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# Digital health in oncology in Africa: A scoping review and cross-sectional survey

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ABSTRACT

*Background:* Low- and middle-income countries, especially in Africa, face a growing cancer burden. Adoption of digital health solutions has the potential to improve cancer care delivery and research in these countries. However, the extent of implementation and the impact of digital health interventions across the cancer continuum in Africa have not been studied.

*Aims:* To describe the current landscape of digital health interventions in oncology in Africa.

*Methods:* We conducted a scoping literature review and supplemented this with a survey. Following the PRISMA for Scoping Reviews guidelines, we searched literature in PubMed and Embase for keywords and synonyms for cancer, digital health, and African countries, and abstracted data using a structured form. For the survey, participants were delegates of the 2019 conference of the African Organization for Research and Training in Cancer.

*Results:* The literature review identified 57 articles describing 40 digital health interventions or solutions from 17 African countries, while the survey included 111 respondents from 18 African countries, and these reported 25 different digital health systems. Six articles (10.5%) reported randomized controlled trials. The other 51 articles (89.5%) were descriptive or quasi-experimental studies. The interventions mostly targeted cancer prevention (28 articles, 49.1%) or diagnosis and treatment (23 articles, 40.4%). Four articles (7.0%) targeted survivorship and end of life, and the rest were cross-cutting. Cervical cancer was the most targeted cancer (25 articles, 43.9%). Regarding WHO classification of digital interventions, most were for *providers* (35 articles, 61.4%) or *clients* (13, 22.8%), while the others were for *data services* or cut across these categories. The interventions were mostly isolated pilots using basic technologies such as SMS and telephone calls for notifying patients of their appointments or results, or for cancer awareness; image capture apps for cervical cancer screening, and teleconferencing for tele-pathology and mentorship.

Generally positive results were reported, but evaluation focused on structure and process measures such as ease of use, infrastructure requirements, and acceptability of intervention; or general benefits e.g. supporting training and mentorship of providers, communication among providers and clients, and improving data collection and management. No studies evaluated individualized clinical outcomes, and there were no interventions in literature for *health system managers* although the systems identified in the survey had such functionality, e.g. inventory management. The survey also indicated that none of the digital health systems had all the functionalities for a comprehensive EHR, and major barriers for digital health were initial and ongoing costs, resistance from clinical staff, and lack of fit between the EHR and the clinical workflows.

*Conclusion:* Digital health interventions in oncology in Africa are at early maturity stages but promising. Barriers such as funding, fit between digital health tools and clinical workflows, and inertia towards technology, shall need to be addressed to allow for advancement of digital health solutions to support all parts of the cancer continuum. Future research should investigate the impact of digital health solutions on long-term cancer outcomes such as cancer mortality, morbidity and quality of life.

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## 1. Introduction

### 1.1. Background

The cancer burden continues to grow globally, exerting tremendous physical, emotional and financial strain on individuals, families, communities and health systems [1]. Low-and-middle income countries (LMICs), particularly in Africa, are disproportionately affected by this insidious pandemic, partly because of the poor health systems, and because cancer has not been prioritized in favor of the traditional public health problems including maternal and child mortality, and infectious diseases e.g., malaria, HIV/AIDS and tuberculosis [1–3]. Consequently, Africa is predicted to have the largest increase in cancer incidence and mortality over the next decade according to the latest (2020) data from the International Agency for Research on Cancer (IARC) Global Cancer Observatory (GLOBOCAN) [4] (see appendices).

Digital health tools and interventions such as electronic medical records (EMRs) or electronic health records (EHRs), computerized clinical decision support systems (CDSS), telemedicine and mHealth have the potential to improve healthcare delivery, for example through prevention, early diagnosis, treatment adherence by patients, guideline adherence by providers, medication safety, improved care coordination, documentation, data management and research, among others [5–11]. If embraced and properly implemented across the cancer continuum, digital health solutions can contribute to better cancer care delivery and research [12,13], thus contributing to a reduction in cancer related morbidity and mortality in Africa. However, there is a lack of published literature on application of digital health solutions in oncology in Africa [14]. Most of the available literature focuses on infectious diseases such as HIV/AIDS, Malaria and Tuberculosis [15–20].

### 1.2. Related work

There are several studies reporting a range of digital health interventions across the cancer continuum with promising results. However, a majority are conducted in high-income countries, and only a few in Africa or other LMICs. Other studies focus on specific types or features of digital health solutions, on parts of the cancer continuum, or on a subset of cancer patients groups.

A review by Aapro and others [21] summarized 66 articles on patient-centric digital health tools for self management, supportive care and patient reported outcomes including passively collected data from sensors. Their findings show that electronically collected patient-reported outcomes provide clinical and health economic benefits, and that these digital tools can be integrated into routine supportive care in oncology practice to provide improved patient-centered care. None of the studies included in this review came from Africa or other LMICs. A similar review by Escriva-Boulley and others [22] looked at engagement and psychosocial effects of digital interventions for cancer patients and survivors, concluding that despite the heterogeneity in studies and inconsistency in results, digital interventions "constitute an excellent means to help cancer patients and survivors cope better with the disease and with treatment side effects, as they can improve self-management and wellbeing". In this review too, none of the 29 included studies came from Africa or other LMICs. The review by Ramsey et al [23] looked at eHealth and mHealth interventions to assist children and young adults living with cancer, in which they summarized studies of different patient-facing technologies such as social robots to reduce emotional distress, virtual reality to reduce procedure-related anxiety, and web or text messaging interventions for health behavior change, physical functioning and cognitive functioning. Their findings demonstrated feasibility and acceptability but evidence on efficacy was mixed. Only 1 of the 21 included studies came from a LMIC (Iran).

