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Artificial Intelligence and Mobile Technologies in Clinical Trial Operations and Recruitment in Cancer Research: A Four-Year Retrospective Analysis of Adult Oncology Trials

Ome Valentina Akpughe *, Timothy Olorundare

Health Informatics, Harrisburg University of Science and Technology, Harrisburg, USA.

*Corresponding Author: Ome Valentina Akpughe; *ome.akpughe@gmail.com*

Abstract

Patient recruitment and retention remain persistent challenges in oncology clinical trials, often leading to delays, increased costs and compromised data validity. Traditional recruitment strategies frequently fail to identify suitable participants efficiently which may result in under-enrollment and high dropout rates that limit the generalizability of trial outcomes. This paper examines how the use of artificial intelligence (AI) and mobile technologies affect patient recruitment and retention in oncology clinical trials. Employing a retrospective analysis of adult oncology trials conducted in the United States between 2017 and 2021, the study utilizes data from adult clinical trial registries to evaluate recruitment patterns and outcomes. Findings demonstrate that AI and mobile health (mHealth) tools can significantly streamline recruitment processes, reduce participant attrition and enhance overall trial efficiency. Integrating these technologies into clinical research operations may aid oncology trials to achieve more reliable data, accelerate therapeutic discoveries and ultimately contribute to improved cancer care outcomes. The study concludes that the integration of AI and mobile health technologies will not only improve operational efficiency but also help address disparities in participation, particularly among underrepresented groups. Therefore, this study recommends that clinical trial administrators should adopt AI and mobile health (mHealth) tools for patient matching, recruitment optimization and retention tracking.

Keywords: ***Oncology Clinical Trials, Artificial Intelligence, mHealth Technologies, Patient Recruitment & Retention.***

1. Introduction

Recruitment and retention of patients in oncology clinical trials remain among the most critical and persistent challenges in cancer research. Inadequate recruitment often leads to delays, increased costs, and compromised validity of trial results. As cancer remains a major cause of morbidity and mortality globally, ensuring robust patient participation is essential for the advancement of effective therapies and evidence-based interventions. In recent years, the integration of artificial intelligence (AI) and mobile health technologies has emerged as a transformative approach to improving clinical trial processes. These technologies offer powerful tools for identifying eligible participants, enhancing engagement, monitoring adherence, and improving data accuracy. AI systems, particularly when integrated with electronic health records (EHRs), can automate patient matching based on inclusion and exclusion criteria, thereby accelerating recruitment and optimizing retention. Mobile health tools complement these efforts by enabling continuous communication, symptom tracking, and compliance monitoring throughout the study period.

This study examines how artificial intelligence (AI) and mobile technologies affect patient recruitment and retention in oncology clinical trials. A persistent challenge in cancer research is achieving adequate participant enrollment and maintaining patient engagement throughout the study period. To address this, the present research conducts a retrospective analysis of adult oncology trials conducted between 2017 and 2021, drawing on data from adult registries. Emerging technologies, particularly AI and mobile health (mHealth) applications, offer innovative solutions to the long-standing issues of recruitment and retention. These tools can efficiently identify eligible participants based on inclusion and exclusion criteria, support sustained engagement and enhance compliance with clinical trial protocols.

Despite significant advancements in oncology clinical trials, patient recruitment and retention remain persistent challenges, particularly for rare cancers and underrepresented populations. The literature highlights that conventional recruitment strategies often rely on manual screening, physician referrals, and localized outreach, which can be time-consuming, resource-intensive, and prone to bias (Chen *et al.*, 2022; Marino *et al.*, 2024). While AI and mobile health tools have emerged as promising solutions, most studies to date have been limited to pilot interventions or focused on single cancer types. Additionally, existing research largely overlooks the integration of AI-driven analytics with comprehensive national cancer registry datasets to optimize recruitment across multiple cancer types and regions. Furthermore, there is a paucity of research

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examining how these technologies impact long-term retention, participant adherence, and inclusivity, particularly in diverse demographic and geographic populations.

