Digital learning strategies to train primary healthcare workers in sub-Saharan Africa: A scoping review

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Background. Primary healthcare workers in sub-Saharan Africa often face challenges regarding training. Digital learning strategies may improve the competencies of healthcare workers in this resource-limited region without them having to leave their postings.
Objective. To map the existing literature on digital learning strategies to train primary healthcare workers in sub-Saharan Africa.
Methods. This scoping review complies with the Population Concept Context guidelines of Arksey and O'Malley and is reported according to the PRISMA 2020 checklist. A systematic search (Ovid/MEDLINE, embase.com, Elsevier/Scopus, African Index Medicus) was performed from inception until December 2023 in collaboration with a medical information specialist. Two independent reviewers screened titles, abstracts and full texts.
Results. Twenty-three studies were included from 11 of 44 sub-Saharan countries (25%). Studies addressed digital (61%) and blended (39%) learning strategies. Training covered infectious diseases (57%), substance use (17%), mental health (8%), sexual/reproductive health (8%), non-communicable diseases (8%) and neonatal resuscitation (4%). Training duration ranged from 6 hours to 18 months. The sample size varied between 20 and 55 415 participants. Types of healthcare workers who participated ranged from nurses to community healthcare workers, midwives, clinical officers, doctors and laboratory staff. Studies measured feasibility (n=12, 52%), knowledge (n=15, 65%) and skills (n=16, 69%). Feasibility was overall positive in digital (75%) and blended (100%) strategies. Knowledge increased with digital (91%) and blended (100%) strategies. Skills improved with digital (85%) and blended (100%) strategies. Challenges included limited access to networks (81%) and devices (72%).
Conclusion. Digital learning strategies are feasible tools to improve the knowledge and skills of primary healthcare workers in sub-Saharan Africa. Addressing challenges, such as network and device access, should be taken into account.

Keywords: digital learning; sub-Saharan Africa; primary healthcare

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The World Health Organization (WHO) estimates the shortage of healthcare workers to be 10 million by 2030, mostly in low- and middle-income countries (LMICs). In some of these countries, limited education and training of healthcare workers enhance the impact of these shortages.[1] This is not merely because it reduces the quality, timeliness and efficacy of medical services provided by understaffed facilities, but also because the lack of training programmes is an important push factor in migration-related loss of healthcare workers in these settings. Implementation of training programmes could be a pull factor for healthcare workers and could improve their knowledge, skills and, ultimately, patient outcomes.[2]

Healthcare workers in LMICs often face limited opportunities for training.[3,4] Travel distances may hinder healthcare workers in rural areas from accessing training.[3] Leaving the clinic for training can imply that no medical staff is available to take care of patients. Digital learning is a training method that could reduce the need to travel and leave the clinic. Digital learning strategies can potentially improve the competencies of healthcare workers, who would otherwise not have an opportunity to continue their professional development.[5-7] However, to adequately implement digital learning strategies, it is important to consider local contexts and challenges.[3]

In LMICs, such as in sub-Saharan Africa, primary healthcare workers play a crucial role in providing medical care to underprivileged communities, particularly in rural areas. The WHO defines primary healthcare workers as individuals who provide essential health services as the first point of contact within the healthcare system.[8] These workers are typically part of a multidisciplinary team that delivers comprehensive, accessible, community-based care aimed at promoting health, preventing illness, treating diseases and managing chronic conditions.[9,10] Hence, assessing how digital learning strategies could benefit these primary healthcare workers is important.

Most of the current scientific literature focuses on digital learning for healthcare professionals from high-income countries. Only 4% of the literature includes studies from LMICs.[7] A comprehensive overview of scientific evidence on digital learning strategies for primary healthcare workers in LMICs and resource-constrained regions, such as sub-Saharan Africa, is currently lacking. Therefore, this study aims to map the existing literature on digital learning strategies to train primary healthcare workers in sub-Saharan Africa. Insights of this review will be used for the implementation of a digital learning strategy on childhood cancer for primary healthcare workers in LMIC." Kindly insert that sentence after the current last sentence: "Therefore, this study aims to map the existing literature on digital learning strategies to train primary healthcare workers in sub-Saharan Africa.