Some studies have reported on specific digital tools such as phone-based interventions [24], text messaging [25] mobile apps [26] or CDSS [27]. Liptrott and others [24] looked at the acceptability of telephone support for follow-up, side effects and toxicity monitoring, and psycho-education for adult cancer patients. This narrative review summarized 50 studies from 48 articles and showed that despite the heterogeneity of the interventions, telephone support was accepted due to convenience, enhanced communication, accessibility to care and prompt reassurance, among other benefits. None of the included studies were from Africa. Uy et al [25] reviewed the effect of text messaging interventions on cancer screening rates, with only 1 of the 9 included articles coming from a LMIC (Malaysia). This review found that text messaging interventions moderately increase screening rates for breast, cervical and colorectal cancers. The review by Ana and others [26] focused on mobile apps in oncology, and reported on 54 studies. A majority of these were from high-income countries, and a few from LMICs such as Brazil, China and India. None were performed in Africa. The apps reported on in this review mostly targeted early detection of cancers especially melanoma, treatment monitoring and prevention of side effects, and for supporting survivorship. The review noted that while studies on mobile apps in oncology are increasing, the apps tend to disappear from the app stores when the studies are completed. Pawloski et al [27] reviewed CDDS for clinical oncology, concluding that available evidence, albeit limited and not very rigorous, suggests that CDSS have a positive impact on the quality of cancer care delivery. Of the 24 included studies in this review, only 1 came from a LMIC, Pakistan.

In the review by Salmani et al [28], 8 of the 23 included studies came from Africa, i.e. Ghana, Kenya, Madagascar, Tanzania and South Africa. However, this study reviewed only mHealth tools and focused on cancer screening. It concluded that mHealth solutions have a positive impact on different aspects of cancer screening (providing information, goal setting, training, remote diagnosis, etc), and that users were satisfied with these interventions. Bloomfield and others [14] conducted a systematic review on mHealth tools for non-communicable diseases in general. They included only two interventions about cancer: a system for tele-consultation on digital images taken during cancer screening in Zambia, and an arrangement for patients to contact their oncologists via telephone calls in Nigeria. Another study that focused on point-of-care technologies for cancer care in LMICs [29] reported on equipment or hardware such as portable imaging and molecular diagnostic devices, low cost chemotherapy infusion pumps, and cryotherapy systems commonly used for managing cervical lesions during cancer screening in many African countries. This study concludes by calling the global research community to support international technology development collaborations and funding of technological innovations for translation in low-resource settings, and training the next generation of scientists and engineers in resource-appropriate technology design.

### 1.3. Aims and research questions

The present study aims to describe the landscape of digital health interventions in oncology in Africa in order to answer the question: **What is the extent of implementation and use of digital health in cancer care in Africa?** The aim and research question are broad and exploratory so as to give a comprehensive coverage of the different facets of digital health. This includes the types of systems implemented, their features and functionalities, the clinical domains or contexts in which the systems are used, barriers and facilitators of adoption, and reported benefits or impact on cancer care outcomes. The term digital health is also used here broadly to refer to the use of information and communication technologies to support and improve health and well-being of individuals and populations [30–33]. It encompasses systems and applications for healthcare administration (patient registration, scheduling, billing, registries and other health information exchange/aggregation), tools for collaboration and communication amongst providers and patients (SMS, voice and video calls/conferencing), systems to support clinical tasks (EMRs, CDSS, laboratory and imaging information systems) among others.

The findings can be used to guide future implementation efforts, for example, by providing oncology practitioners and digital health implementers with a catalogue of systems that have been shown to be effective and acceptable in their contexts or healthcare systems. In addition, this study can form a baseline for monitoring improvements in digital health innovations and adoption over time. Finally, identified gaps in evidence or knowledge can also guide future research.

## 2. Methods

We conducted a scoping review of literature on digital health interventions across the cancer continuum, with a focus on Africa. A scoping review is appropriate for such a study where the aim is "reconnaissance" and "when a body of literature has not yet been comprehensively reviewed, or exhibits a complex or heterogeneous nature not amenable to a more precise systematic review" [34,35]. Arksey and O'Malley [35] state that, "rather than being guided by a highly focused research question that lends itself to searching for particular study designs (as might be the case in a systematic review), the scoping study method is guided by a requirement to identify all relevant literature regardless of study design."

Given that many digital health projects, especially those that were non-successful or had non-significant results, are underreported [36–38], we supplemented the literature review with a cross-sectional survey of oncology researchers and practitioners in Africa, to get primary data that might not have been reported in literature.

### 2.1. Literature review

We searched PubMed and Embase to find scientific literature on digital health interventions in oncology in Africa. We used a combination of keywords, synonyms and related terms for ***oncology***, e.g., cancer, clinical oncology, palliative care, etc; ***digital health*** e.g., ehealth, electronic medical records, telemedicine, mHealth, health information systems, etc; and ***Africa***, e.g., Africa, sub Saharan Africa, low and middle income countr*, developing countr* and individual names of African countries. The reference lists of the retrieved articles were hand-searched to indentify additional articles. The literature search was conducted in September and October 2019 to inform the survey, and then updated in January and February 2021.

We included all articles with available full text in English, on all digital health interventions, tools and systems at any part of the cancer continuum in Africa, and for any target users or beneficiaries. We classified the identified systems and interventions using the World Health Organization (WHO)'s classification of digital health interventions [39] into systems or interventions for: (i) clients e.g., mHealth interventions using SMS reminders and alerts to patients, (ii) healthcare providers e.g. EMRs/EHRs, CDSS, and tele-medicine, (iii) health system managers, e.g. registries, enterprise resource planning and other facility management information systems, and (iv) data services, e.g. data collection applications, terminologies and information exchange systems. We did not put any limits on publication dates or study design. We excluded reports where no intervention was implemented, such as those describing needs assessment, feasibility or user's opinions about an intervention without actually implementing one. We also excluded bioinformatics studies such as those on tumor biology genetic analysis, or studies exploring use of artificial intelligence approaches e.g. in radiology image analysis.