This study addresses these gaps by providing a retrospective, multi-year quantitative analysis of adult oncology clinical trials in the United States from 2017 to 2021, leveraging datasets from the Cancer Research Data Commons (CRDC) and the National Cancer Institute (NCI). By examining recruitment patterns across ten major cancer types and linking them to demographic, regional, and prevalence trends, this research offers several novel contributions. For instance, unlike previous studies that focus on high-prevalence cancers or isolated interventions, this study evaluates recruitment and retention patterns across both common and rare cancers, highlighting disparities and areas requiring targeted strategies. The findings of this study highlight practical strategies to improve trial inclusivity, efficiency and adherence, contributing to the design of more equitable and effective oncology clinical trials. In sum, this study contributes to knowledge by bridging the gap between AI/mHealth innovations and practical implementation in large-scale clinical trial recruitment, offering guidance to healthcare institutions, policymakers and researchers seeking to enhance both trial efficiency and patient-centered care in oncology.

2. Literature Review

Oncology clinical trials rely heavily on effective patient recruitment and retention strategies to ensure valid and generalizable results. Between 2017 and 2021, variations in selection criteria across trials have significantly influenced participation patterns, especially as artificial intelligence (AI) and mobile health technologies increasingly shape the recruitment process. Recent studies highlight that AI-driven systems can improve patient identification, streamline inclusion criteria, and reduce unnecessary exclusions, thereby enhancing trial efficiency (Ismail *et al.*, 2023). Patient eligibility often depends on multiple factors such as cancer type, demographic distribution, and the availability of technological tools to facilitate data analysis and outreach.

The integration of AI within electronic health records (EHRs) has notably advanced the precision and speed of patient matching. By automating the identification of potential participants who meet complex inclusion parameters, AI reduces recruitment time while minimizing human error (Ismail *et al.*, 2023). Common cancer types, such as breast and prostate cancer, tend to show higher inclusion rates due to established screening programs, large patient registries, and proactive recruitment strategies (Chow *et al.*, 2023). Meanwhile, the use of mobile technologies has been shown to enhance patient engagement, improve adherence to trial protocols, and support higher retention rates through continuous communication and monitoring (Mudaranthakam *et al.*, 2022).

Despite these advances, exclusion criteria continue to pose significant challenges in clinical research. Trials involving rare cancers, such as certain forms of leukemia, often experience lower recruitment rates due to limited screening initiatives and insufficient investment in outreach to small patient populations (Marino *et al.*, 2024). Furthermore, systemic biases in clinical registry data exacerbate disparities in participation, as underrepresented demographic groups, particularly those with restricted healthcare access or limited digital literacy, face higher exclusion rates (Chen *et al.*, 2022). The absence of patient-centered retention strategies further contributes to dropout rates, ultimately compromising the representativeness and reliability of trial outcomes (Idossa *et al.*, 2023).

In sum, the literature underscores the importance of adopting inclusive recruitment and retention frameworks in oncology clinical trials. AI and mobile technologies present promising avenues for mitigating recruitment disparities by optimizing patient identification and engagement while minimizing exclusion biases. To further promote inclusivity and participant satisfaction, future research should integrate qualitative methods, such as patient interviews and physician focus groups, to explore barriers to participation and design more responsive interventions (Marino *et al.*, 2024). By refining selection criteria and leveraging technological innovation, oncology trials can evolve toward greater equity, efficiency, and effectiveness in improving cancer care outcomes.

3. Methodology

This study adopts a retrospective quantitative research design to examine patient recruitment and retention trends in oncology clinical trials conducted between 2017 and 2021. The primary objective is to identify the key factors influencing recruitment and retention outcomes across different cancer types and to explore how the integration of artificial intelligence (AI) and mobile health technologies can enhance these processes. By focusing on historical data, this approach provides a comprehensive understanding of patterns, disparities, and opportunities for improvement in cancer trial participation.

