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ORIGINAL RESEARCH

Leveraging mHealth for the Treatment and Management of PLHIV

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Objective: The objective of this systematic review was to analyze published literature from the last five years to assess facilitators and barriers to the adoption of mHealth as interventions to treat and manage HIV for PLHIV (people living with HIV). The primary outcomes were physical and mental conditions. The secondary outcomes were behavior based (substance use, care engagement, and healthy habits).

Methods: Four databases (PubMed, CINAHL, Web of Science, and ScienceDirect) were queried on 9/2/2022 for peer-reviewed studies on the treatment and management of PLHIV with mHealth as the intervention. The review was conducted in accordance with the Kruse Protocol and reported in accordance with PRISMA 2020.

Results: Five mHealth interventions were identified across 32 studies that resulted in improvements in physical health, mental health, care engagement, and behavior change. mHealth interventions offer both convenience and privacy, meet a digital preference, increase health knowledge, decrease healthcare utilization, and increase quality of life. Barriers are cost of technology and incentives, training of staff, security concerns, digital literacy gap, distribution of technology, technical issues, usability, and visual cues are not available over the phone.

Conclusion: mHealth offers interventions to improve physical health, mental health, care engagement, and behavior for PLHIV. There are many advantages to this intervention and very few barriers to its adoption. The barriers are strong, however, and should be addressed through policy. Further research should focus on specific apps for younger versus older PLHIV, based on preferences and the digital literacy gap.

Keywords: mHealth, eHealth, telehealth, telemedicine, human immunodeficiency virus, HIV

Plain Language Summary

mHealth is being used to help manage the symptoms and spread of HIV. This modality is being used in at least seven countries. Thirty-two studies from seven countries were analyzed for the effectiveness of leveraging mHealth. Five interventions were identified in the literature. These resulted in improvements in physical and mental health, care management, and behavior change. This intervention offers both convenience and privacy. It meets a digital preference of many users, increases the health knowledge of users, decreases healthcare utilization, and increases quality of life. While several barriers to adoption were noted in the literature, the facilitators to adoption outweighed the barriers. mHealth should be seen as a viable option for the management of symptoms and behavior change to improve care and reduce the spread of HIV.

Introduction

Rationale

Human immunodeficiency virus (HIV) affects the white-blood cells, targeting the immune system, which in turn, weakens the body's defense against sickness, infection, and some cancers.[1] The prevalence of PLHIV in the world was 38.4 million, at the end of 2021 (486 per 100,000), two-thirds of whom (25.6 million) reside in the African region. Also, in 2021, 650,000 died of HIV and approximately 1.5 million more acquired the condition (incidence is difficult to

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identify because testing is neither ubiquitous nor universal). There is no cure for HIV, but it is no longer a death sentence. The statistics show that transmission of the disease continues to outpace deaths, so the prevalence of people living with HIV (PLHIV) continues to climb.

HIV is transmitted through bodily fluids such as blood, breast milk, semen, and vaginal secretions. PLHIV taking antiretroviral therapy (ART) are virally suppressed and do not transmit HIV to their sexual partners.[1] Acquired immunodeficiency syndrome (AIDS) is an advanced stage of HIV, which is defined by the development of cancers, infections, and other long-term conditions. To limit transmission of HIV, it is vital to educate the population about healthy sexual habits, getting tested, and if positive, to develop new healthy habits for both sexual activity, treatment and management of HIV symptoms. mHealth can help in this regard. HIV is disproportionately found in low-to-middle-income countries due to funding for and access to prevention and treatment services.[2] Additionally, sexualized drug use, or *chemsex*, is a behavioral factor common in men who have sex with men (MSM) community, which increases the risk of HIV transmission.[3]

mHealth is a subset of telemedicine. Telemedicine and telehealth are defined by the World Health Organization (WHO) as healing at a distance through the use of information communication technologies to improve health outcomes.[4] The WHO does not distinguish between telemedicine and telehealth, so these terms may be used interchangeably in this study. mHealth, specifically, is a component of eHealth that enables the practice of medicine and public or population health through mobile devices, such as phones, tablets, or patient monitoring devices.[5] Mobile devices have blurred the lines between computers and tablets because the processing power of the two have become similar. Many applications work the same on these two modalities.

mHealth has been used for the management of many conditions such as HIV, and it is associated with high satisfaction.[6–8] It is a convenient modality of care and education due to the prevalence of smartphones across the spectrum of country wealth.[7] It can deliver education through text messages, or simple message system (SMS), track risky behaviors and drug cravings, and remind patients to take medication.[9]

A systematic literature review was published in 2022 that analyzed six studies from three databases over five years to assess the tele-education capabilities of mHealth.[10] It focused on patients with HIV/AIDS and their families during treatment. It is concluded that the development of mHealth applications for the treatment and management of HIV can provide rigorous monitoring, research, and evaluation. The group of articles for analysis was very small, so its external validity is questionable.

A systematic literature review was published in 2021 that analyzed 20 studies from five databases over five years to assess the ability of mHealth for HIV prevention. It focused on emerging adults in sub-Saharan Africa.[11] It identified themes of social and structural drivers for transmission and current gaps in understanding HIV prevention. It did not provide an assessment of effectiveness.

Objectives

The purpose of this review is to analyze the facilitators and barriers to the adoption of mHealth interventions for the treatment and management of PLHIV through examination of published, peer-reviewed literature over the last five years. The primary outcome is treatment (reminders for ART, etc.) and management (primary and secondary symptoms of physical health and mental health) of PLHIV. The secondary outcome is the management of personal behavior to develop healthy habits for both the PLHIV and their partner (condom use, sexual agreements, substance use, etc.).

Materials and Methods

Eligibility Criteria

To be eligible for this review, studies must have been published in peer-reviewed academic journals over the last five years, used adult PLHIV for participants, and used mHealth in either a treatment or management role. Five years was chosen due to the rapid growth of mHealth technology. Articles were eliminated if they did not address these elements of the study objective. As established by published precedent, other reviews were eliminated from the group for analysis to prevent confounding the results.[12,13]

Information Sources

We queried four research databases: PubMed (MEDLINE), the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, and Science Direct on 9/2/2022. MEDLINE was excluded from all databases except PubMed to avoid duplicates. These databases were chosen due to their common availability, exhaustive ability to query existing literature, and the ability for other scientists to duplicate this work. We chose only published literature to ensure the work was peer-reviewed.

Search Strategy

We created a Boolean search string to combine key terms listed in the Medical Subject Headings (MeSH) of the US Library of Medicine. We used the same search strategy in all databases: (mHealth OR telemedicine) AND (hiv OR aids) AND (prevention OR management). We used similar filter strategies because not all databases have the same filter tools.

