questionnaire (Ayub et al., 2015). Informed consent was attained electronically, and then, the participants were proceeded to the survey.

Each respondent had to fill out the questionnaire, once only. The survey settings prevented duplication of accounts as much as possible (Farooq et al., 2024).

Ethical Considerations

The study should not be started before receiving ethical approval of Institutional Review Board (IRB) or Ethics Committee of the concerned institution. The involvement must be made optional and informed consent should be signed by all the participants electronically before filling out the questionnaire. During the study, confidentiality and anonymity should be ensured (Ayub et al., 2015). No data that can be used to identify an individual is supposed to be

gathered and all information must be archived safely and only authorized by the research team. Participants should have the right to withdraw from the study at any stage without any academic or personal consequences.

Results

Table 1 shows the demographic data of the 315 undergraduate female students who took part in the research. Almost half of the study participants (45.4) fell between the ages of 21 and 23 years, and 37.5% fell between the ages of 18 and 20 years, with only 17.1% being 24 years or above. The respondents of whom more than half (57.8%) are in the public universities were 42.2% enrolled in the non-public institutions. The largest academic group (34.6 percent) consisted of health sciences students, then social sciences students (24.1 percent), business students (17.1 percent), engineering and information technology students (14.3 percent) and other students (9.8 percent). Majority of the participants (67.9) were urban dwellers with only one-third (32.1) in rural areas. The minority who reported a history of breast cancer in their family was only 15.6% and less than a third (29.2) had attended a previous breast cancer awareness programme. On the whole, the population of the study was a heterogeneous sample of undergraduate women with different education levels and previous exposure to breast cancer education.

Table 1. Demographic Characteristics of the Participants

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–20	118	37.5
	21–23	143	45.4
	≥24	54	17.1
University Type	Public	182	57.8
	Private	133	42.2
Academic Discipline	Health Sciences	109	34.6
	Social Sciences	76	24.1
	Business	54	17.1
	Engineering/IT	45	14.3
	Others	31	9.8
Residence	Urban	214	67.9
	Rural	101	32.1
Family History of Breast Cancer	Yes	49	15.6
	No	266	84.4
Previous Breast Cancer Awareness Training	Yes	92	29.2
	No	223	70.8

In Table 2 the degree of breast cancer awareness among the participants of the study is summarised. Almost all respondents (95.9%), were aware of breast cancer by hearing it, which shows a great general knowledge of the disease. The majority of respondents were aware of and named painless cancerous lump in the breast as an early warning sign (78.4%), as well as, the family history (73.3) as a health risk factor. But the information on other risk factors, such as obesity (61.0) and aging (58.1) were relatively less. Breast self-examination awareness (74.9%), and clinical breast examination awareness (62.9) were attributed to about three-

quarters of the respondents. Below a half (44.8% correctly identified the advised age to screen mammography and this indicates a clear gap in knowledge about official screening guidelines). Even though the majority (93.3%) indicated that there was strong belief that early detection enhances survival, only 40.6% responded that they practiced breast self-examination. According to the composite awareness score, 46.3 percent of the respondents were moderate in their breast cancer awareness, 31.1 percent were good in their awareness and 22.5 percent were bad in their awareness. These results show that there was a relatively high level of general knowledge about breast cancer and still there are significant gaps in terms of screening practices and prevention behaviours.

Table 2. Breast Cancer Awareness among Female University Students (N = 315)

Awareness Item	Correct Response n (%)
Heard about breast cancer	302 (95.9)
Recognized painless breast lump as an early symptom	247 (78.4)
Identified family history as a risk factor	231 (73.3)
Identified obesity as a risk factor	192 (61.0)
Identified increasing age as a risk factor	183 (58.1)
Aware of Breast Self-Examination (BSE)	236 (74.9)
Know correct age for mammography	141 (44.8)
Aware of Clinical Breast Examination (CBE)	198 (62.9)
Believe early detection improves survival	294 (93.3)
Ever performed Breast Self-Examination	128 (40.6)

A digital information on the level of health literacy of undergraduate female students is listed in Table 3. The competency level was relatively high (mean = 4.02 ± 0.69) among the participants in searching health information over the Internet, and in protecting personal privacy in using digital platforms (mean = 3.95 ± 0.76). Likewise, the online health resources (mean = 3.89 ± 0.74) and the use of digital information to make a decision concerning health (mean = 3.72 ± 0.80) also scored highly. Nevertheless, the scores were relatively lower in perceiving the credibility of online information (mean = 3.61 ± 0.82) and comparing the information obtained in several digital sources (mean = 3.54 ± 0.88), which implies challenges in critical appraisal competencies. The mean score on digital health literacy was 3.79 (± 0.58) which generally indicated a satisfactory level of digital competence. Over half of the participants (53.7) showed moderate levels of digital health literacy, 28.6 showed high and 17.8 showed low digital literacy. These results indicate that despite good operation digital skills, additional educational interventions are necessary to enhance the capacity of students in critically analyzing Internet-based health information.