The data for this analysis were obtained from the Cancer Research Data Commons (CRDC) and the National Cancer Institute (NCI) databases. These repositories provide rich, standardized datasets that include information on cancer incidence, demographic characteristics such as race and sex, and population-level data for major cancer types in the United States, including breast, lung, colorectal, and prostate cancers. Using these datasets allows for an in-depth examination of how demographic and disease-specific factors shape patient recruitment and retention outcomes. The data also provide a foundation for evaluating the potential role of AI and mobile technologies in refining selection criteria and improving participant engagement.

The retrospective analysis focuses on identifying variations in recruitment and retention patterns among different cancer types and demographic groups. Particular emphasis is placed on highly prevalent cancers, such as breast and prostate cancer, which typically demonstrate higher recruitment rates due to extensive screening programs, public awareness, and active outreach. The analysis also explores the capacity of AI-driven analytics and mobile health tools to improve recruitment efficiency by identifying eligible participants more accurately and promoting long-term retention through continuous digital engagement. These technologies can reveal participation gaps, particularly among underrepresented populations, and suggest strategies to enhance inclusivity and adherence to clinical trial protocols.

In addition to the quantitative analysis, a systematic literature search was conducted to support the empirical findings. The search was performed across three academic databases, PubMed, Google Scholar, and BASE, using the keyword phrase “Oncology Clinical Trials.” This search was carried out to identify peer-reviewed studies relevant to recruitment and retention trends, particularly those involving the use of AI and mobile health tools. As of January 31, 2025, the PubMed database contained 67,094 articles, showing no change from the previous search. Google Scholar showed an increase from 793,000 to 799,000 articles, representing approximately 6,000 newly indexed publications, while the BASE database remained constant at 762,109 articles. The final search, conducted on January 31, 2025, at 3:30 PM, revealed no newly published studies that would significantly alter the findings of

this research. Therefore, the dataset used for the current analysis remains unchanged.

This methodological framework combines secondary data analysis with systematic literature synthesis to provide a robust assessment of recruitment and retention trends in oncology clinical trials. The integration of AI and mobile health perspectives ensures that the analysis not only evaluates past performance but also anticipates the transformative potential of emerging technologies. This approach allows for a forward-looking understanding of how digital innovation can optimize clinical trial designs, promote greater equity in participation, and ultimately contribute to improved cancer care outcomes.

4. Results

This analysis examined the relationship between cancer types and the number of reported cases in the United States from 2017 to 2021, with particular attention to how these findings inform the application of artificial intelligence (AI) technologies in patient recruitment. Using the USCSTopTen dataset, which provides detailed information on ten of the most common cancer types, the study evaluated incidence rates, demographic distribution, and overall case counts to identify patterns that can guide technology-driven recruitment strategies.