Database search, screening of retrieved articles, and data extraction was done by the first author (JKK) using a spreadsheet developed in consultation with the last author (RC). This was checked by the third author (EK), who independently reviewed a random sample of 10% of all the articles retrieved from the database search including the data extraction from the selected articles. The authors regularly reviewed and discussed the included articles and extracted data. The data items included author, year of publication, country of intervention, study design, clinical domain or context, cancer type, number of participants or beneficiaries, period of intervention, part of cancer continuum, i.e. from primary prevention, secondary prevention, diagnosis and treatment, or survivorship and end of life or palliative care [12], name or description of system/technology or intervention, purpose of study or system, WHO digital health intervention class [39], and summary of findings or clinical impact. Because scoping reviews are intended to provide an overview of the literature rather than synthesizing evidence on effectiveness of a particular intervention, and because studies with varying designs and interventions were included, we did not do a formal assessment of quality of studies or weighing of the evidence [34,35].

### 2.2. Survey

We adapted the survey questionnaire from Jha et al [40] to study the extent of adoption of EHRs in the USA. The EMR/EHR is the fundamental digital health platform onto which other tools or features such as CDSS or order entry systems are built as maturity level increases [40–45]. Jha's questionnaire focused on the different functionalities, such as documentation of different clinical and practice management data, decision support, order entry, views of laboratory or imaging results, etc. Based on extent of implementation of these functionalities, the systems were classified as basic or comprehensive (See appendices). Some functionalities and features of EMR/EHRs can be provided by other digital health tools (e.g. clinical documentation via mHealth apps), and there is lack of agreement on what constitutes a true EMR/EHR due to variations in configurations and functionalities. We therefore considered Jha's questionnaire to be exploring digital health broadly beyond typical EMR/EHRs. Moreover, we adapted Jha's questionnaire items and added items on other digital health tools or uses such as telemedicine, patient portals, and health information exchange. We also added questions on perceived barriers to implementation of digital health. A copy of the questionnaire is attached in the **supplementary files.**

The survey participants were delegates of the 2019 African Organization on Research and Training in Cancer (AORTIC) which took place in November 2019 in Maputo, Mozambique. The questionnaire was in English, and a convenience sampling approach was followed. The first author (JKK) proactively approached conference delegates and distributed the paper questionnaire or the link to the electronic version on Google Forms, depending on participant's preference, to those who agreed to take part. The paper questionnaires were double entered into the Google form by a trained clerk. Data analysis was done by descriptive statistics.

For each of the digital health systems mentioned in the survey, a Google search was conducted to triangulate what was reported in the survey and to find more information about the system such as technical details, vendor, implementation context and scope of use. The search terms used included the name of the system or vendor/developer, the country and institution.

Research ethics review was sought from the Medical Ethics Review Committee of the Academic Medical Center at Amsterdam UMC, Location AMC and the study was given exemption (Reference number W19_341#19.401). Participants provided informed consent before voluntarily completing the questionnaire by signing on the paper questionnaire or by ticking a mandatory agreement box in Google Forms.

## 3. Results

### 3.1. Literature review

Fig. 1 shows the PRISMA flow chart, while Fig. 2 and Table 1 summarize the included articles. A detailed list of the articles is also provided in the appendices. We identified 57 articles published from 40 different interventions or systems in 17 countries. Uganda was the most represented country (11 articles from 9 interventions), followed by and Tanzania (8 articles, 5 interventions), Kenya (7 articles, 5 interventions),