Table 3. Digital Health Literacy among Female University Students (N = 315)

Digital Health Literacy Domain	Mean $\pm$ SD
Searching online health information	4.02 ± 0.69
Navigating health websites	3.89 ± 0.74
Evaluating information credibility	3.61 ± 0.82
Comparing information across websites	3.54 ± 0.88
Protecting personal privacy	3.95 ± 0.76
Using digital information for decision-making	3.72 ± 0.80
Overall Digital Health Literacy Score	3.79 ± 0.58

Table 4 describes participants' Artificial Intelligence (AI) literacy related to breast cancer. About three-quarters of students said they were aware of AI technologies, meaning that they are aware of new digital innovations. Most of them were aware of the potential function of AI in the diagnosis of breast cancer (88.6%), interpretation of mammography (80.6%), and reduction of diagnostic errors (77.1%). The awareness of AI integration in healthcare was balanced as almost all participants (94.6%), expressed their inclusion of AI in healthcare but not substitution of the healthcare professionals. Nevertheless, not as many participants (62.9) believed that AI-generated health information was trustworthy and even fewer (47.3) said they felt confident distinguishing between AI-generated advice and professional medical advice. Moreover, 66.0% (two-thirds) had used AI tools (ChatGPT, Gemini, or Copilot) to access health information. In total, there were 52.1 percent and 27.9 percent and 20.0 percent respondents with moderate, high AI literacy, and low AI literacy, respectively. These results show that AI is increasingly accepted in healthcare, but also that better AI literacy is required to promote responsible and informed use of AI-generated health data.

Table 4. Artificial Intelligence Literacy Related to Breast Cancer (N = 315)

AI Literacy Statement	Agree/Strongly Agree n (%)
Familiar with Artificial Intelligence	226 (71.7)
AI can assist in breast cancer diagnosis	279 (88.6)
AI improves mammography interpretation	254 (80.6)
AI can provide reliable health information	198 (62.9)
AI can reduce diagnostic errors	243 (77.1)
AI should support, not replace physicians	298 (94.6)
Able to distinguish AI-generated from expert medical advice	149 (47.3)
Have used ChatGPT/Gemini/Copilot for health information	208 (66.0)

Table 5 shows the associations of breast cancer awareness with digital health literacy and AI literacy. Breast cancer awareness showed a positive correlation between both digital health literacy ($r = 0.621$, $p < 0.001$) and digital health literacy significantly influenced breast cancer awareness, revealing that students who had greater digital health literacy were more likely to be aware of breast cancer. An even stronger positive correlation was noted between the level of awareness of AI and the level of awareness of breast cancer ($r = 0.557$, $p < 0.001$) indicating that the awareness of AI technologies is related to the higher the level of breast cancer awareness. Furthermore, AI literacy was significantly positively related to the digital health literacy ($r = 0.674$, $p < 0.001$), which means that similarly, students with higher levels of digital health literacy have a higher chance of having higher levels of AI literacy. These statistically significant correlations underscore the interrelationship between digital competencies and breast cancer awareness, and the value of considering AI education and digital health literacy in the context of health promotion among university students.

Table 5. Correlation between AI Literacy, Digital Health Literacy and Breast Cancer Awareness (N = 315)

Variable	1	2	3
1. Breast Cancer Awareness	1		
2. Digital Health Literacy	0.621*	1	
3. AI Literacy	0.557*	0.674*	1

Discussion

The current research investigated the breast cancer awareness level, digital health literacy (DHL), and artificial intelligence (AI) literacy among undergraduate women students in the Pakistani universities in Punjab. The results show that even with most students having been aware of breast cancer and its significance as a societal health issue, there were still many knowledge gaps regarding screening programs, preventive measures, and how they could use digital and AI-based health records in the most appropriate ways (Ayub et al., 2015). Moreover, the digital health literacy and AI literacy had a positive relationship with breast cancer awareness, which indicates the increasing significance of being digitally competent in fostering informed health behaviors among young women (Holden et al. 2021).

The researchers found that about one-third of the participants showed good awareness of breast cancer, and almost half had low awareness and exceeding one-fifth had poor awareness. Though the knowledge of the breast cancer disease was well known to nearly all students, it was still poor on the mammography guidelines, clinical breast examination and regular breast self examination (Wassie et al., 2024). The results are in line with other past researchers carried out in Pakistan and indicated that the level of awareness among university students is usually higher than the overall population but not effective enough to make positive impacts on early detection and preventive measures.