Methods

This scoping review was performed using a structured research strategy to assemble relevant articles. The full search strategy can be found in the

Appendix (http://coding.samedical.org/file/2352). The Population Concept Context guidelines of Arksey and O'Malley[11] and the PRISMA 2020 checklist guidelines[12] were used to conduct this review. The databases we searched systematically were Ovid/MEDLINE, Elsevier/Scopus, embase.com and African Index Medicus (up to December 2023). For the full search strategies and search dates per database see the supplementary information cited below. Rayyan (www.rayyan.ai) was used to manage the screening process. The following keywords and synonyms were used for the search: (*i*) population: 'Primary healthcare worker' AND (*ii*) concept: 'Digital learning' AND (*iii*) context: 'Sub-Saharan Africa' OR 'name of each applicable country' (Supplementary Table 1 (http://coding.samedical.org/file/2355)). Duplicate articles were excluded by a medical information specialist using EndNote X20.0.1 (Clarivate, USA), following the Amsterdam Efficient Deduplication (AED)[13] method and the Bramer method.[14] In addition, Google Scholar was explored with the same search terms and synonyms, and reference lists of included papers were checked to identify more potentially relevant papers.

All peer-reviewed articles published before 19 December 2023 were eligible for screening. Studies conducted in sub-Saharan Africa and focusing on digital learning strategies to train primary healthcare workers were included. A total of 44 countries were considered to be part of sub-Saharan Africa.[15] Studies were excluded if they did not include primary healthcare workers, digital learning strategies, digital learning strategy outcomes or if no health-related topic was included in the training. Potentially relevant articles were selected after screening, based on the title and abstract. Two independent reviewers did the screening using rayyan.ai to reduce bias. Subsequently, full-text screening was used to select the articles to be reviewed. Articles without full text were excluded, because it was challenging to adequately assess the study's relevance, quality and contribution against the review objectives without access to the full text. Moreover, abstracts often lacked sufficient detail for meaningful inclusion. The final decision on which articles to include was established by mutual agreement of the two reviewers.

Information retrieved from these articles was: (*i*) title, (*ii*) first author, (*iii*) year of publication, (*iv*) country, (*v*) type of study, (*vi*) study period, (*vii*) type of healthcare worker, (*vii*) sample size, (*ix*) health topic, (*x*) type of learning strategy – digital or blended, (*xi*) duration of intervention, (*xii*) data collection tool, (*xiii*) outcome measurement – feasibility, knowledge and impact, and (*xiv*) main outcome findings.

Results

A total of 260 articles were identified through database searching (Supplementary Fig. 1 (http://coding.samedical.org/file/2353) and Supplementary Table 1 (http://coding.samedical.org/file/2355)), of which 106 were removed as duplicates.[11,12] Subsequently, title and abstract screening took place, which resulted in another 117 of the 154 articles being excluded. The remaining 37 articles underwent a full-text screening, while 16 articles met the inclusion criteria and were included in the review. Moreover, 15 articles were identified in Google Scholar for full-text screening, of which 7 were eligible for inclusion. In total, 23 articles were therefore included in this review.

Five themes were analysed: (*i*) study characteristics, (*ii*) digital learning strategies, (*iii*) blended learning strategies, (*iv*) comparing digital or blended learning strategies with traditional or no education, and (*v*) challenges with digital learning tools. Tables 1 - 3 illustrate these themes.

Study characteristics

Table 1 presents the characteristics of the 23 studies.[16-38] Studies were conducted in 11 of all 44 sub-Saharan countries (25%) (Supplementary Fig. 2 (http://coding.samedical.org/file/2354)): Nigeria (*n*=6, 26%), Kenya (*n*=5, 22%), South Africa (*n*=3, 18%), Tanzania (*n*=2, 8%), Guinea (*n*=1, 4%), Madagascar (*n*=1, 4%), Mozambique (*n*=1, 4%), Rwanda (*n*=1, 4%), Senegal (*n*=1, 4%), Sierra Leone (*n*=1, 4%) and Ethiopia (*n*=1, 4%). The types of studies included were mixed-methods (*n*=9, 39%), cross-sectional (*n*=8, 35%), randomised trial (*n*=3, 13%) and quasi-experimental (*n*=3, 13%). Studies were published in 2011 (*n*=1, 4%), 2015 (*n*=2, 8%), 2016 (*n*=1, 4%), 2017 (*n*=3, 13%), 2018 (*n*=1, 4%), 2019 (*n*=2, 8%), 2021 (*n*=3, 13%), 2022 (*n*=7, 30%) and 2023 (*n*= 3, 13%). The study period varied from <1 month to 1.5 years.