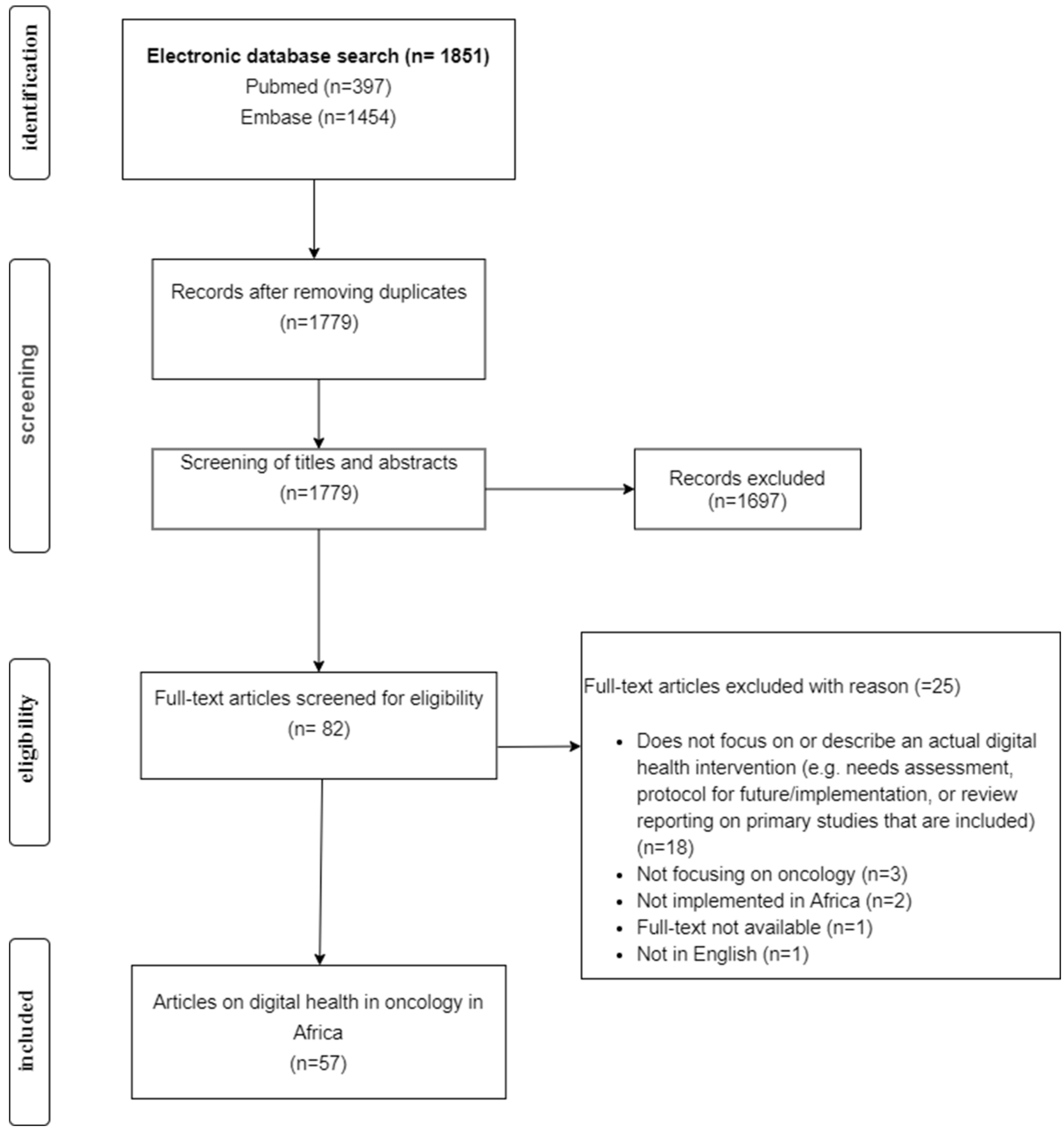


**Fig. 1.** PRISMA for Scoping Reviews Flowchart.

Malawi (6 articles, 5 interventions), Nigeria (6 articles, 5 interventions) and Madagascar (6 articles, 1 intervention). The articles were published between 2008 and 2021, and often about 2 years after implementation of the intervention.

Six (10.5%) of the articles reported randomized controlled trials (RCTs) with specific outcomes including cancer screening uptake and re-attendance or reduction of loss to follow-up. The remainder (51 articles, 89.5%) reported on descriptive or quasi-experimental studies. The interventions were mostly isolated pilots using basic technologies such as SMS, telephone calls, email and online conferencing platforms, and outcomes were generally positive. Evaluation focused on structure and process measures [46], for example, ease of use, infrastructure requirements, and acceptability of the digital health tools. Other measures were general healthcare system benefits such as communication between providers and clients for cancer awareness or appointment reminders, supporting training and mentorship of providers to improve diagnosis accuracy, collaborative case management by providers e.g. tumor boards, and improving data collection and management. No studies evaluated individualized clinical outcomes [46].

Cervical cancer (CaCx) was the most commonly targeted cancer type, with 25 (43.9%) of the articles describing interventions for CaCx, particularly screening using phone-based visual inspection with acetic acid (VIA). Twenty-one (36.8%) of the articles described interventions that target multiple cancers, e.g. general cancer awareness telephone lines, and tele-pathology and remote consultation among providers. The remaining interventions concerned cancers of breast (4 articles, 7.0%), gastro-intestinal (3 articles, 5.3%), and hematological (3 articles, 5.3%) and skin (1 article, 1.8%).

With regards to the cancer continuum, the majority of the interventions targeted cancer prevention (24 articles, 49.1%) or diagnosis and treatment (23 articles, 40.4%). Four articles (7.0%) reported on interventions targeted towards survivorship and end of life, and the remainder were cross-cutting. In terms of WHO classification of digital interventions, the majority (35 articles, 61.4%) were *interventions for healthcare providers*, particularly for remote consultation or mentorship during diagnosis. Thirteen articles (22.8%) reported on *intervention for clients*, mostly in the form of SMS and/or telephone systems for accessing cancer awareness information or reminders. The rest were *interventions for data services* or cut across these categories.

Challenges were rarely reported in the literature, and varied. They included lack of funding, poor infrastructure (e.g. lack of, or slow and unreliable internet, unreliable electricity), lack of technical skills, and inertia or resistance from the clinical teams. Health system challenges that go beyond digital health were also reported, e.g. lack of human