Selection Process

In accordance with the Kruse Protocol, we searched using key terms in all databases, filtered the results, and screened the abstracts for applicability.[14] The Kruse Protocol was chosen because it is a published protocol from which 47 other systematic literature reviews were published. At least two, but no more than three reviewers screened all abstracts. Studies that did not address the research objective were omitted.

Data Collection Process

We used a standardized Excel spreadsheet as a data extraction tool collecting additional data at each step of the process. This spreadsheet was standardized in the Kruse Protocol and provides fields that are valuable to both clinicians and administrators. Three consensus meetings were held to identify articles for full analysis, data extraction, and theme identification.

Data Items

In accordance with the Kruse Protocol, we collected the following fields at each process step: Google Scholar search (date of publication, authors, study title, journal, impact factor from Journal Citations Reports, study design, key terms, experimental intervention, results, and comments from each reviewer); filter article step (the number of results before and after each filter applied in all four databases); abstract screening step (database source, date of publication, authors, study title, journal, screening decision for each reviewer, notes about rejections, consensus meeting one, determination of screening decision, and a set of rejection criteria); analysis step (database source, date of publication, authors, study title, participants, experimental intervention, results compared with a control group, medical outcomes, study design, sample size, bias effect size, country of origin, statistics used, patient satisfaction, facilitators to adoption, barriers to adoption, and the strength and quality of evidence).

Study Risk and Reporting of Bias Assessment

We observed individual cases of bias and combined these observations with the quality assessment of each study using the Johns Hopkins Nursing Evidence-Based Practice tool (JHNEBP).[15] Strength of Evidence is defined by the JHNEBP as follows: Level I studies are RCTs or experiments with controls and randomization, Level II studies are quasi-experimental (control group but no randomization), Level III studies are observational, qualitative, or other non-experimental methods, and Levels IV and V are opinions. Levels IV and V were not accepted for this study. We considered the instances of bias in how to interpret the results because bias can limit external validity.[16]

Effect Measures

Because we accepted three qualitative, two non-experimental, and one observational studies, we were unable to standardize summary measures, as would be performed in a meta-analysis. Measures of effect are summarized in tables for those studies in which it was reported. Measures of effect were reported as Cohen's *d*, Odds Ratios, *beta*, and Wald's *w*. For those studies that reported an effect size, a weighted average effect size was calculated.

Synthesis Methods

Reviewers also performed a thematic analysis to make sense of the data extracted.[17] The same or similar observations were consolidated into themes. These themes, and the individual observations that did not fit into themes, were tabulated into affinity matrices for further analysis.

Additional Analyses and Certainty Assessment

Effect sizes were tabulated and included in the data extraction step. Certainty assessment was performed by combining the narrative analysis with the effect sizes. The frequency of observations was tabulated. Frequency of themes is not intended to imply importance: It only provides the probability of encountering the theme in the group of articles for analysis.

Results

Study Selection

Figure 1 illustrates the study selection process. The query of four databases resulted in 6151 results; however, 5715 of these results were duplicates. After filtering and screening, reviewers were left with 32 articles eligible for review. Many

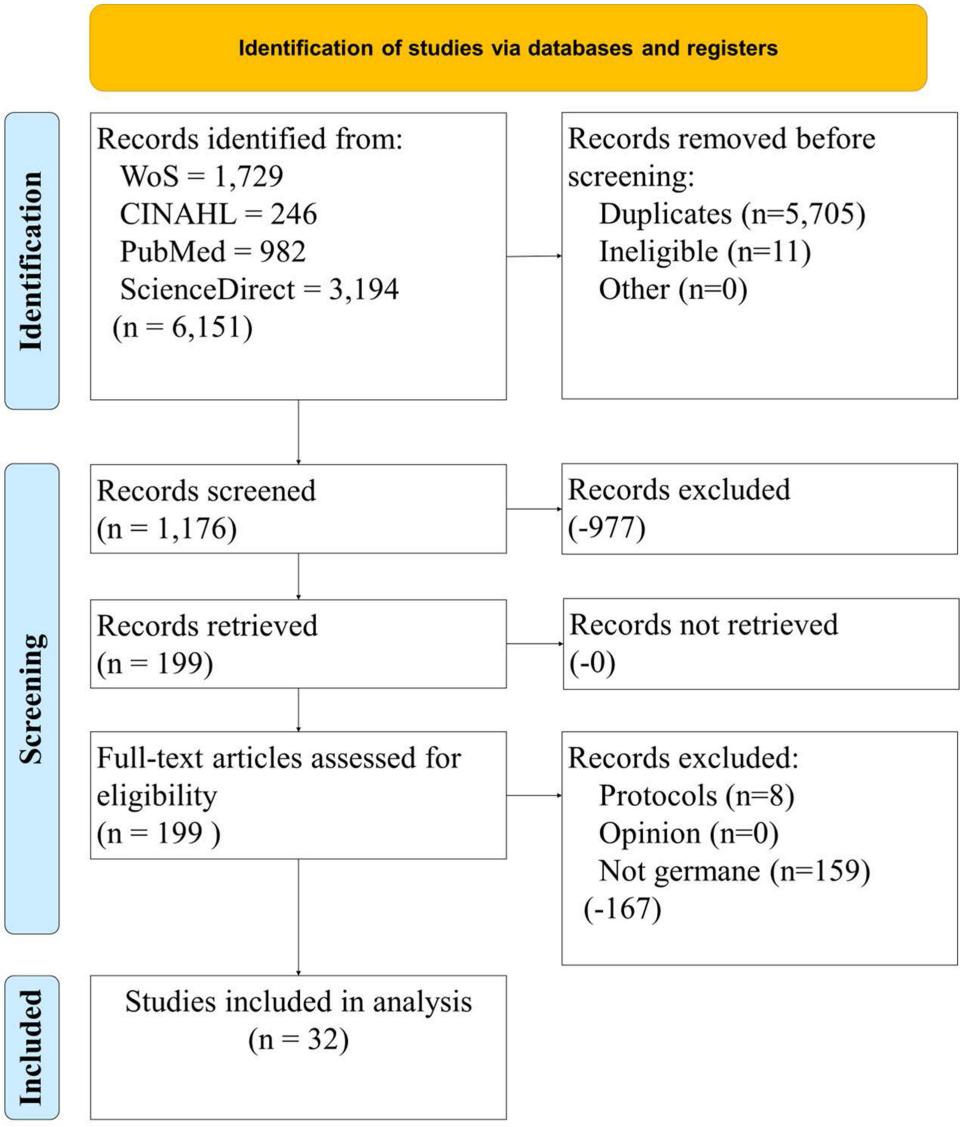

Figure 1 Study selection process.