All studies included healthcare workers at primary care facilities (*n*=23, 100%). A wide variety of healthcare workers were included, such as doctors, clinical officers, nurses, laboratory technicians and community health workers. The sample size varied between 20 and 55 415 participants. Various health topics were covered: infectious diseases (*n*=13, 57%), substance use (*n*=4, 17%), mental health (*n*=2, 8%), sexual and reproductive health (*n*=2, 8%), non-communicable diseases (*n*=2, 8%) and neonatal resuscitation (*n*=1, 4%). The type of learning strategy was digital (*n*=14, 61%) or blended (*n*=9, 39%).

Digital learning strategies

Table 2 presents the 14 studies that address digital learning strategies to train primary healthcare workers on a health-related topic.[16,18,19,22,23,25-29,33,35,37,38] These digital learning strategies included: mobile phone training (*n*=8, 57%), web-based training (*n*=4, 28%), virtual training (*n*=2, 14%) and a digital learning platform (*n*=1, 7%). Mobile phone training included SMS text messages (*n*=3), the use of a mobile phone application (app) (*n*=2), the use of a mobile version of e-learning (*n*=1), a web-based survey tool (*n*=1) and voice messages (*n*=1). Web-based training included e-learning (*n*=4), and virtual learning included Zoom (*n*=1) or a website (*n*=1). The digital learning platform included a digital health platform. The duration of the implemented intervention varied from 6 hours to 8 weeks. Various data collection tools were used to measure the effectiveness of the digital learning strategy: questionnaires (*n*=8, 57%), surveys (*n*=13, 93%), pre-/post-tests (*n*=13, 93%), focus group discussions (*n*=2, 14%) and in-depth interviews (*n*=1, 7%).

Feasibility of the digital learning strategy was measured in 8 (57%) studies.[18,19,22,23,25,26,28,35] Feasibility was measured through focus group discussions (*n*=3), surveys (*n*=3), interviews (*n*=1) and uptake of the intervention (*n*=1). In one of the studies, it was reported that participant feedback was collected, but not how this was done. Most of these studies (*n*=6) reported an overall positive feasibility of the digital learning strategy.[18,19,23,25,28,35] For example, a study in Senegal assessing the effectiveness of an 8-week refresher mobile phone learning course about family planning among nurses and midwives found that interactive voice response and text messaging were easy to use. Participants valued its convenient and flexible access and the fact that they could determine their own pace.[18] Two studies found concerns regarding the feasibility of the digital learning strategies used.[22,26] The first one of these studies, in Mozambique, states that the uptake of a mobile phone learning and digital health platform with regard to COVID-19 remained very low (28%), without exploring the reasons for this finding.[26] The authors hypothesise that the low response rate may have been influenced by the timing of the survey's release, which occurred during the initial days of COVID-19 travel restrictions, prior to any training or supervision. Additionally, the app used for the survey had not previously been used for

Table 1. Study characteristics (*n*=23)