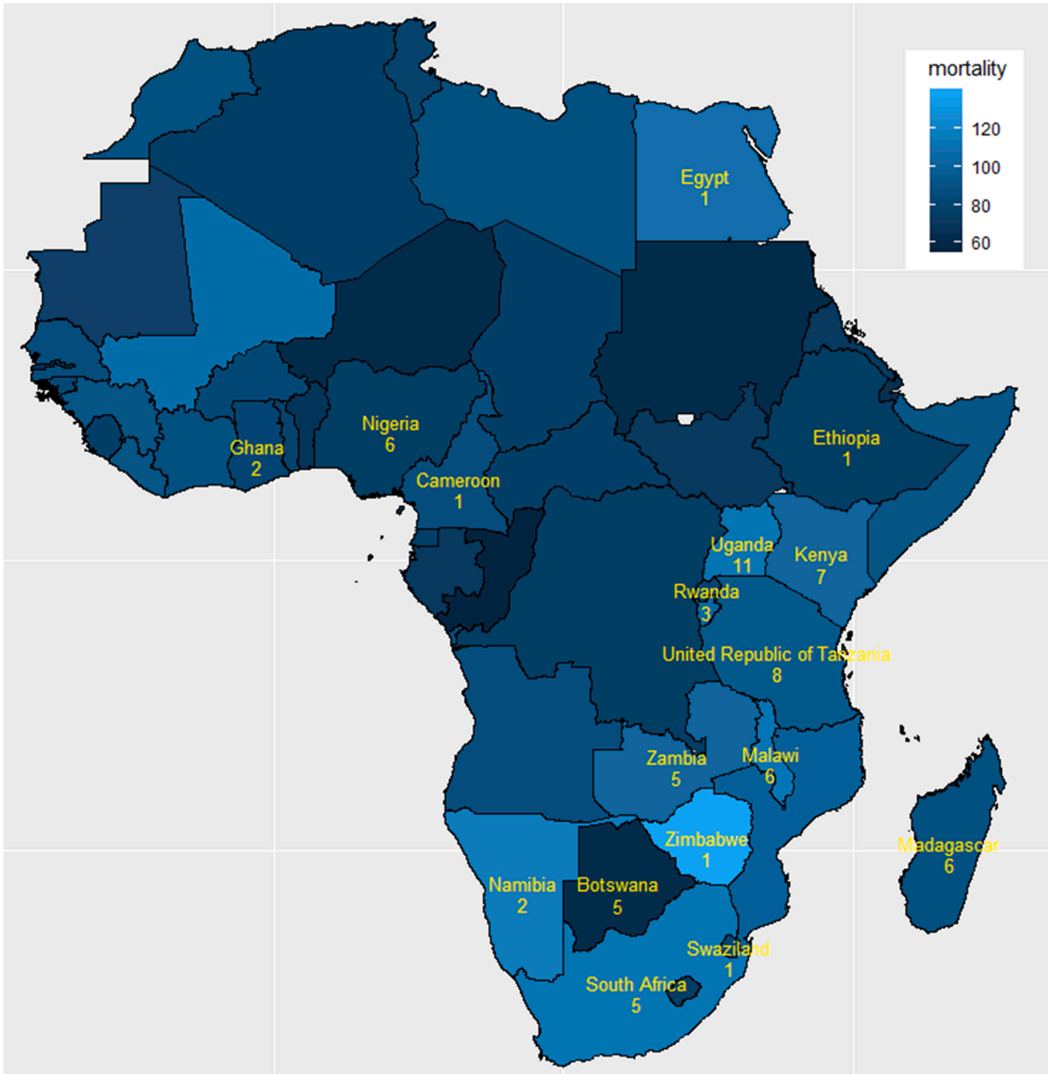


**Fig. 2.** Map of Africa showing the number of articles on digital health interventions in each country. The sum of the numbers exceeds 57 because some articles reported on more than one country, i.e. multi-country interventions. The countries are colored according to their age standardized cancer mortality rate per 100,000 based on GLOBOCAN 2020 statistics (https://gco.iarc.fr/).

resource such as pathologists, and poor pathology labs.

### 3.2. Survey

Table 2 shows the characteristics of survey respondents. They represented at least 18 African countries, and a variety of job descriptions within the oncology domain including clinical, public health, administration and ICT related roles. There was an even distribution by sex, and a majority was less than 40 years of age. Self-reported computer usage was "almost daily" in 98% of the respondents, and self reported computer proficiency was "average" or above, i.e. score of 3 and above on a 5-point Likert scale with 1 as basic and 5 as proficient, in 95% of the respondents.

Table 3 shows the functionalities of digital health solutions reported by survey respondents, while a brief description of each of the 25 systems is given in the appendices. The solutions were used mostly for the purposes of clinical documentation such as patient demographics (75.2% of respondents), clinical history and follow up notes (60.6%), and vital signs (54.5%), for order entry such as laboratory (49.5%) and radiology (47.5%) investigations, for billing (47.4%), and for inventory management (44.3%). CDSS features were less frequently reported, e.g. computerized chemotherapy protocols (25.3%), dosing support (11.3%) and allergies alerts (18.4%) and drug contraindication alerts (11.2%). Similarly, patient portals were less frequent, e.g. patients being able to view or schedule appointments (18.4%) or request drug refills online (11.3%). While our literature search did not return any studies on systems aimed at benefiting *health system managers*, some of the systems reported in the survey fall under this category, e.g., the cancer registration software CanReg from WHO/IARC and the health management information system DHIS2 (see appendices).

Overall, 10 (9%) of the respondents reported having all the features of a basic EHR as per Jha's criteria [40,45], i.e. documentation of patient demographics, problem lists, medication lists, discharge summaries, and results for laboratory, imaging and pathology. Furthermore, none of the digital health systems had all the functionalities for a comprehensive EHR.

Major barriers to implementation of digital health solutions were issues of initial and ongoing costs, and lack of fit between the EMR and the clinical workflows, and resistance from clinical staff (Table 4). On the other hand, issues around benefits of EMRs, EMR security, and staff computer skills were the least of barriers.

**Table 1**
Summary of included articles.

| Variable | | n (%) | Citations |
|---|---|---|---|
| Total | | 57 (100) | |
| Study type | RCT | 6 (10.5) | [47–52] |
| | Other (Descriptive, Quasi-experimental, etc) | 51 (89.5) | [53–103] |
| Cancer type | Cervical cancer | 25 (43.9) | [47,49–53,55–64,66,87,96,98–103] |
| | General - multiple cancers (such as cervical and skin) and/or non-cancer conditions (general pathology for cancer and non-cancer conditions) | 21 (36.8) | [65,67,68,72–77,79–82,86,88–94] |
| | Breast cancer | 4 (7.0) | [54,84,85,97] |
| | Gastro-intestinal cancers | 3 (5.3) | [48,71,95] |
| | Hematological cancers | 3 (5.3) | [69,70,83] |
| | Skin cancer | 1 (1.8) | [78] |
| Part of the cancer continuum | Primary prevention | 4 (7.0) | [54,65,76,96] |
| | Secondary prevention | 24 (42.1) | [47,49–53,55–64,66,87,98–103] |
| | Diagnosis and treatment | 23 (40.4) | [48,67–75,77–80,82–86,88,89,95,97] |
| | Survivorship and end of life | 4 (7.0) | [90–92,94] |
| | Cross-cutting | 2 (3.5) | [81,93] |
| WHO digital health intervention class | Interventions for healthcare providers | 35 (61.4) | [55,57–61,63,64,66–75,77–82,84,85,91,95,97–103] |
| | Interventions for healthcare clients | 13 (22.8) | [47,49–54,65,76,83,86,87,96] |
| | Interventions for both providers and clients | 4 (7.0) | [48,90,93,94] |
| | Interventions for data services | 1 (1.8) | [62] |
| | Interventions both providers and data services | 4 (7.0) | [56,88,89,92] |

## 4. Discussion

In this study we conducted a scoping review of literature on digital health interventions for oncology in Africa. We supplemented the literature with a cross-sectional survey of African cancer care providers and researchers. Our findings show that digital health interventions and solutions are being implemented across the entire cancer continuum, but cancer prevention (i.e., awareness and screening) and cancer diagnosis and treatment are the most targeted parts of the continuum. Interventions for supporting survivorship and end of life (palliative care) are rare. CaCx is the most commonly targeted cancer, and the Eastern Africa region was the most represented both in the literature and the survey.