records were eliminated as "not germane" because they did not address the objective statement. The kappa statistic was calculated to report agreement among reviewers (k=0.88, strong agreement).[18,19]

Study Characteristics

Following the PRISMA checklist and the Kruse Protocol, our group extracted data and created tables to summarize findings. As established in the literature, a summary table is provided in Table 1: PICOS (participants, intervention, comparison (to control or other group), observation, study design). Of the 32 studies analyzed over the 5-year period, two were from 2017,[20,21] five were from 2018,[22–26] ten were from 2019,[27–36] seven were from 2020,[37–43] five were from 2021,[44–48] and three were from 2022.[49–51] All the studies used adults as participants (>18). About 59% (19/32) used an mHealth app, 16% (5/32) used eHealth over any platform, 13% (4/32) used telephone (counseling, educating, psychotherapy, video), 6% (2/32) used mHealth SMS and the same number used telemedicine over mobile platform. Of the group for analysis, 26 of the studies used strong methodologies such as RCT or robust experiments. No quasi-experimental studies were analyzed, but 6 of the studies were either qualitative, non-experimental, or observational.

Risk of Bias in and Across Studies

The JHNEBP quality assessment tool identified the following both strength and quality of evidence. This tool qualifies strength through methodologies. Our group for the analysis consisted of 81% (26/32) Level I (RCTs and other robust experiments) and 18% (6/32) Level III (qualitative, non-experimental, and observational). The JHNEBP tool assesses the quality of evidence by sample size, consistency of results, control groups, consistency of conclusions, and adequate literature reviews. Our group of articles for analysis consisted of 88% (28/32) Level A and 13% (4/32) Level B. There were no Level C studies in the group for analysis.

Our group of reviewers also noted instances of study bias. There were 31 cases of selection bias and 29 cases of sample bias, which affect the internal and external validity, respectively. Selection bias occurred when participants were collected from one location in one country (convenience sample), and sample bias occurred when participants consisted of a high percentage of one gender or race.

Results of Individual Studies

Table 2 summarizes the results of individual studies through the themes identified in the thematic analysis. An observation-to-theme match is provided in Appendices A and B. Additional observations and data collected (sample size, bias, effect size, country of origin, statistics used, and JHNEBP strength and quality of evidence) are provided in Appendix C. The average sample size for all studies was 270, and for Level I studies it was 280. The weighted average effect size was 1,84 (large). Studies originated in seven countries.

Results of Syntheses, Additional Analysis, and Certainty of Evidence

Our team conducted a thematic analysis to make sense of the data extracted. Although thematic analysis is often associated with qualitative research, other systematic reviews in the literature used this technique to make sense of the observations collected, regardless of the methodology used in the studies analyzed.[52,53] Themes and observations are tabulated in affinity matrices for interpretation.

Patient Satisfaction

Although participant satisfaction was not always reported, there were zero reports of dissatisfaction with the technology-related interventions. In our group for analysis, 30/32 (94%) reported some level of satisfaction, while only two studies did not report user satisfaction. Users were not bothered by SMS messages or reminders. They worked well with the technology. The only report that was not entirely positive was that apps need to be updated to work better with a younger population.

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Table 1 PICOS (Participants, Intervention, Comparison to the Control, Medical Outcome, Study Design), Sorted Chronologically by Author

Authors	Participants	Experimental Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Heckman et al[20]	Older adults average age 51.9, 75% Caucasian, all with HIV and 81% with depressive disorder	Telephone-administered interpersonal psychotherapy (IPT)	Intervention reported significantly lower depressive symptoms (BDI, $p = 0.012$) and fewer interpersonal problems (IIP, $p = 0.002$) than the control	Decreased depression and interpersonal problems	RCT
Himelhoch, et al[21]	Older adults average age 47.3 with HIV + drug use, 66% female (as assigned at birth)	mHealth app (Heart2HAART)	No statistical difference in medicine adherence	Decreased drug cravings, equally as effective with medication adherence	Robust experiment
Kalichman et al[22]	Adults with HIV, 76% male (as assigned at birth)	mHealth app (B-TasP)	Lower HIV RNA ($p = 0.01$), greater cART adherence ($p = 0.01$), fewer indicators of GTI ($p = 0.05$), decreased substance abuse than control	Reduced HIV RNA, increase in medication adherence, decreased genital tract inflammation, and decreased substance abuse	RCT
Sayegh et al[23]	Young adults average age 20.4, 62% male (as assigned at birth), 70% African American, with HIV	mHealth app	Intervention group reported significant decreases in perceived stress ($p = 0.02$), illicit substance use ($p = 0.05$), a short-term decrease in depression ($p = 0.02$), and a short-term increases in self-efficacy ($p = 0.04$) in comparison to control.	Decreased stress, decreased depression, decreased substance use, increase in self-efficacy, and fewer physician visits	Non-experimental (no randomization and no control)
Schnall et al[24]	Older adults average age 50.4, 52.5% female (as assigned at birth), 68.8% Caucasian, with HIV	mHealth app (mVIP)	Improvement in anxiety ($p = 0.001$), depression ($p = 0.001$), neuropathy ($p = 0.002$), fever/chills/sweat ($p = 0.037$), weight loss/wasting ($p = 0.020$), and medication adherence over the control group	Decrease in anxiety, decrease in depression, improvement in neuropathy, decrease in fever/chills/sweat, improvement in weight loss, and improvement in medication adherence	Robust experiment
Stonbraker et al[25]	Older adults with HIV, average age 54.4, 60% female (as assigned at birth), 85% African American	mHealth app (VIP-HANA)	No control group. Good usability, but needs improvement	Not reported	Non-experimental (no randomization, no control)
van der Kop et al[26]	Adults with HIV, 60% female (as assigned at birth)	mHealth SMS	No effect on retention or treatment outcomes	No effect on treatment outcomes	RCT
Basaran et al[27]	Young adult (18–30, average age 24) men (as assigned at birth) with HIV	eHealth interactive, video-based safe sex intervention (SOLVE)	Decreased risk-taking behavior compared with the control group	Decreased risk-taking behavior	RCT
Brantley et al[28]	Adults with HIV, 69.3% Black, 69.3% male (as assigned at birth)	videoconferencing	No significant improvement in the linkage to care	None reported	Robust experiment