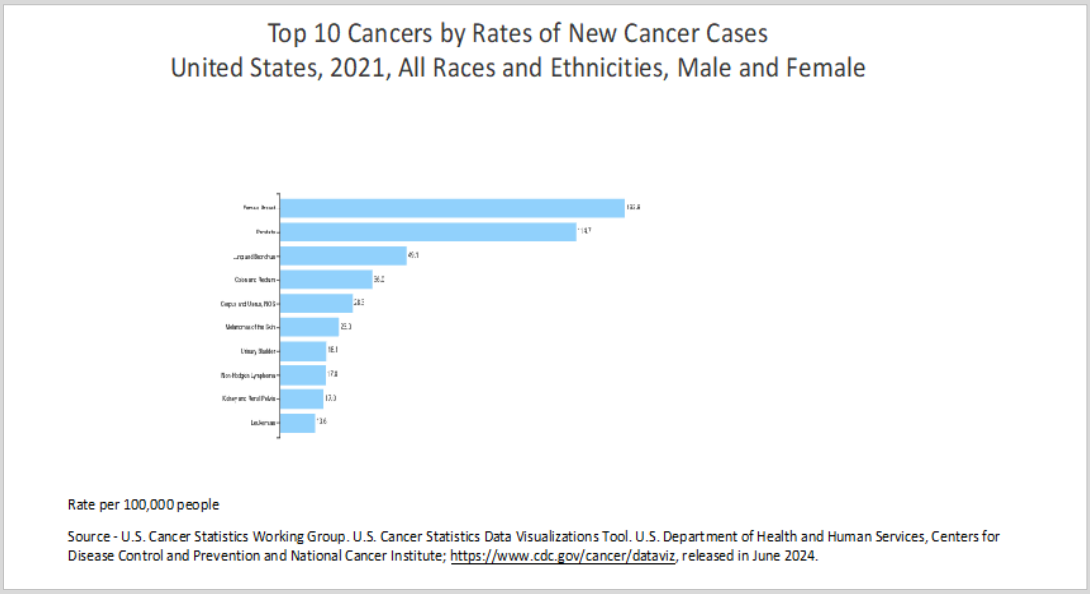


Figure 1: Top 10 Cancers by Rates of New Cancer Cases

The geographical distribution of new cancer cases during the study period revealed notable regional variations across the United States. States in the Southeast and Northeast consistently exhibited higher cancer incidence rates, represented by darker shades on the heat map, while many Midwestern and Western states showed comparatively lower rates of new diagnoses. These regional disparities may reflect differences in environmental exposure, lifestyle behaviors, healthcare accessibility, and demographic composition. Recognizing these geographic patterns is essential for designing targeted prevention programs and directing clinical trial recruitment efforts toward high-incidence areas where large patient pools are available.

Analysis of the population distribution by cancer type shows that colon and rectum, kidney and renal pelvis, leukemias, lung and bronchus, melanomas of the skin, non-Hodgkin lymphoma, and urinary bladder cancers each recorded a cumulative population count of approximately 1.62 billion, while corpus and uterus NOS and female breast cancers followed with 0.81 billion each, and prostate cancer totaled 0.80 billion.