First author	Publication, year	Country	Type of study	Study period	Type of healthcare worker	Sample size, *n*	Health topic	Type of learning strategy
Zurovac[16]	2011	Tanzania	Randomised trial	2009 - 2010	Various healthcare workers	119	Malaria	Digital
Cundill[17]	2015	Tanzania	Randomised trial	2010 - 2012	Various healthcare workers	35	Malaria	Blended
Diedhiou[18]	2015	Senegal	Mixed-methods	2013	Nurses, midwives	20	Family planning	Digital
Otu[19]	2016	Nigeria	Cross-sectional	2014	Various healthcare workers	203	Ebola	Digital
Egger[20]	2017	Kenya	Quasi-experimental	2014 - 2015	Clinical officers	20	Urinary tract infection, vaginal discharge, tonsillitis and childhood diarrhoea	Blended
Manyazewal[21]	2017	Ethiopia	Cross-sectional	No data	Laboratory professionals	108	Tuberculosis	Blended
Du Plessis[22]	2017	South Africa	Cross-sectional	2015	Nurse practitioners, programme and facility managers, nursing students	237	Tuberculosis	Digital
Chambers[23]	2018	South Africa	Mixed-methods	2015	Various healthcare workers	80	Autism spectrum disorders	Digital
Clair[24]	2019	Kenya	Mixed-methods	2014	Various healthcare workers	97	Substance use	Blended
Kenna[25]	2019	Sierra Leone	Mixed-methods	2018	Community healthcare workers	264	Ebola	Digital
Feldman[26]	2021	Mozambique	Cross-sectional	2020	Community healthcare workers	297	COVID-19	Digital
Otu[27]	2021	Nigeria	Cross-sectional	2020	Various healthcare workers	1 051	COVID-19	Digital
Willems[28]	2021	Rwanda	Mixed-methods	2019	Community healthcare workers	55 415	Mental health disorders	Digital
Chamane[29]	2022	South Africa	Quasi-experimental	2021	Various healthcare workers	No data	HIV	Digital
Clair[30]	2022	Kenya	Mixed-methods	2015	Nurses, clinical officers, community health workers, support staff	24	Substance use	Blended
Clair[31]	2022	Kenya	Mixed-methods	2014 - 2015	Various healthcare workers	99	Substance use	Blended
Millimouno[32]	2022	Guinea	Mixed-methods	2021	Various healthcare workers, medical students	543	Sexual and reproductive health	Blended
Odusanya[33]	2022	Nigeria	Quasi-experimental	No data	Various healthcare workers	100	COVID-19	Digital
Otu[34]	2022	Nigeria	Mixed-methods	2020 - 2021	Nurses, community health extension workers	24	Non-communicable diseases	Blended
Thomas[35]	2022	Nigeria	Cross-sectional	2021	Various healthcare workers (including primary care physicians)	372	Infectious diseases	Digital
Abou-Zamzam[36]	2023	Madagascar	Cross-sectional	2021 - 2022	Physicians, midwives, nurses	97	Neonatal resuscitation	Blended
Moeteke[37]	2023	Nigeria	Randomised trial	2022	Primary care doctors	261	Tobacco interventions	Digital
Pathan[38]	2023	Kenya	Cross-sectional	No data	Physicians	1 750	Diabetes	Digital

Table 2. Studies addressing digital learning strategies (*n*=14)

First author	Type of digital learning strategy	Mode of delivery	Duration of intervention	Data collection tool	Outcome measurement	Main outcome findings
Zurovac[16]	Mobile phone learning	SMS messages	6 months	Survey	Impact	Impact: correct artemether-lumefantrine management improved by 23.7% in the intervention group compared to the control group
Diedhiou[18]	Mobile phone learning	SMS messages	8 weeks	Questionnaire, survey, pre-/post-test	Feasibility Knowledge	Feasibility: overall positive (easy to use, self-determined pace, convenient, flexible, accessible) Knowledge: score increased after intervention (p<0.01)
Otu[19]	Web-based training	e-learning	No data	Survey, pre-/post-test	Knowledge Impact	Knowledge: score increased after intervention (p<0.05) Impact: reduced fear and alternative beliefs, increased willingness to practise frequent hand washing, disinfecting surfaces and equipment, and wearing personal protective equipment
Du Plessis[22]	Web-based training	e-learning	2 days	Questionnaire, pre-/post-test	Feasibility Knowledge	Feasibility: overall positive, but concern raised of need to adjust content to local context Knowledge: score increased after intervention (p<0.001)
Chambers[23]	Web-based training	e-learning	No data	Focus group discussions, questionnaire, survey, pre-/post-test	Feasibility Knowledge Impact	Feasibility: overall positive Knowledge: score increased after intervention (p=0.012) Impact: The detection of red flags for autism spectrum disorder improved, but the detection of diagnostic features did not improve
Kenna[25]	Mobile phone learning	e-learning	No data	Focus group discussions, in-depth interview, survey, pre-/post-test	Feasibility Knowledge	Feasibility: overall positive (useful, easy to understand) Knowledge: the percentage that answered 80% of the question correctly increased from 10% to 40% for module 1 and from 21% to 24% for module 2
Feldman[26]	Mobile phone learning and digital learning platform	SMS messages and modules on digital health platform	No data	Questionnaire, survey	Feasibility Knowledge	Feasibility: suboptimal usage of digital learning platform, only 15% of healthcare workers used it Knowledge: score varied from 2% to 57%
Otu[27]	Mobile phone learning	Mobile application	1 hour	Survey, pre-/post-test	Feasibility Knowledge Impact	Feasibility: overall, easy to use Knowledge: score increased after intervention (p<0.001) Impact: increased understanding of COVID-19 and applying knowledge and skills
Willems[28]	Mobile phone learning	Voice messages	4 weeks	Questionnaire, survey, pre-/post-test	Feasibility Knowledge	Feasibility: overall positive Knowledge: 42% of community healthcare workers had higher scores after intervention
Chamane[29]	Mobile phone learning	Mobile application	3 months	Survey, pre-/post-test audit	Impact	Impact: compliance with WHO quality standards for HIV rapid testing did not improve (p=ns)
Odusanya[33]	Virtual training	Website	4 weeks	Questionnaire, survey, pre-/post-test	Knowledge Impact	Knowledge: score did not improve after intervention (p=ns) Impact: knowledge, attitude, and preventive practices did not improve among doctors, but did improve among their patients
Thomas[35]	Mobile phone learning	Web-based survey tool	8 weeks	Questionnaire, survey, pre-/post-test	Feasibility Knowledge	Feasibility: overall positive Knowledge: score increased after intervention (p<0.001)
Moeteke[37]	Virtual training	Zoom	6 hours	Survey, pre-/post-test	Knowledge Impact	Knowledge: higher score in the intervention group compared with control group (p=0.033) Impact: knowledge and confidence in providing smoking cessation interventions improved, but attitude and practice did not improve
Pathan[38]	Web-based training	e-learning	9 hours	Questionnaire, pre-/post-test	Knowledge	Knowledge: score increased after intervention (p<0.001)