While generally positive results were reported in literature, most of the studies were descriptive or quasi-experimental, and reported on short-term outcomes including aspects of implementation (e.g., ease of use, infrastructure requirements, and acceptability) or general healthcare system benefits such as supporting training and mentorship of providers, communication among providers and clients, and improving data collection and management. Only one tenth of the studies were RCTs, and no study reported on long-term cancer control and treatment outcomes such as incidence, survival, and quality of life [104]. Our findings also show that the majority of interventions reported in literature are supporting healthcare providers, and less than a quarter of the interventions target clients or data services. Interventions for healthcare managers were never reported on in literature, although the systems from the survey provide these features and functionalities, for example inventory management and billing.

Moreover, most of the digital health solutions are at early stages of maturity [40,45,105]. Basic features and functionalities such as data registration and ancillary system functionalities (laboratory and imaging) are being implemented, and the implementations are not integrated or interoperable. For example, electronic exchange of information or integration with external systems was reported in only 22.4% of the cases. Furthermore, many of the interventions are isolated pilots or early explorations of simple mHealth solutions such as SMS for appointment reminders or notification of results, telephone lines for getting cancer awareness messages, or telemedicine platforms for collaboration, mentorship or consultation among healthcare providers. Complex digital health systems that can support the entire cancer patient care workflow or those with advanced features and functionalities such as full CDSS or interoperability and data exchange mechanisms were lacking in both literature and survey.

Our findings are comparable to previous studies of digital health interventions in Africa. For example, the study by Jahangirian and Taylor [106] also found that East African countries, especially Uganda and Kenya, had the largest number of ehealth projects. This is thought to be due to the "IT culture" as these countries are the earliest technology adopters. CaCx is the second most common cancer in Africa, and East African countries have the highest burden [107] as well as ongoing CaCx research [108]. This can explain why there are many interventions targeting CaCx, especially the VIA (image capture and sharing) interventions since VIA is the commonest CaCx screening method in low resource settings [109,110]. The fact that many digital health interventions in Africa are donor funded [106,111] yet cancer care has not been a priority for funders [2,112] can also explain the observed trends, particularly with regards to end of life (palliative care) as this part of the cancer continuum has generally not been prioritized in Africa [113–116].

The immaturity of digital health solutions, as evidenced by basic technologies such as phones [106,117], basic functionalities, a.k.a. the digital "advance use" divide [118], lack of emphasis on data services, and isolation of implementations, has also been reported in literature and dubbed "pilotitis" [106,111,119,120]. It can be attributed to the prevailing technological trends, especially the mobile telephony infrastructure, and the challenges facing oncology in Africa in general, such as nascence of digital health interventions, and the isolated nature of oncology services often with one cancer center in each country and no need for interoperability or data sharing. Issues relating to data services, such as structured and coded clinical data or use of ontologies, interoperability standards, health information exchange and data warehousing, become increasingly important and prioritized as health information systems mature [105], and therefore are yet to be implemented and studied in this setting where systems are mostly pilots or

**Table 2**
Survey participants' characteristics.

| Characteristic | N (%) |
|---|---|
| Total | 111 (100) |
| Sex | |
| Female | 53 (47.7) |
| Male | 58 (52.3) |
| Age ranges | |
| less than 30 | 11 (9.9) |
| 30 – 39 | 51 (45.9) |
| 40–49 | 37 (33.3) |
| 50–59 | 6 (5.4) |
| >60 | 4 (3.6) |
| Missing | 2 (1.8) |
| Computer usage | |
| Almost daily | 109 (98.2) |
| A few times a week | 1 (0.9) |
| A few times a month | 0 (0) |
| Missing | 1 (0.9) |
| Self reported computer proficiency *(1 = Basic computer skills (need help with internet and email or office applications), 5 = Proficient (able to do advanced tasks such as database management or programming)* | |
| 5 (Proficient) | 54 (48.6) |
| 4 | 21 (18.9) |
| 3 | 31 (27.9) |
| 2 | 4 (3.6) |
| 1 (Basic) | 1 (0.9) |
| Countries where participants come from* | |
| Uganda | 27 (24.3) |
| Kenya | 24 (21.6) |
| Tanzania | 10 (9.0) |
| Nigeria | 7 (6.3) |
| South Africa | 7 (6.3) |
| Malawi | 6 (5.4) |
| Ethiopia | 4 (3.6) |
| Zambia | 4 (3.6) |
| Ivory Coast | 3 (2.7) |
| Mozambique | 3 (2.7) |
| Rwanda | 3 (2.7) |
| Senegal | 3 (2.7) |
| Botswana | 2 (1.8) |
| Ghana | 2 (1.8) |
| Namibia | 2 (1.8) |
| Cameroon | 1 (0.9) |
| Mali | 1 (0.9) |
| Tunisia | 1 (0.9) |
| Multiple African countries | 1 (0.9) |
| Job description/title | |
| Oncologist or oncology fellows/residents | 28 (25.2) |
| General doctor/Physician (Non oncologist) | 20 (18.0) |
| Administrator | 13 (11.7) |
| Epidemiologist/Biostatistician/Data manager/Cancer registrar | 13 (11.7) |
| Nurse | 8 (7.2) |
| IT/Informatics | 6 (5.4) |
| Allied health worker (e.g. lab tech, health educator) | 4 (3.6) |
| Pathologist | 4 (3.6) |
| Surgeon | 4 (3.6) |
| Palliative care/Psychologist/Social worker | 3 (2.7) |
| Pharmacist | 3 (2.7) |
| Researcher/Research coordinator/PhD student | 3 (2.7) |
| Radiologist | 1 (0.9) |
| Missing | 1 (0.9) |

*Participants from Italy, Canada and Haiti removed.

disparate. Moreover, we found that many of the systems used as EMRs were repurposed accounting or enterprise resource planning software such as Navision (Microsoft Dynamics), or electronic data capture software for clinical research such as REDCap. Other systems are developed by small companies with limited capacity to test or customize the software to meet oncology needs, and use proprietary software limiting external audit and scientific evaluation. This means that many of these systems lack proper support for complex clinical oncology workflows and decision support, and therefore oncology practitioners, researchers and patients in Africa are yet to realize the full benefits of digital health solutions.