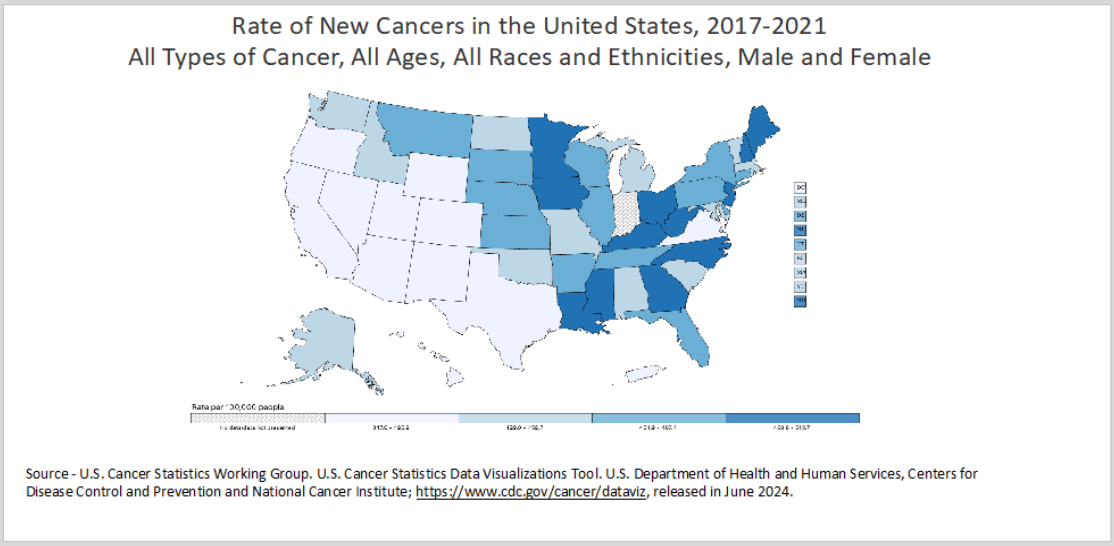
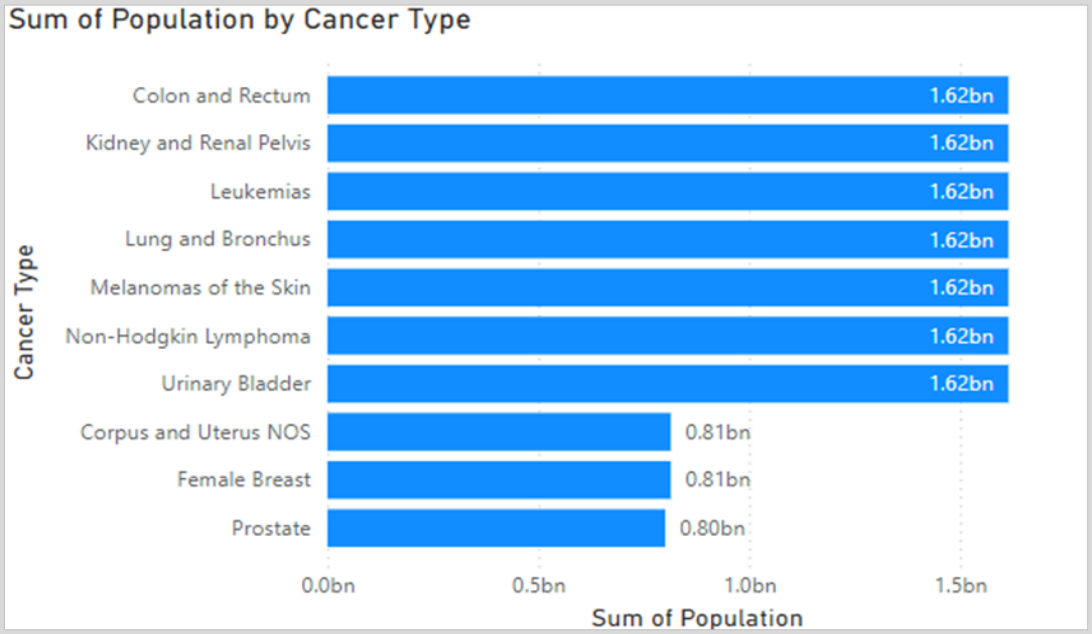


Figure 2: Rate of New Cancers in the United States

This uneven distribution significantly influences clinical trial recruitment: cancers with larger patient populations generally benefit from broader participant pools, whereas lower-prevalence cancers face persistent enrollment challenges. Consequently, tailored recruitment strategies are needed to ensure equitable representation across all cancer types and to improve the generalizability of clinical trial outcomes.