Cho et al[29]	Older adults with HIV, average age 47.6, 79% African American, 60% female (as assigned at birth)	mHealth app to pill bottle (Wise App)	No control group. Increased medication adherence, and increased self-efficacy	Increased medication adherence and increased self-efficacy	Robust experiment
Hirshfield et al[30]	Adult men (as assigned at birth) with HIV, average age 39, 50% Caucasian	eHealth video-based intervention (Sex Positive)	Reduced risky behavior more than the control group	Reduced risky sexual behavior	Robust experiment
Kuo et al[31]	Adults with HIV, average age 41.5, 58% male (as assigned at birth), 19% transgender (male-to-female), 85% Black	mHealth app (CARE + Corrections)	Increased odds of viral suppression (not statistically significant) and increase in care engagement compared with control group	Increased viral suppression and increased care engagement	Robust experiment
Kurth et al[32]	Adults with HIV, 80% female (as assigned at birth), 100% Black, average age 37.5	eHealth	Reduced viral load ($p = 0.0007$) compared with the control group	Reduced viral load	RCT
Li et al[33]	Adults with HIV, 100% Chinese, 92.3% male (as assigned at birth), average age 27.5	mHealth WeChat (Run4Love)	Reduced suicide rate ($p = 0.02$), reduced stress and depressive symptoms ($p = 0.001$) compared to control	Reduced suicide, reduced stress, and reduced depression	RCT
Sarna et al[34]	Adult females (as assigned at birth) with HIV, 100% Black, average age 25	mHealth app	Retention in counseling was higher in the intervention, HIV testing of infants was higher in the intervention group, and positive infant HIV tests were lower in intervention because of medication adherence	Increased retention, increased HIV testing of infants, increased medication adherence, and decreased HIV transmission to infants	RCT
Soni et al[35]	Adult males (as assigned at birth) with HIV, 100% Black, average age 24.3	mHealth app (HealthMpowerment, HMP)	32% lower condomless anal intercourse (CAI) in the intervention group (short-term effect only). Among HIV-positive participants, it was 82% lower CAI than the control.	Decrease in sexual risk behaviors	RCT
Zhu et al[36]	Adults with HIV, 100% Chinese, average age 27.5, 92.3% male (as assigned at birth)	mHealth WeChat app (Run4Love) + phone calls	Decreased depressive symptoms, positive coping, and decreased HIV stigma compared to the control	Decreased depression, increased coping, and decreased HIV stigma	RCT
Barroso et al[37]	Older adults with HIV, average age 51.2, 66.5% Black, 63% male (as assigned at birth)	mHealth CBT stress management	Decreased fatigue compared to the control	Decreased fatigue	RCT

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Table 1 (Continued).

Authors	Participants	Experimental Intervention	Results (Compared to Control Group)	Medical Outcomes Reported	Study Design
Carey et al[38]	Older adults with HIV, 50% male (as assigned at birth), 52% male (gender identity), average age 47.5, 43% Caucasian	Telephone-delivered mindfulness training	Improved medication adherence, increased mindfulness, reduced sexual risk behavior, reduced anxiety, reduced depressive symptoms, decreased stress, decreased impulsivity – no statistical difference with control	Improved medication adherence, increased mindfulness, reduced sexual risk behavior, reduced anxiety, reduced depressive symptoms, decreased stress, and decreased impulsivity	RCT
Fahey et al[39]	Adults (18–35) with HIV, 100% Black, 62.3% female (as assigned at birth)	mHealth app	Intervention increased retention in treatment and achieved viral suppression, incentive size and viral suppression were positively correlated (*P*-trend = 0.0032)	Increase in viral suppression and program retention	RCT
Guo et al[40]	Adults with HIV, 100% Chinese, 92.3% male (as assigned at birth), average age 27.5	mHealth WeChat app (Run4Love)	Significant reduction in CES-D score in the intervention group ($p<0.001$)	Reduction in depression symptoms	RCT
Marhefka et al[41]	Adults (18–70) with HIV, 59.6% male (as assigned at birth), 1.1% transgender, 51.2% Black	eHealth (project TECH)	No control group. Older participants less likely to use technology, Hispanics less likely to use technology for HIV issues	Not reported	Observational
Uhrig et al[42]	Adults with HIV, average age 42, 86% Black, 58% male (as assigned at birth), and 18% transgender	mHealth SMS (Care+)	Participant preferred the customized messages	Not reported	RCT
Zeng et al[43]	Adults with HIV, 94.7% male (as assigned at birth), 100% Chinese, average age 28	mHealth app	Decreased depressive symptoms	Decreased depression	RCT
Li et al[44]	Adults with HIV, 100% Chinese, 92.3% male (as assigned at birth), average age 27.5	mHealth WeChat app (Run4Love)	Increased quality of life (p = 0.001), reduced HIV-related stigma (p = 0.003), and reduced depressive symptoms (p = 0.001)	Increased QOL, reduced HIV-stigma, and reduced depression	RCT
Plomer et al[45]	Adults males (as assigned at birth) with HIV, median age 40	mHealth app (PrEP)	No control group. Users appreciated the confidence the app gave them to enjoy their sex lives	Increased confidence, increased patient-to-provider relationship	Qualitative
Policarpo et al[46]	Older adults average age 54, 74.2% male (as assigned at birth), non-alcohol fatty liver disease (NAFLD) patients with HIV	Video and phone counseling on diet (standard vs Mediterranean)	Greater diet changes in intervention group (p < 0.01), but both groups gained weight, but the intervention gained less (p < 0.002)	Diet habits improved, not as much weight was gained	RCT

Twimukye et al[47]	Young adults (18–24) with HIV, 76% female (as assigned at birth)	mHealth app (CFLU)	No control group. Increased medication adherence, strengthened relationships with provider, increased health knowledge	Increased medication adherence, strengthened relationships with provider, and increased health knowledge	Qualitative
Yelverton et al[48]	Adult carers for PLWH	Telehealth	No control group. Security concerns, digital literacy gap	Not reported	Qualitative
Guo et al[49]	Adults with HIV, 92.3% male (as assigned at birth), 100% Chinese, average age 28.3	mHealth WeChat app (Run4Love)	Decreased depressive symptoms (p = 0.002)	Decreased depression	RCT
Stephenson et al[50]	Adult males with HIV, average age 30.4, 75% Caucasian, 100% male (as assigned at birth)	Telehealth couples counseling and testing (CHTC)	Couples in the intervention group reported safer sexual agreements (p = 0.007), lower odds of discordant relationships (p = 0.048), lower odds of breaking their sexual agreement (p = 0.000)	Decreased interpersonal problems	RCT
Zeng et al[51]	Adults with HIV, 92.3% male (as assigned at birth), 100% Chinese, average age 27.5	mHealth WeChat app (Run4Love)	Increased quality of life through positive coping (p = 0.006) over control	Increased quality of life	RCT