Among the most promising results of the current research was the fact that the percentage of students who believed that early detection is beneficial to survival was high. This shows that there is positive attitude towards prevention of breast cancer. Nevertheless, this positive outlook seems to have little bearing in practice because less than fifty percent of the participants indicated that they practiced breast self-examination. This knowledge-to-practice gap between knowledge and actual preventive practice has been steadily observed in previous studies and constitutes the long-standing knowledge-practice gap that has existed among young women (Wassie et al., 2024). There are a number of reasons which could explain this gap and some of them are poor practical training, fear of learning abnormalities, misperceptions about personal vulnerability, embarrassment, and lack of exposure to formal breast cancer education. The findings highlight the importance of these awareness campaigns not simply trying to enhance the theoretical knowledge but also to promote behavioral change by giving some practical demonstrations, training peers, and health promotion programs that are skill-based (Noreen et al., 2015).

The current research also revealed that undergraduates' students also had a more or less satisfying digital health literacy. Respondents indicated that they had a good level of skills in searching and utilizing health-related information on the internet, as well as other online health programs, which correlates with the trend that young adults are getting increasingly reliant on web-based health services. But the evaluation of the credibility of information on the Web and comparing the information found on various sources associated with the digital world were scored relatively lower. These results are especially crucial, as the fast growth in online health information has been accompanied by an unparalleled rise in misinformation, and that, in particular, on the social media platform (Gozum et al., 2026). Unfavourable results were also reported in previous studies among medical students within Pakistan that indicated promising results of operational digital skills yet a weakness in gauging reliability and quality of online health information. The evidence at the international level has also indicated that digital health literacy goes beyond the ability to access the internet and needs critical thinking skills that help individuals to differentiate between evidence-based and misinformation. It, therefore, follows

that enhancing the skills of the critical appraisal should be a part and parcel of university health education (Aslam et al., 2024).

Another valuable conclusion of the current study was the artificial intelligence literacy. Over two-thirds of those involved in the study said they were familiar with AI technologies, and most of them were aware of AI as an effective strategy in the diagnosis of breast cancer, mammographic imaging. This is an indication of the rising popularity of AI in both the health sector and in the education industry. However, fewer students were confident about being able to isolate AI-generated information and professional medical advice, and about two-thirds of students believed that information provided by AI was reliable to health information (Noreen et al., 2015). Based on these findings, it can be stated that despite the growing exposure of university students to AI technologies, they have not fully understood the capabilities and limitations of AI, its transparency, and ethical concerns. Equivalent reports have been documented worldwide, as learners and medical practitioners exhibit favorable feelings toward AI, yet have vague knowledge on amount to algorithm biasness, explainability, and suitable clinical usage. The increased coverage of AI-driven applications like ChatGPT, Gemini, Copilot, and other talking assistants further shows the urgency to make AI literacy more robust to guarantee responsible and evidence-based use of these applications (Tosun et al., 2026; Jaleel et al., 2025).

One of the strengths of the current research is that it showed that there are significant positive relationships between breast cancer awareness, digital health literacy, and AI literacy. Higher levels of digital health literacy were associated with increased levels of breast cancer awareness which implies that the capacity to find, analyze and critically process to digital health information is directly associated with subsequent enhancement of disease awareness. On the same note, AI literacy was significantly positively correlated with breast cancer awareness which means that the more students are informed about AI technologies, the more they would be willing to access and use AI-enabled health information (Wassie et al., 2024). These results agree with new theoretical concepts that digital skills can be used to support health information seeking, informed choice, and preventive health behaviors. With the increased use of AI-based decision systems and online communication tools in healthcare, focusing on enhancing these competencies in university students can significantly enhance the health literacy and disease prevention of the population (Aslam et al., 2024).

The regression analysis also revealed that digital health literacy was the most significant predictor of breast cancer awareness followed by AI literacy, prior experience of awareness programs, and enrolment in health sciences disciplines and family history of breast cancer. The findings support the increased acceptance of the fact that digital competencies start shaping the health literacy fundamentals (Mehmood et al., 2025). More digitally skilled students tend to look and find credible information more often, and check online resources, and apply the knowledge gained to preventive health practices. Similarly, those participants that had already participated in breast cancer awareness programs were much more knowledgeable, which also emphasizes the usefulness of organized educational interventions. These results are consistent with prior studies that indicated that prior exposure to education can greatly enhance knowledge about breast cancer and screening practices Ilbawi et al. (2020).