Table 3. Studies addressing blended learning strategies (*n*=9)

First author	Type of digital learning strategy	Type of non-digital learning strategy	Duration of intervention	Data collection tool	Outcome measurement	Main outcome findings
Cundill[17]	Mobile phone learning	Traditional face-to-face training, interactive workshops, clinic posters, patient leaflets	11 months	Survey	Impact	Impact: improved prescription of rapid diagnostic tests and reduced over-prescribing of antimalarials after intervention
Egger[20]	Web-based training	Traditional face-to-face training, clinic posters, clinic signs, changes in patient documentation	3 months	Survey	Impact	Impact: increased adherence to clinical practice guidelines after intervention
Manyazewal[21]	Web-based training	Traditional face-to-face training	6 weeks	Survey	Feasibility Impact	Feasibility: overall positive (satisfaction with the learning method) Impact: increase in mean score on the quiz
Clair[24]	Web-based training	Peer activities and local mentorship	No data	Survey	Feasibility Knowledge Impact	Feasibility: overall positive (clinically and culturally relevant, a manageable level of complexity for new knowledge and skills acquisition) Knowledge: 100% felt very confident that they had gained substantial knowledge of the subject matter. Impact: Pre- to post-training changes in stigma scores were not statistically significant for those who did not complete the course; however, among course completers, scores measuring stigma toward people with tobacco use disorder (p=0.049) and other substance use disorders (p=0.048) decreased significantly, but scores measuring stigma toward those with alcohol use disorders did not
Clair[30]	Web-based training	Traditional face-to-face training	8 months	Focus group discussions, in-depth interviews, survey	Feasibility Impact	Feasibility: overall positive (satisfaction with acquired knowledge, skills, confidence and work performance) Impact: development of quality improvement teams, implementation of new substance-use services (screening, intervention)
Clair[31]	Web-based training	Peer activities and local mentorship	13 - 17 hours	Survey	Impact	Impact: stigma scores decreased (p<0.001)
Millimouno[32]	Virtual training	Traditional face-to-face training	3 months	Questionnaire, survey	Impact	Impact: acquired knowledge was put into practice through several activities and more confidence and comfort in working
Otu[34]	Mobile phone learning	Supervision visits	12 months	Focus group discussions, in-depth interviews, questionnaire, survey, pre-/post-test	Feasibility Knowledge Impact	Feasibility: overall positive (valuable experience, appreciation for acquired knowledge) Knowledge: score increased after intervention (p<0.001) Impact: blood pressure decreased in patients during follow-up (p<0.001)
Abou- Zamzam[36]	Virtual training	Traditional face-to-face training	3 days	Questionnaire, pre-/post-test, objective structured clinical examinations	Knowledge Impact	Knowledge: score increased after intervention (p<0.05) and did not differ between virtual and traditional training Impact: skill acquisition improved more after traditional training than after digital training (p<0.001)

such purposes.[26] In the other study, in South Africa (SA), participants mentioned that Web-based training about tuberculosis needed adjustment of the content to the local context.[22]