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Table 2 Summary of Analysis, Sorted Chronologically by Author

Authors	Intervention Theme	Results Themes	Medical Outcomes Themes	Patient Satisfaction Themes	Facilitator Themes	Barrier Themes
Heckman et al[20]	Telephone	Improved mental health conditions Decreased interpersonal problems	Improved mental health conditions Decreased interpersonal problems	Satisfied	Convenience No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff Visual cues not available over phone
Himelhoch et al[21]	mHealth app	Decreased substance use Increased care engagement No statistical difference	Decreased substance use Increased care engagement	Satisfied	Convenience Meets a digital preference of patient Increases care engagement	Cost of technology Training of staff
Kalichman et al[22]	mHealth app	Reduced HIV RNA Increased care engagement Increased physical health conditions Decreased substance use	Reduced HIV RNA Increased care engagement Increased physical health conditions Decreased substance use	Satisfied	Convenience Meets a digital preference of patient Improvement in medical condition(s) Increases care engagement	Cost of technology Training of staff
Sayegh, et al[23]	mHealth app	Improved mental health conditions Decreased substance use Improved mental health conditions Increased care engagement Decreased physician visits	Improved mental health conditions Decreased substance use Improved mental health conditions Increased care engagement Decreased physician visits	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s) Increases care engagement	Cost of technology Training of staff
Schnall et al[24]	mHealth app	Improved mental health conditions Improved mental health conditions Increased physical health conditions Increased physical health conditions Increased care engagement	Improved mental health conditions Improved mental health conditions Increased physical health conditions Increased physical health conditions Increased care engagement	Satisfied	Convenience Meets a digital preference of patient Improvement in medical condition(s) Low healthcare utilization Increases care engagement	Cost of technology Training of staff

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Stonbraker et al[25]	mHealth app	Good usability of app	Not reported	Satisfied	Convenience Meets a digital preference of patient Ease of use Ease of use	Cost of technology Training of staff Usability
van der Kop et al[26]	mHealth SMS	No effect on treatment outcomes	No effect on treatment outcomes	Satisfied	Convenience Meets a digital preference of patient	Cost of technology Training of staff
Basaran et al[27]	eHealth	Changed behavior	Changed behavior	Satisfied	Convenience Meets a digital preference of patient	Cost of technology Training of staff
Brantley et al[28]	eHealth	No statistical difference	Not reported	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic	Cost of technology Training of staff
Cho et al[29]	mHealth app	Increased care engagement	Increased care engagement	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Increases care engagement	Cost of technology Training of staff
Hirshfield et al[30]	eHealth	Changed behavior	Changed behavior	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic	Cost of technology Training of staff
Kuo et al[31]	mHealth app	Reduced HIV RNA No statistical difference Increased care engagement	Reduced HIV RNA Increased care engagement	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Increases care engagement Improvement in medical condition(s)	Cost of technology Training of staff

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Table 2 (Continued).

Authors	Intervention Theme	Results Themes	Medical Outcomes Themes	Patient Satisfaction Themes	Facilitator Themes	Barrier Themes
Kurth et al[32]	eHealth	Reduced HIV RNA	Reduced HIV RNA	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Li et al[33]	mHealth app	Improved mental health conditions Improved mental health conditions Improved mental health conditions	Improved mental health conditions Improved mental health conditions Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Sarna et al[34]	mHealth app	Increased care engagement Increased HIV testing of infants Decreased HIV transmission to infants Increased care engagement	Increased care engagement Increased HIV testing of infants Decreased HIV transmission to infants Increased care engagement	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Increases care engagement	Cost of technology Training of staff
Soni et al[35]	mHealth app	Changed behavior	Changed behavior	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic	Cost of technology Training of staff
Zhu et al[36]	mHealth app	Improved mental health conditions Improved mental health conditions Decreased HIV stigma	Improved mental health conditions Improved mental health conditions Decreased HIV stigma	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff

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Barroso et al[37]	mHealth app	Increased physical health conditions	Increased physical health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Carey et al[38]	Telephone	Increased care engagement Changed behavior Changed behavior Improved mental health conditions Improved mental health conditions Improved mental health conditions Changed behavior No statistical difference	Increased care engagement Changed behavior Changed behavior Improved mental health conditions Improved mental health conditions Improved mental health conditions Changed behavior	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s) Increases care engagement	Cost of technology Training of staff
Fahey et al[39]	mHealth app	Increased care engagement Reduced HIV RNA Changed behavior	Increased care engagement Reduced HIV RNA Changed behavior	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Cost of incentives Training of staff
Guo et al[40]	mHealth app	Improved mental health conditions	Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff

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Table 2 (Continued).

Authors	Intervention Theme	Results Themes	Medical Outcomes Themes	Patient Satisfaction Themes	Facilitator Themes	Barrier Themes
Marhefka et al[41]	eHealth	Digital literacy gap Security concerns	Not reported	Not reported	Convenience Meets a digital preference of patient No HIV stigma associated with clinic	Digital literacy gap Security concerns
Uhrig et al[42]	mHealth SMS	Users preferred customizable messages	Not reported	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Customizable messages	Cost of technology Training of staff
Zeng et al[43]	mHealth app	Improved mental health conditions	Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Li et al[44]	mHealth app	Increased quality of life Decreased HIV stigma Improved mental health conditions	Increased quality of life Decreased HIV stigma Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Plomer et al[45]	Telephone	Increased quality of life	Increased quality of life	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Increased quality of life	Cost of technology Training of staff Security concerns
Policarpo et al[46]	Telephone	Changed behavior	Changed behavior	Satisfied	Convenience Meets a digital preference of patient	Cost of technology Training of staff

Twimukye et al[47]	mHealth app	Increased care engagement Increased care engagement Increased health knowledge	Increased care engagement Increased care engagement Increased health knowledge	Satisfied	Convenience Meets a digital preference of patient Increased health knowledge Increases care engagement Increases care engagement	Cost of technology Training of staff Needs to be youth friendly Technical issues
Yelverton, et al[48]	Telemedicine	Security concerns Digital literacy gap	Not reported	Not reported	Convenience Meets a digital preference of patient	Cost of technology Training of staff Distribution of technology Digital literacy gap Low reimbursement Security concerns Socio-economic status of patient
Guo et al[49]	mHealth app	Improved mental health conditions	Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improvement in medical condition(s)	Cost of technology Training of staff
Stephenson et al[50]	Telemedicine	Changed behavior Decreased interpersonal problems Changed behavior	Decreased interpersonal problems	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Improved behaviors	Cost of technology Training of staff
Zeng et al[51]	mHealth app	Increased quality of life Improved mental health conditions	Increased quality of life Improved mental health conditions	Satisfied	Convenience Meets a digital preference of patient No HIV stigma associated with clinic Increased quality of life	Cost of technology Training of staff