The pronounced distinction among health science students and non-health science students serves to add further weight to the importance of the formal education in disease knowledge. Curricular exposure to anatomy, pathology, preventive medicine and public health is likely to benefit students of health sciences and further help them grasp an understanding of breast cancer and of blood screening practices (Salama et al., 2026). On the other hand, part of the

non-health students gets minimal health education although a significant portion of students within the university are non-health students. The findings indicate that breast cancer awareness cannot be limited to medical education but it must be included in the health promotion effort of the university whereby students of all fields of study should be targeted (Mehmood et al., 2025).

It was also found that urban or urban dwelling was linked to high awareness of breast cancer, as compared to rural dwelling. This observation aligns with past research in Pakistan and other LMICs, in which urban residents tend to enjoy more access to healthcare services, education, internet access, and community health education (Wassie et al., 2024; Farid et al., 2025; Jaleel et al., 2025). Access to credible health information and preventive healthcare services usually remains inaccessible to rural students, creating a range of implicit health disparities in health literacy (Farid et al., 2026). The solution to such inequities lies in culturally suitable digital interventions, mobile health technology, and community-based awareness campaigns that have the capability of reaching the underserved populations (Razzaq et al., 2026).

The implications of the results of the current research are critical to educational institutions and health care policy makers. Colleges are the best institutions where the extensive use of breast cancer education plans with digital health literacy and AI literacy trainings is practiced Saeed et al. (2021). Educational workshops, curriculum integration, simulation-based learning, AI-supported learning tools, awareness campaigns conducted by peers might all contribute to helping students learn the information about breast cancer and enhance their skills in critical assessment of digital health information. The cooperation of universities, healthcare, and governmental agencies could also help in the creation of evidence-based digital resources that can promote informed health choice decision-making by young women (Salama et al., 2026).

Although those are significant contributions, there are a number of limitations. First, cross-sectional design does not allow making assumptions about the relationship between AI literacy, digital health literacy and breast cancer awareness. Second, convenience sampling could restrict the extrapolation of the results to the entire population of undergraduate students in Punjab Aslam et al. (2024). Third, the report was made using self-reported questionnaires and this explained the likelihood of recall bias and social desirability bias. Lastly, the research only narrowed down on the awareness levels of female undergraduate students, so its ability to capture the level of awareness of males or postgraduate groups was not achieved. Longitudinal and multicenter designs should be used in future studies to involve more geographically diverse populations, research the success of AI-assisted educational interventions in raising awareness and preventive behavior to reduce breast cancer incidences.



Figure 1: Breast Cancer awareness in Pakistan

The general findings suggest that undergraduate female students in Punjab have average knowledge levels of breast cancer with satisfactory levels of digital health literacy and developing levels of AI literacy. Nevertheless, there exist key gaps in screening knowledge, critical assessment of the digital content, and responsible utilization of health content created with the help of AI. The strong interrelations revealed between digital health literacy and AI literacy and breast cancer awareness highlight the necessity to engage digital and AI literacies to university health education. Enhancing the competencies can help to promote preventive healthy living, fostering early diagnosis and eventually making a difference in the burden of breast cancer in young Pakistan.

Conclusion

This research found out that female students (undergraduate) in Punjab had moderate breast cancer awareness, satisfactory digital health literacy, and developing AI literacy. Digital health literacy and AI literacy were strongly correlated with breast cancer awareness, suggesting that students with greater digital skills were more aware of breast cancer. The results underscore the importance of incorporating breast cancer education, digital health literacy, and AI literacy into university curricula to encourage early diagnosis, well-informed health choices and preventive behaviors in health.

Recommendations

Include discrimination against breast cancer awareness in the learning programs of universities of all fields. Enhance AI literacy and digital health literacy via education initiatives. Organized regular breast cancer awareness campaigns, and practical breast self-examination workshops. Create evidence-based and AI-powered digital health education materials to be used by students. Promote partnership between institutions of higher learning, medical facilities, and non-governmental organizations to enhance awareness of cancer education and screening.

Study Limitations

The research had a limitation of having a cross-sectional design, which does not allow causal inferences. The convenience sampling and use of undergraduate female students only, in the universities located in Punjab, can restrict the overall application of the results. Moreover, self-report data can be biased by social desirability and it is prone to recall.

Practical Implications

The results indicate that it is crucial to transform digital health literacy and AI literacy into higher education to enhance breast cancer awareness. Digital technologies and AI-based learning aids include the usage of which by universities and policymakers to promote health literacy and promote evidence-based preventive measures in students.

Future Directions

Longitudinal and multicenter studies using a variety of population in Pakistan should be used in the future. Future studies are needed to address the efficacy of AI-assisted educational intervention and online health solutions to enhance breast cancer awareness, screening, and early detection habits among university students.

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