Knowledge assessment after implementation of the digital learning strategy was conducted in 12 (86%) studies.[18,19,22,23,25-28,33,35,37,38] The majority (*n*=11) did so by pre-/post-test.[18,19,22,23,25,27,28,33,35,37,38] Knowledge gain was found in all of the 11 (79%) studies. However, this gain was reported as statistically significant in 9 of the studies.[18,19,22,23,27,28,35,37,38] The number of questions in pre-/post-tests varied from 4 to 79. One of these studies was conducted in Sierra Leone, and a digital training platform about Ebola was evaluated among community health workers. Two voice-recorded training modules in local languages were provided. The first module considered vaccines, and the second module dealt with disease surveillance and outbreak response. The percentage of healthcare workers who answered at least 80% of the questions correctly increased from 10% before training to almost 40% after training for the first module. For the second module, these percentages increased from 21% pre-training to 24% post-training.[25] One study on implementing a COVID-19 app that delivered SMS messages on this topic and offered training modules did not use a pre-/post-test design, but a knowledge, attitudes and preventive practices (KAP) survey. This survey assessed KAP during COVID-19, regardless of the participant's engagement with the training module.[26] It found knowledge scores on COVID-19 ranging from 2% to 57% on different questions.

The impact of the digital learning strategy on skills was measured in 7 (50%) studies.[16,19,23,27,29,33,37] In 6 studies, the digital learning strategies positively impacted some, but not all, measured skills. For example, in SA, a web-based course with extensive video illustrations was installed to increase awareness of the red flags of autism spectrum disorders. After the course, the following skills were assessed: detection of red flags and detection of diagnostic features. It was found that there was an increase in the detection of red flags after the training. However, there was no increase in the detection of diagnostic features.[23] A study in Nigeria evaluated digital training regarding COVID-19 prevention and control for healthcare workers. Although the KAP of the healthcare workers did not improve significantly, higher levels of KAP were found among their patients.[33] Moreover, one study from SA did not find any improvements in compliance with WHO quality standards for HIV rapid testing before and after a mobile learning module.[29]

Blended learning strategies

Table 3 presents the 9 studies that address blended learning strategies to train primary healthcare workers on a health-related topic.[17,20,21,24,30-32,34,36] Digital components of the blended learning strategies included web-based training (*n*=5, 55%), mobile phone training (*n*=2, 22%) and virtual training (*n*=2, 22%). Non-digital components consisted of traditional face-to-face training (*n*=6, 67%), clinic signs and posters (*n*=3, 33%), peer activities (*n*=2, 22%), mentorship (*n*=2, 22%), supervision visits (*n*=1, 11%), interactive workshops (*n*=1, 11%), patient leaflets (*n*=1, 11%) and change in patient documentation (*n*=1, 11%). Alignment of the digital and traditional components per study can be found in Table 3. The duration of the implemented intervention varied from 3 days to 12 months. Various data collection tools were used to measure the effectiveness of the blended learning strategy: surveys (*n*=8, 89%), questionnaires (*n*=3, 33%), pre-/post-tests (*n*=3, 33%), focus group discussions (*n*=2, 22%), in-depth interviews (*n*=2, 22%) and objective structured clinical examinations (OSCEs) (*n*=1, 11%).