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Results of Interventions, Compared with Control Groups

Table 3 summarizes the results of studies, compared with control groups (where appropriate). Six studies were qualitative, non-experimental, or observational studies. Although these studies did not have control groups, their results were still reported. Twelve themes and six individual observations were identified by the reviewers for a total of 74 observations. Because these are themes, there were multiple instances of one theme in the same article, which will be explained. There were 18/74 (24%) instances of "improved mental health conditions" which included the following observations: Decreased anxiety, decreased depression, decreased stress, reduced suicidal ideations, and increased coping.[20,23,24,33,36,38,40,43,44,49,51] There were 13/74 (18%) instances of "increased care engagement" which included the following: increased patient-to-provider relationship, increased retention in treatment program, improved medication adherence, and increased self-efficacy.[21–24,29,31,34,38,39,47] There were 10/74 (14%) instances of changed behavior, which included the following: decreased risk-taking behavior, decreased risky sex behavior, increased mindfulness, decreased impulsivity, decreased condomless anal intercourse, changed diet, and safer sex agreements with partner.[27,30,35,38,39,46,50] There were 4/74 (5%) instances of three themes: increased physical health outcomes, which included fever, chills, sweats, neuropathy, weight loss, fatigue, and genital tract inflammation,[22,24,37] no statistical difference in improvement with the control group, which means it is equally as effective as traditional care,[21,28,31,38] and reduced HIV RNA or increased viral suppression.[22,31,32,39] There were 3/74 (4%) instances of two themes: decreased substance use, which included a decrease in drug cravings,[21–23] and an increased quality of life, which included peace of mind or increased confidence to enjoy a sex life.[44,45,51] There were 2/74 (3%) instances of four themes: decreased PLHIV stigma[36,44] and decreased interpersonal problems, which included fewer discordant relationships,[20,50] highlighting a digital literacy gap[41,48] and security or privacy concerns.[41,48] The last two results are also listed as barriers to adoption. The following observations only occurred once in the literature: decreased HIV transmission to infants, decreased physician visits, good usability of app, increased health knowledge, increased HIV testing of infants, no effect on treatment outcomes, and users preferred customizable messages.[23,25,26,34,42,47]

Table 3 Summary of Results Compared to the Control

Results Themes and Observations	Frequency
Improved mental health conditions[20,23,24,33,34,38,40,43,44,49,51]*	18
Increased care engagement[21–24,29,31,34,38,39,47]*	13
Changed behavior[27,30,35,38,39,46,50]*	10
Increased physical health conditions[22,24,37]*	4
No statistical difference[21,28,31,38]	4
Reduced HIV RNA[22,31,32,39]	4
Decreased substance use[21–23]	3
Increased quality of life[44,45,51]	3
Decreased HIV stigma[36,44]	2
Decreased interpersonal problems[20,50]	2
Digital literacy gap[41,48]	2
Security concerns[40,47]	2
Decreased HIV transmission to infants[34]	1
Decreased physician visits[23]	1
Good usability of app[25]	1
Increased health knowledge[47]	1
Increased HIV testing of infants[34]	1
No effect on treatment outcomes[26]	1
Users preferred customizable messages[42]	1
Total	74

Notes: *Multiple occurrences observed in one study.

Medical Outcomes Commensurate with the Intervention

Table 4 summarizes the medical outcomes commensurate with the interventions. Eight themes and six individual observations were identified by the reviewers for a total of 67 occurrences in the literature. The Results compared to the control group and medical outcomes were highly similar, but they are focused on themes and observations for the provider. For instance, observations about security, usability, and literacy gap are not included.

Facilitators to the Intervention of mHealth to Manage HIV

Table 5 summarizes the facilitators observed. Seven themes and four individual observations were identified by the reviewers for a total of 119 occurrences in the literature. Convenience was identified in 32/119 (27%) instances, which included no travel and managing HIV from the comfort of the home.[20–51] The intervention meets a digital preference of the patient and was identified 31/119 (26%) times.[21–51] The intervention frees the patient from a typical HIV stigma usually felt when visiting the clinic occurred 23/119 (19%) times.[20,23,28–45,49–51] There were 15/119 (13%) instances of improvements in medical conditions, which included the following: weight loss, chills, sweats, fever, neuropathy, fatigue, genital tract inflammation, anxiety, depression,

Table 4 Medical Outcomes Commensurate with the Interventions

Medical Outcomes Themes and Observations	Frequency
Improved mental health conditions[20,23,24,33,36,38,40,43,44,49,51]*	18
Increased care engagement[21–24,29,31,34,38,39,47]*	13
Changed behavior[27,30,35,38,39,46,50]*	8
Increased physical health conditions[22,24,37]*	4
Reduced HIV RNA[22,31,32,39]	4
Decreased substance use[21–23]	3
Increased quality of life[44,45,51]	3
Decreased HIV stigma[36,44]	2
Decreased interpersonal problems[20,50]	2
Decreased HIV transmission to infants[34]	1
Decreased physician visits[23]	1
Increased health knowledge[47]	1
Increased HIV testing of infants[34]	1
No effect on treatment outcomes[26]	1
Not reported[25,28,41,42,48]	5
Total	67

Notes: *Multiple occurrences observed in one study.

Table 5 Facilitators to the Intervention of mHealth to Manage HIV

Facilitator Themes and Observations	Frequency
Convenience[20–51]	32
Meets a digital preference of patient[21–51]	31
No HIV stigma usually associated with clinic visit[20,23,28–45,49–51]	23
Improvement in medical condition(s)[20,22–24,31–33,36–40,43,44,49]	15
Increases care engagement[21–24,29,31,34,38,47]	10
Ease of use[25]*	2
Increased quality of life[45,51]	2
Customizable messages[42]	1
Improved behaviors[50]	1
Increased health knowledge[47]	1
Low healthcare utilization[24]	1

Notes: *Multiple occurrences observed in one study.

stress, suicide ideation, coping, substance use, and substance cravings.[20,22–24,31–33,36–40,43,44,49] There were 10/119 (8%) instances of increased care engagement which included building relationships with provider, treatment adherence, medication adherence, self-efficacy, and viral load.[21–24,29,31,34,38,47] There were 2/119 (2%) instances of two themes: ease of use, which included look and feel,[25] and increased quality of life, which included increased confidence to enjoy a sex life.[45,51] The following observations only occurred once in the literature: customizable messages, improved behaviors, increased health knowledge, and low healthcare utilization.[24,42,47,50]