Furthermore, key cancer control and treatment outcomes, e.g. reduction in incidence or improvement in survival or quality of life [104], are long-term and influenced by several other health system-wide factors, hence difficult to attribute to a single digital health intervention. On the other hand, digital health interventions are complex and can affect multiple aspects of healthcare directly or indirectly with outcomes, e.g. convenience with which patients access healthcare services or patients' access to health information, that are difficult to measure or might be considered less important [121,122]. This explains why most of the outcomes reported in literature focus on the implementation process which can easily be evaluated in pilots.

This study also showed that more digital health interventions and solutions have been implemented than found in published scientific literature. An example of such a digital health solution that we found in the survey but not in the literature search is the cancer registration software CanReg developed by IARC at WHO. This software is widely used in many countries in Africa and beyond for entry of basic cancer data, cancer-specific statistical analysis, and aggregation across regions and countries [123–128]. The mismatch between real-world implementations and our findings from scientific publications could be a limitation of our search strategy, and in the case of CanReg, it could be that there are few studies looking into its usability, acceptability, implementation process, or outcomes in the same way as other contemporary digital health tools, because it is a trusted software from WHO that has been around for over 30 years [129]. However, the mismatch could also be due to publication bias which has been previously reported [36–38], and undermines the evidence for such solutions. It also shows the importance of conducting further research, particularly when digital health interventions in oncology in Africa mature and encompass the entire cancer continuum. This further research should focus on long-term impact of digital health solutions on cancer outcomes such as morbidity, mortality and quality of life.

A strength of this study is that, to our knowledge, it is the first to review digital health interventions across the cancer continuum in Africa, and thus it can provide a baseline for future monitoring of developments in this area. Supplementing the literature with a survey, we ensured that our study provides comprehensive coverage. A weakness of this study is that we could not quantitatively aggregate the outcomes due to the wide variation in the outcomes published. In addition, there was no independent review and abstraction of data from the retrieved articles by a second person. However, the aim of the scoping review was to ensure wider coverage of the landscape rather than quantification. We also held regular meetings among all the authors to discuss the review process as a way to minimize bias.

## 5. Conclusion

Digital health interventions and tools have been implemented across the cancer continuum in Africa, predominantly in screening and diagnosis. Promising results have been reported but limited to implementation aspects rather than broad, long-term cancer outcomes such as incidence and survival. Moreover, most of the solutions are immature, offer basic functionalities, or are simple, stand-alone mHealth interventions. For cancer care in Africa to fully benefit from digital health, barriers such as limited funding, lack of fit between digital health tools and clinical workflows, inertia towards technology, limited technological infrastructure, and general health system challenges, e.g. funding for oncology, shall need to be addressed to allow for advancement of digital health solutions to support all parts of the cancer continuum.

## 6. Summary table

What was already known:

**Table 3**
Functionalities of the digital health tools reported on from the survey ordered by prevalence of the feature.