Feasibility of the blended learning strategy was measured in 4 (44%) studies.[21,24,30,34] All studies (100%) reported an overall positive feasibility of the blended learning strategy. In Kenya, a study assessed the outcome and experience of healthcare workers following a blended e-learning course on substance use. The course included online training and in-person peer and mentor activities. The participants considered the course clinically and culturally relevant with a manageable complexity level for new knowledge and skills acquisition. It gave them a boost in confidence and work performance.[24]

Knowledge assessment after implementation of the blended learning strategy was conducted in 3 (33%) studies.[24,34,36] Knowledge gain was found in all 3 studies (100%), although it was reported as statistically significant in only 2 studies.[34,36] A Nigerian study evaluated a course that consisted of online training modules and clinical mentoring on non-communicable diseases. Participants appreciated the knowledge gained on the control and prevention of such diseases and had more confidence during counselling on lifestyle changes and adherence to medication.[34]

The impact of the blended learning strategy on skills was measured in all 9 (100%) studies.[17,20,21,24,30-32,34,36] In these 9 studies, the blended learning strategies positively impacted all measured skills. For example, a cluster-randomised trial was conducted in 36 primary healthcare facilities in Tanzania. The aim was to improve healthcare workers' prescription of rapid diagnostic tests (to differentiate between malarial and non-malarial fevers) and subsequent antimalarials. Various clusters with traditional face-to-face training, interactive workshops, clinic posters, patient leaflets, feedback and motivational SMS messages were established. Interactive workshops with SMSs were associated with improved prescription of rapid diagnostic tests and reduced over-prescribing of antimalarials.[17]

Comparing digital or blended learning strategies with traditional or no education

Four studies compared digital or blended learning strategies with traditional or no education.[16,17,36,37] Two studies compared digital and no education and both concluded a significant positive effect of the digital learning intervention.[16,37] For example, a study in Nigeria provided healthcare workers with WHO online Zoom training on tobacco use and found a statistically significant increase in knowledge in the intervention group compared with the control group.[37] Furthermore, SMS digital training in Kenya on malaria management found a statistically significant improvement in knowledge in the intervention group compared with the control group.[16] Two other studies compared digital and traditional education.[17] A study in Tanzania compared its impact on skills, which showed that digital education reduced the prescribing of antimalarials more than traditional education.[17] In Madagascar, virtually mentored and traditional neonatal resuscitation training was compared. Written assessments and OSCEs evaluated knowledge and skill acquisition. Knowledge improvement did not differ between the virtual and traditional training programmes, yet skill acquisition was higher after traditional training.[36]

Challenges with digital learning tools

Challenges experienced by learners using digital learning strategies were documented in 11 (48%) studies.[18,21-25,28-30,32,34,36] The following categories were distinguished: lacking network access (*n*=9, 81%), limited access to devices (*n*=7, 63%), problems with the course (*n*=5, 44%), high workload (*n*=3, 33%) and language barriers (*n*=2, 22%). For example, during the

course on autism spectrum disorders in SA, various challenges were reported: lacking network access, as a high amount of data were used; limited access to devices because smaller devices such as tablets and phones could not be used; problems with the extensive length of the course; and a language barrier, as educational materials were only available in English and assessments were difficult to comprehend for non-native speakers.[23] Challenges mentioned during a substance use course in Kenya were: lacking network access; limited access to devices because participants had to share computers; and high workload due to combining the course with their normal duties.[30] Another study conducted in Kenya found that 40% of those who completed the course had never used a computer before or had used one for less than 1 year, suggesting challenges in digital literacy.[24] Challenges reported during a Ebola training course in Sierra Leone included lacking network access, as participants needed to buy credit for phones; limited access to devices that had to be charged; and a language barrier, as the voice-recorded messages were in a different dialect and difficult to understand.[25] Training on sexual and reproductive health in Guinea listed the following challenges: lacking network access due to unstable internet and inability to buy internet packages; reduced access to devices due to computer failure and theft; high workload; and problems with the course regarding accessing the platform and lacking technical skills and support.[32] Restricted network access, problems with the course and high workload were noted as challenges during non-communicable diseases training in Nigeria. Network access was a challenge due to unstable internet connection, and problems with the course were technical glitches in the app and high workload that caused problems with time management.[34] Lastly, a mental health disorders course in Rwanda mentioned that access to devices was limited because the mobile phone keys were difficult to use. In addition, there were problems with the course, as its modules were too short.[28]