Barriers to the Intervention of mHealth for the Management of HIV

Very few barriers were identified in the literature that could create a theme. The burden of cost, for the equipment, the app, and the incentives, appeared in 32/75 (42%) of occurrences.[20–51] The requirement to train staff appeared in 31/75 (41%) of occurrences.[20–40,42–51] Security concerns appeared in 3/75 (4%) of occurrences.[41,45,48] The existence of a digital literacy gap appeared in 2/75 (3%) of occurrences.[41,48] Seven individual observations appeared in 1/75 (1%) of occurrences: distribution of technology, low reimbursement, needs to be youth friendly, socio-economic status of patients, technical issues, usability, and visual cues not available over the phone.[20,25,47,48]

Interactions Between Observations

The telephone interventions were predominantly used with older adults as the participants.[20,21,24,29,37,38,46] These interventions were effective with this older population, and they resulted in improved mental health conditions, decreased interpersonal problems, increased physical health, decreased substance use, increased care engagement, and changed behavior. This intervention is a good solution in the face of the digital literacy gap.[41,48] One study even highlighted the preference of older participants away from mHealth apps.[41] Young adults and mid-range adults were comfortable with mHealth apps and eHealth apps used on mobile devices.

Discussion

Summary of Evidence

This systematic literature review analyzed 32 studies from seven countries published over the last five years to analyze the facilitators and barriers to the use of mHealth for the treatment and management of PLHIV. Five interventions were studied (mHealth app, mHealth SMS, eHealth, telephone, and telemedicine). The lines between mHealth and eHealth are blurred due to the robust capabilities of mobile phones and other devices. mHealth apps, eHealth apps, and mHealth SMS comprised 71% (26/32) of the modalities analyzed.[21–37,39,41,42,44,47] Also, 26/32 (71%) used either RCT or other robust experiments as the modality.[20–22,24,26–40,42–44,46,49–51] Although effectiveness was not one of the objectives of this review, the results of physical and mental health (primary outcomes),[20,22–24,31–33,36–40,43,44,49] changes in behavior (secondary outcomes),[27,30,35,38,39,46,50] and increases in care engagement,[21–24,29,31,34,38,47] are all excellent cases for the effectiveness of this modality.

Significantly more facilitators were identified than barriers. The largest barrier is one of the convenience and preference. Managing PLHIV symptoms through an mHealth app reduces the number of times a patient must visit the HIV clinic, which reduces the stigma of coming into the clinic.[20,23,28–45,49–51] The lack of stigma may also play a role in why mHealth and eHealth apps increase engagement in care.[21–24,29,31,34,38,47] Users were very pleased with the modality, interfaced with it well, and commented on ease of use.[25] There were zero reports of negative satisfaction with the interventions. The only negative comments were about making the apps more friendly to a younger audience,[47] the digital literacy gap,[41,48] fixing small usability challenges,[25,47] and helping users feel more comfortable about the security of their data.[41,45,48] There are larger institutional barriers to the adoption of this modality in terms of the cost of technology,[20–51] training of staff,[20–40,42–51] and low reimbursement.[48]

Future research should focus on distinct apps for age groups. Some apps could be developed to be more friendly to younger audiences, and other apps could be simplified for an older audience. Because ART is so vital to limit the spread of HIV, and mHealth is effective in the improvement of medication adherence,[21,22,24,29,31,32,34,39] future research should integrate ART reminders into other apps. The customization of SMS messages was popular with one study,[42] so future

research on SMS interventions should allow customization. Because risky behavior and substance abuse are socialized into many PLHIV circles,[27,30,35,38,46,50] it is vital that additional research seeks behavior changing interventions.

The results of this review should enable providers to adopt effective mHealth interventions for their PLHIV population with confidence. The results should help PLHIV develop healthy habits and limit transmission of HIV. Administrators should feel confident that the infrastructure necessary to adopt telemedicine practices like mHealth interventions is effective at improving physical health, mental health, care engagement, and changing behavior.

Limitations

We queried four research databases in order to limit sample bias. However, had we used other databases, we may have identified other studies with additional mHealth interventions for the treatment and management of PLHIV. We used only peer-reviewed, published literature in order to control for validity, but this poses a risk of publication bias. Opening the search up to the grey literature could have controlled for publication bias, but it may have introduced additional validity issues. We identified several instances of both selection and sample bias. We did not determine these instances were significant enough to discount the studies from analysis; however, these forms of bias threaten internal and external validity. To control for design bias, we used a published protocol for the conduct of this systematic literature review.

Conclusions

mHealth offers several interventions that are effective in the treatment and management of PLHIV. These interventions create improvements in physical health, mental health, care engagement and behavior management. While a few barriers stand in the way of universal adoption, there are many facilitators to the adoption of mHealth interventions that far outweigh the barriers. mHealth interventions are necessary to develop an atmosphere of ART adherence and non-risky sexual behavior to treat and manage HIV and limit the spread of the condition.

Protocol and Registration

This review is conducted in accordance with the Kruse Protocol for writing a systematic review. This protocol was published in 2019, and from it, 47 systematic literature reviews have been published. This systematic literature review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA 2020). It is registered with PROSPERO: CRD42021266719.

Data Sharing Statement

Data from this study can be obtained by contacting the lead author.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors declare that they have no competing interests.

References

1. World Health Organization. HIV; 2022. Available from: https://www.who.int/news-room/fact-sheets/detail/hiv-aids. Accessed September 1, 2022.
2. Shao Y, Williamson C. The HIV-1 epidemic: low-to middle-income countries. *Cold Spring Harb Perspect Med*. 2012;2(3):a007187. doi:10.1101/cshperspect.a007187
3. Koblin BA, Husnik MJ, Colfax G, et al. Risk factors for HIV infection among men who have sex with men. *Aids*. 2006;20(5):731–739. doi:10.1097/01.aids.0000216374.61442.55
4. World Health Organization. *Telemedicine: Opportunities and Developments in Member States. Report on the Second Global Survey on eHealth*. World Health Organization; 2010.