| Group | Feature | % Yes | % No | I don't know | Total responses |
|---|---|---|---|---|---|
| Electronic Clinical Documentation | Patient Demographics | 75.2 | 20.8 | 4 | 101 |
| Electronic Clinical Documentation | Clinical history and follow up notes | 60.6 | 35.4 | 4 | 99 |
| Electronic Clinical Documentation | Vital signs | 54.5 | 40.4 | 5 | 99 |
| Electronic ordering | Laboratory Tests | 53.5 | 40.4 | 6 | 99 |
| Electronic Clinical Documentation | Medication Lists | 52.0 | 39.0 | 9 | 100 |
| Electronic Results Viewing | Lab Reports (e.g., CBC, RFTs, LFTs) | 49.5 | 44.4 | 6 | 99 |
| Electronic ordering | Radiology Tests | 47.5 | 47.5 | 5 | 99 |
| Other Functionalities | Reporting health management information (HMIS) e.g. to DHIS2 | 48.0 | 38.8 | 13 | 98 |
| Electronic Clinical Documentation | Nursing notes e.g., recording of administered drugs | 46.9 | 46.9 | 6 | 98 |
| Other Functionalities | Electronic billing | 47.4 | 43.3 | 9 | 97 |
| Electronic Clinical Documentation | Problem Lists | 44.9 | 44.9 | 10 | 98 |
| Electronic Results Viewing | Radiology reports | 44.3 | 46.4 | 9 | 97 |
| Other Functionalities | Inventory (stores) and supply chain management | 44.3 | 44.3 | 11 | 97 |
| Electronic Clinical Documentation | Discharge Summaries | 41.2 | 48.5 | 10 | 97 |
| Electronic ordering | Consultation Requests | 39.4 | 52.5 | 8 | 99 |
| Electronic ordering | Medications orders (prescription sent to pharmacy electronically) | 39.4 | 54.5 | 6 | 99 |
| Electronic Results Viewing | Radiology images (e.g. view CT scans) | 38.4 | 49.5 | 12 | 99 |
| Electronic Results Viewing | Pathology reports | 37.4 | 55.6 | 7 | 99 |
| Other Functionalities | Cancer registration e.g., into CanReg | 36.7 | 46.9 | 16 | 98 |
| Decision Support | Scheduling reminders (e.g., patient return dates) | 34.7 | 55.1 | 10 | 98 |
| Electronic Results Viewing | Consultant Reports | 34.3 | 55.6 | 10 | 99 |
| Other Functionalities | Access to electronic medical records on mobile devices such as iPad or other Tablets by doctors or nurses | 34.7 | 59.2 | 6 | 98 |
| Other Functionalities | Telemedicine | 34.0 | 55.7 | 10 | 97 |
| Bar Coding | Patient ID (e.g. wrist bands) | 29.6 | 63.3 | 7 | 98 |
| Electronic ordering | Nursing Orders | 29.0 | 59.0 | 12 | 100 |
| Bar Coding | Laboratory specimens | 27.6 | 65.3 | 7 | 98 |
| Decision Support | Clinical Guidelines (e.g., standardized cancer treatment protocols) | 25.3 | 67.7 | 7 | 99 |
| Bar Coding | Drugs to be administered | 23.5 | 68.4 | 8 | 98 |
| Decision Support | Out-of-range lab results highlighted | 23.5 | 66.3 | 10 | 98 |
| Online Patient portal | View clinical note | 23.5 | 70.4 | 6 | 98 |
| Other Functionalities | Reporting of quality indicators (e.g., rates of pain control for patients, or percentage of receptor positive breast cancer patients who receive hormonal therapy) | 23.7 | 63.9 | 12 | 97 |
| Other Functionalities | Electronic exchange of information (integration) with external systems e.g., external labs or pharmacies | 22.4 | 63.3 | 14 | 98 |
| Online Patient portal | Enter information e.g. height, weight, physical activity | 21.4 | 72.4 | 6 | 98 |
| Online Patient portal | View investigation results e.g. lab or imaging reports | 21.4 | 70.4 | 8 | 98 |
| Electronic Results Viewing | Pathology images (microscopy slides from a slide scanner) | 22.9 | 61.4 | 13 | 83 |
| Decision Support | Allergy alerts | 18.4 | 71.4 | 10 | 98 |
| Electronic Results Viewing | Tumor board reports | 18.2 | 68.7 | 13 | 99 |
| Online Patient portal | View or schedule appointments | 18.4 | 73.5 | 8 | 98 |
| Online Patient portal | Receive instructions | 16.3 | 77.6 | 6 | 98 |
| Decision Support | Drug-drug Interaction or contraindication alerts | 11.2 | 77.6 | 11 | 98 |
| Decision Support | Drug dosing support (e.g., renal dose guidance or lifetime ceiling dose for anthracyclines) | 11.3 | 77.3 | 11 | 97 |
| Online Patient portal | Request drug refills | 11.3 | 80.4 | 8 | 97 |

- Low and middle income countries face a huge cancer burden, with Africa predicated to have the highest increase in cancer cases over the coming decades.
- Adoption of digital health solutions can improve healthcare delivery.
- Available literature on digital health interventions in Africa has focused mainly on infectious diseases.

What this study adds to our knowledge:

- It provides a landscape of digital health interventions across the cancer continuum in Africa and can form a basis for further research.
- There are several digital health projects in oncology in Africa but they are mostly isolated pilots, provide limited or basic features and functionalities, and use simple technologies e.g. SMS, phone calls, image capture and sharing, and video-conferencing for tele-consultation.
- While generally positive results have been reported, evaluations have focused on structure and process measures such as acceptability and ease of use, and not on clinical oncology outcomes such as cancer incidence or mortality.

Funding

**Table 4**
Barriers to digital health adoption, and percentage of participants who consider them major, minor or not a barrier.

| Barrier | Major barrier (%) | Minor barrier (%) | Not a barrier (%) | Total responses (n) |
|---|---|---|---|---|
| The amount of capital needed to purchase and implement an EMR | 62.4 | 21.8 | 15.8 | 101 |
| Concerns about the ongoing cost of maintaining an EMR system | 57.3 | 25.2 | 17.5 | 103 |
| Resistance to implementation from clinical staff (e.g., doctors, nurses) | 46.6 | 25.2 | 28.2 | 103 |
| Concerns about EMR disrupting clinical care or clinician-patient interaction | 43.3 | 28.8 | 27.9 | 104 |
| Finding an EMR system that meets your organization's needs or clinical processes | 41.3 | 37.5 | 21.2 | 104 |
| Lack of organizational or national policies that encourage and guide EMR implementation | 37.3 | 40.2 | 22.5 | 102 |
| Lack of adequate IT staff | 37.1 | 30.5 | 32.4 | 105 |
| Time pressure (EMRs take a lot of time and clinicians are busy) | 36.3 | 43.1 | 20.6 | 102 |
| Resistance to implementation from non-clinical staff (e.g., administrators) | 35.6 | 29.7 | 34.7 | 101 |
| Lack of future support from vendors for customizing and maintaining the system | 35.6 | 35.6 | 28.7 | 101 |
| Lack of involvement of clinicians in EMR and other e-health technology implementation processes | 34.3 | 38.2 | 27.5 | 102 |
| Concerns about illegal record tampering or hacking (electronic systems are not secure) | 34.3 | 42.9 | 22.9 | 105 |
| Uncertainty about the return on investment (ROI) from an EMR | 33.3 | 39.2 | 27.5 | 102 |
| Lack of interoperable IT systems in the market place (having to use multiple systems) | 33.3 | 38.2 | 28.4 | 102 |
| Lack of capacity to select, contract for, and implement an EMR | 31.4 | 45.1 | 23.5 | 102 |
| Concerns about inappropriate disclosure of patient information | 29.1 | 46.6 | 24.3 | 103 |
| Lack of computer skills by the clinical staff | 28.6 | 43.8 | 27.6 | 105 |
| Prior dissatisfaction with EMRs or other e-health technologies by staff | 26.7 | 34.3 | 39.0 | 105 |
| Lack of convincing evidence about effectiveness of EMR and other e-health technology | 22.1 | 44.2 | 33.7 | 104 |

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijmedinf.2021.104659.

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