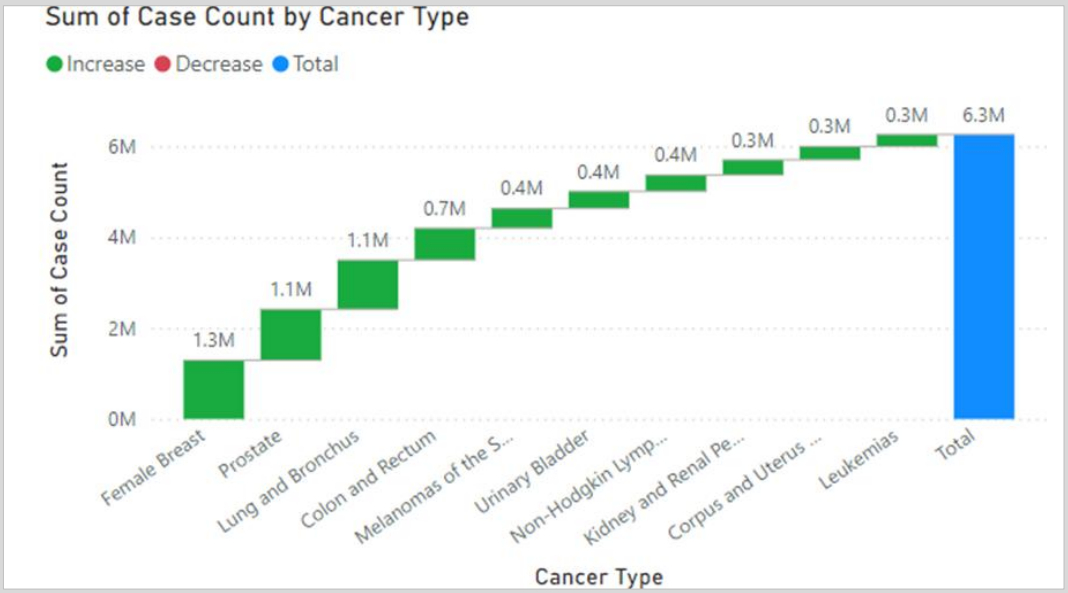
In 2021, female breast cancer recorded the highest incidence rate at **119.8 per 100,000 persons, followed closely by prostate cancer at 114.7 per 100,000.



Source: (Akpughe, 2025) **Figure 3: Sum of Population by Cancer Type**

Lung and bronchus cancer ranked third at 49.1, with colon and rectum cancer at 36.0 per 100,000. Other notable cancers included corpus and uterus NOS (28.3), melanoma of the skin (23.0), and urinary bladder cancer (14.1). The lowest incidence rates among the top ten were observed in non-Hodgkin lymphoma (17.8), kidney and renal pelvis (17.0), and leukemia (15.6). These figures underscore significant differences in cancer prevalence, highlighting the need for differentiated screening and recruitment strategies that prioritize high-burden diseases while addressing inclusion gaps for rarer cancers.

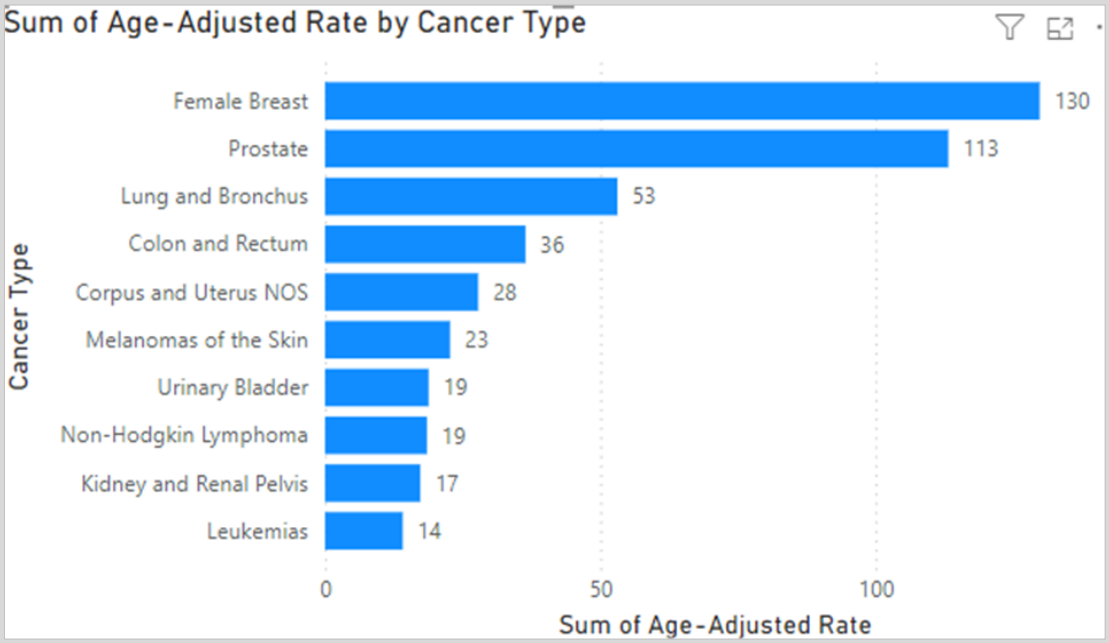
Across the entire study period, the total number of cancer cases reported reached approximately 6.3 million.