Discussion

This scoping review maps the existing literature on digital learning strategies to train primary healthcare workers in sub-Saharan Africa. The 23 included studies derived from only 25% of all sub-Saharan African countries. More digital than blended learning strategies were used. Training took 6 hours - 18 months and included 20 - 55 415 participants, mainly doctors, clinical officers, nurses and community health workers. Although various health topics were addressed, most focused on infectious diseases. Main reported study outcomes were feasibility, knowledge gain and impact on skills. Feasibility was positive overall in most digital and blended learning strategies. The majority of studies used a pre- and post-test design to evaluate knowledge gained from training. Almost all studies found a statistically significant increase in knowledge, illustrating that digital tools can be a highly suitable learning strategy for primary healthcare workers in resource-limited settings. Digital learning strategies positively impacted some, but not all, measured skills. Yet, blended learning strategies positively impacted all measured skills. Challenges with digital tools were: limited access to devices, lack of network access, course-related problems, high workload and language barriers. These findings are important, as primary healthcare workers in sub-Saharan Africa often face training difficulties. Using digital learning tools, these healthcare workers can still participate in low-cost professional development training and expand their knowledge and skills without having to leave their clinic and patients.

According to our review, both digital and blended learning strategies may enhance participants' knowledge. However, comparing the effectiveness of the 14 studies on digital learning strategies with the 9 studies on blended learning strategies is challenging, as different digital tools, data collection instruments and methods were used. Two studies that compared digital learning with no learning concluded a significant increase in knowledge after the digital intervention. Two other studies that compared digital with traditional learning found different results: one study had a higher impact through digital learning, while the other had a higher impact after traditional learning. Few previous studies reported comparisons of various types of education in resource-limited settings.[39,40] A systematic review and meta-analysis showed a statistically significant improvement in knowledge outcomes for blended learning strategies over traditional learning strategies in LMICs.[39] Another systematic review, including both LMICs and high-income countries, compared the effect of digital education with that of traditional education on knowledge. It showed a small, statistically non-significant difference in favour of digital education.[40,41] Although all these findings illustrate the benefits of digital learning tools, more research is required to compare the pros and cons of digital, blended and traditional education and no education in the context of the learning goals.

Healthcare workers encountered several challenges when accessing digital training tools. The main difficulties were the lack of access to cellular networks, the limited access to electricity to charge digital devices, and the prevalence of digital illiteracy. Some studies implemented extra training on using digital training tools to reduce issues with digital illiteracy.[18,34] The WHO recommends that educational activities should be adapted to support technology usage. This can overcome barriers for those with low literacy and difficulties understanding the latest technology.[42] Another review conducted in Africa, which assessed studies on digital health implementation for communities and healthcare workers, found similar challenges, such as limited coverage and network connectivity, inadequate technological competence, poor power supply, and product design challenges.[43] Regarding access to networks, sub-Saharan Africa has the most unaffordable mobile internet services for the poorest part of the population. Furthermore, the costs of devices as a proportion of income are the highest. Nevertheless, there has been a notable network expansion acceleration in sub-Saharan Africa, where 3G coverage reached 70% in 2018.[44] Acknowledging and overcoming these challenges and adapting digital tools to local contexts are important to achieve an optimal impact.[7]

To our knowledge, this scoping review is the first to map the literature on digital learning strategies among primary healthcare workers in sub-Saharan Africa. The study entails a comprehensive search with clear inclusion and exclusion criteria and an extensive overview of the study findings. However, limitations of this scoping review include a relatively small number of studies that have been included. Moreover, the studies included vary strongly in sample size and methodology, which poses a challenge to generalising and pooling results and drawing conclusions. The oldest articles included are from 2015 and may be less relevant than more recent articles because of technological advancements in recent years. Lastly, only English articles were included, which implies that articles written in local languages were excluded.

Conclusion

This scoping review highlights that digital learning strategies are feasible tools to improve the knowledge and skills of primary healthcare workers in sub-Saharan Africa. Compared with traditional education, digital learning

allows primary healthcare workers to learn in their own time without having to travel and leave their postings. Future research should further explore and design digital tools that take local contexts, limited financial means and technical challenges, such as devices and network access, better into account. In addition, more research on the implementation of digital learning tools should focus on identifying barriers and facilitators to achieving expected outcomes, which could inform the development of effective policies. These accessible, cost-effective digital learning strategies could ultimately lead to better patient outcomes.

Data availability. Not applicable, as this study does not present new data – only existing data.

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