Source: (Akpughe, 2025) **Figure 4: Sum of Case Count by Cancer Type**

Female breast cancer accounted for the largest share with 1.3 million cases, followed by prostate cancer at 1.1 million and lung and bronchus cancer at 0.7 million. Other major cancers included colon and rectum (0.4 million), melanoma of the skin (0.4 million), urinary bladder (0.4 million), and non-Hodgkin lymphoma (0.3 million). The consistent rise in case counts across several cancer types underscores the growing public health burden of cancer in the United States and emphasizes the importance of continued investment in early detection, prevention, and advanced recruitment strategies for clinical trials.

When adjusted for age, female breast cancer remained the most prevalent, with an incidence rate of 130 per 100,000 people, followed by prostate cancer at 113 per 100,000. Lung and bronchus cancer (53 per 100,000), colon and rectum (36 per 100,000), and corpus and uterus cancers (28 per 100,000) also recorded substantial rates.



Source: (Akpughe, 2025) **Figure 5: Sum of Age-Adjusted Rate by Cancer Type**

Other cancers, including melanomas of the skin, urinary bladder, non-Hodgkin lymphoma, kidney and renal pelvis, and leukemias, presented lower but still clinically significant rates. These results emphasize the continuing burden of age-related cancers and the importance of maintaining robust, age-specific screening and recruitment frameworks in clinical research.

The findings have important implications for the application of AI technologies in oncology clinical trials. Cancers with high incidence and large patient populations such as breast, prostate, and lung cancers, offer strong recruitment potential but continue to face barriers related to diversity and equitable participation. AI-driven recruitment systems can address these challenges by analyzing large-scale epidemiological data to identify underserved populations, predict optimal recruitment locations, and customize outreach strategies. Through such data-informed approaches, AI can help reduce recruitment time, enhance retention, and promote inclusivity by ensuring broader demographic representation within trial cohorts.

The temporal analysis of oncology trial recruitment from 2021 to 2024 indicates a continued emphasis on improving enrollment efficiency, with the highest recruitment rates observed in cancers affecting the largest populations, notably breast and prostate cancers. The dataset's mode value for case count, 1,291,992, further illustrates the concentration of research and recruitment activity around these common cancer types. Therefore, these results reinforce the vital role of AI and digital technologies in advancing the precision, speed, and equity of patient recruitment and retention in oncology clinical trials.

4.1 Discussion of Findings

The findings from this study reveal important trends in cancer incidence, recruitment potential, and the growing relevance of artificial intelligence (AI) and mobile technologies in optimizing oncology clinical trials. The analysis shows that cancers with higher prevalence, particularly breast, prostate and lung cancers, consistently dominate clinical trial recruitment due to large patient populations and well-established screening infrastructures. In contrast, rarer cancers such as leukemia and kidney cancers face significant recruitment challenges stemming from smaller eligible populations, limited outreach programs, and lower public awareness. This imbalance highlights a persistent gap in clinical trial inclusivity, which AI-driven approaches are well-positioned to address through predictive analytics and data-driven recruitment frameworks.

Geographical variations in cancer incidence across the United States further reinforce the need for regionally adaptive recruitment strategies. The higher case concentrations observed in the Southeast and Northeast suggest that environmental and sociodemographic factors may influence disease patterns and access to care. AI can play a transformative role in addressing these regional disparities by integrating geospatial and epidemiological data to identify high-risk populations, optimize site selection, and allocate resources to underserved areas. This localized approach could enhance recruitment efficiency while ensuring equitable participation across diverse regions.

The study's retrospective analysis also highlights the continuing dominance of age-related cancers, with breast and prostate cancers exhibiting the highest age-adjusted incidence rates. This finding underscores the importance of designing age-sensitive recruitment strategies that account for older patients' technological literacy, accessibility needs, and potential health limitations. Mobile health tools, when tailored appropriately, can bridge these gaps by offering remote monitoring, teleconsultation, and user-friendly communication interfaces that encourage sustained participation and compliance among older adults.

A recurring theme across the results is the relationship between data availability, technological infrastructure, and recruitment success. Cancer types with robust national registries and active digital record systems tend to have higher recruitment rates because patient identification and follow-up processes are more streamlined. The integration of AI within electronic health records (EHRs) enhances this process by rapidly matching eligible patients to trial criteria, minimizing manual screening errors, and shortening recruitment timelines. Such automation not only accelerates trial initiation but also promotes more diverse and representative enrollment by mitigating human biases that often influence participant selection.

Despite these promising developments, the findings also reveal areas where AI adoption remains limited. Many clinical trials, especially those involving rare or complex cancers, still depend on traditional recruitment methods, leading to slower enrollment and higher dropout rates. This underscores the importance of scaling AI

and mobile technologies beyond high-prevalence cancers to ensure that less common conditions benefit equally from technological innovation. Furthermore, ethical considerations surrounding data privacy, algorithmic transparency, and digital access must be addressed to maintain patient trust and safeguard sensitive health information.

5. Conclusion

This study examined the dynamics of patient recruitment and retention in oncology clinical trials, drawing insights from retrospective data between 2017 and 2021. It highlights the growing potential of artificial intelligence (AI) and mobile health (mHealth) technologies in transforming clinical trial management. AI can enable predictive modeling to identify eligible patients, optimize recruitment strategies, and forecast potential dropouts, while mobile platforms can enhance real-time engagement, follow-up, and adherence. The integration of these technologies not only improves operational efficiency but also helps address disparities in participation, particularly among underrepresented groups. The analysis of literature confirms a continued scholarly interest in oncology clinical trials but reveals minimal progress in innovative recruitment and retention strategies. This indicates a need for sustained investment in AI-driven methodologies, patient-centered design and adaptive trial protocols to improve inclusivity and trial efficiency.

Therefore, this study recommends that clinical trial administrators should adopt AI-powered tools for patient matching, recruitment optimization and retention tracking. Mobile applications can facilitate participant engagement and simplify data collection, reducing participant dropout rates. Patient education and continuous engagement through personalized digital interfaces can build trust and improve adherence throughout the trial lifecycle. Collaborative data-sharing initiatives across cancer registries, hospitals and research networks can provide real-time insights into recruitment patterns, and allow for adaptive decision-making.

Limitations and Future Research Directions

First, the retrospective design relies on secondary data from clinical trial registries, which may contain reporting inconsistencies or incomplete information regarding recruitment methods, patient demographics or technology use. This limitations may constrain the precision of the findings and their generalizability across diverse oncology populations. Second, the study focuses primarily on clinical trials conducted between 2017 and 2021, a period that may not fully capture the rapidly evolving landscape of artificial intelligence (AI) and digital health technologies in more recent years. Third, the analysis does not account for variations in institutional infrastructure, technological adoption rates or regulatory environments across different research centers, which could influence recruitment and retention outcomes.

Therefore, future research should address these limitations by employing mixed-method approaches that combine quantitative data with qualitative insights from patients, clinicians and trial coordinators. Longitudinal and comparative studies could provide deeper understanding of how AI and mobile health (mHealth) interventions influence recruitment efficiency, retention rates, and trial completion over time. Expanding the scope to include diverse cancer types, geographic regions and demographic groups would enhance the external validity of future findings. Moreover, experimental or prospective designs could help establish causal links between AI-driven interventions and recruitment performance.

Declarations

Ethical Clearance

Not Applicable

Conflict of interest

None

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