5. World Health Organization. *mHealth: New Horizons for Health Through Mobile Technologies. mHealth: New Horizons for Health Through Mobile Technologies*. World Health Organization; 2011.
6. Cooper V, Clatworthy J, Whetham J, Consortium E. mHealth interventions to support self-management in HIV: a systematic review. *Open AIDS J*. 2017;11:119. doi:10.2174/1874613601711010119
7. Kruse C, Betancourt J, Ortiz S, Luna SMV, Bamrah IK, Segovia N. Barriers to the use of mobile health in improving health outcomes in developing countries: systematic review. *J Med Internet Res*. 2019;21(10):e13263. doi:10.2196/13263
8. Kruse CS, Krowski N, Rodriguez B, Tran L, Vela J, Brooks M. Telehealth and patient satisfaction: a systematic review and narrative analysis. *BMJ open*. 2017;7(8):e016242. doi:10.1136/bmjopen-2017-016242
9. Shrestha R, Maviglia F, Altice FL, et al. Mobile health technology use and the acceptability of an mHealth platform for HIV prevention among men who have sex with men in Malaysia: cross-sectional respondent-driven sampling survey. *J Med Internet Res*. 2022;24(7):e36917. doi:10.2196/36917
10. Wardoyo E, Rohmawati E. Tele-education in family and patients in HIV/AIDS management during treatment: a literature review. *JOSING*. 2022;3(1):7–13. doi:10.31539/josing.v3i1.4087
11. Kiplagat AB, Kako PM, Mkandawire-Valhmu L, et al. The HIV transmission risk factors and opportunities for use of mHealth in HIV prevention among emerging adult population in the Sub-Saharan Africa context: a review of the literature. *Int J Health Prom Educ*;2021. 1–15. doi:10.1080/14635240.2021.1995464
12. Kruse C, Heinemann K. Facilitators and barriers to the adoption of telemedicine during the first year of COVID-19: systematic review. *J Med Internet Res*. 2022;24(1):e31752. doi:10.2196/31752
13. Kruse CS, Mileski M, Dray G, Johnson Z, Shaw C, Shirodkar H. Physician burnout and the electronic health record leading up to and during the first year of COVID-19: systematic review. *J Med Internet Res*. 2022;24(3):e36200. doi:10.2196/36200
14. Kruse CS. Writing a systematic review for publication in a health-related degree program. *JMIR Res Protoc*. 2019;8(10):e15490. doi:10.2196/15490
15. Newhouse R, Dearholt S, Poe S, Pugh L, White K. *The Johns Hopkins Nursing Evidence-Based Practice Rating Scale*. Baltimore, MD: The Johns Hopkins Hospital; 2005.
16. Pannucci CJ, Wilkins EG. Identifying and avoiding bias in research. *Plast Reconstr Surg*. 2010;126(2):619. doi:10.1097/PRS.0b013e3181de24bc
17. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3(2):77–101. doi:10.1191/1478088706qp063oa
18. Light RJ. Measures of response agreement for qualitative data: some generalizations and alternatives. *Psychol Bull*. 1971;76(5):365. doi:10.1037/h0031643
19. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med*. 2012;22(3):276–282. doi:10.11613/BM.2012.031
20. Heckman TG, Heckman BD, Anderson T, et al. Tele-interpersonal psychotherapy acutely reduces depressive symptoms in depressed HIV-infected rural persons: a randomized clinical trial. *Behav Med*. 2017;43(4):285–295. doi:10.1080/08964289.2016.1160025
21. Himelhoch S, Kreyenbuhl J, Palmer-Bacon J, Chu M, Brown C, Potts W. Pilot feasibility study of Heart2HAART: a smartphone application to assist with adherence among substance users living with HIV. *AIDS Care*. 2017;29(7):898–904. doi:10.1080/09540121.2016.1259454
22. Kalichman SC, Cherry C, Kalichman MO, et al. Mobile health intervention to reduce HIV transmission: a randomized trial of behaviorally enhanced HIV treatment as prevention (B-TasP). *J Acquir Immune Defic Syndr*. 2018;78(1):34–42. doi:10.1097/QAI.0000000000001637
23. Sayegh CS, Clark LF, Olson-Kennedy J, et al. The impact of cell phone support on psychosocial outcomes for youth living with HIV nonadherent to antiretroviral therapy. *AIDS Behav*. 2018;22(10):3357–3362. doi:10.1007/s10461-018-2192-4
24. Schnall R, Cho H, Mangone A, Pichon A, Jia H. Mobile health technology for improving symptom management in low income persons living with HIV. *AIDS Behav*. 2018;22(10):3373–3383. doi:10.1007/s10461-017-2014-0
25. Stonbraker S, Hwayoung C, Hermosi G, Pichon A, Schnall R. Usability testing of a mHealth app to support self-management of HIV-associated non-AIDS related symptoms. *Stud Health Technol Inform*. 2018;250:106–110.
26. van der Kop ML, Muhula S, Nagide PI, et al. Effect of an interactive text-messaging service on patient retention during the first year of HIV care in Kenya (WelTel Retain): an open-label, randomised parallel-group study. *Lancet Public Health*. 2018;3(3):e143–e152. doi:10.1016/S2468-2667(17)30239-6
27. Basaran AB, Christensen JL, Miller LC, Appleby PR, Read SJ. The relationship between social norms and sexual risk-reduction intentions and behavior among men who have sex with men: findings from an eHealth intervention. *Psychol Addict Behav*. 2019;33(4):382–391. doi:10.1037/adb0000467
28. Brantley AD, Page KM, Zack B, et al. Making the connection: using videoconferencing to increase linkage to care for incarcerated persons living with HIV post-release. *AIDS Behav*. 2019;23(1):32–40. doi:10.1007/s10461-018-2115-4
29. Cho H, Flynn G, Saylor M, Gradilla M, Schnall R. Use of the FITT framework to understand patients' experiences using a real-time medication monitoring pill bottle linked to a mobile-based HIV self-management app: a qualitative study. *Int J Med Inform*. 2019;131:103949. doi:10.1016/j.ijmedinf.2019.08.009
30. Hirshfield S, Downing MJ, Chiasson MA, et al. Evaluation of sex positive! A video eHealth intervention for men living with HIV. *AIDS Behav*. 2019;23(11):3103–3118. doi:10.1007/s10461-019-02498-5
31. Kuo I, Liu T, Patrick R, et al. Use of an mHealth intervention to improve engagement in HIV community-based care among persons recently released from a correctional facility in Washington, DC: a pilot study. *AIDS Behav*. 2019;23(4):1016–1031. doi:10.1007/s10461-018-02389-1
32. Kurth AE, Sidle JE, Chhun N, et al. Computer-Based Counseling Program (CARE+ Kenya) to promote prevention and HIV health for people living with HIV/AIDS: a randomized controlled trial. *AIDS Educ Prev*. 2019;31(5):395–406. doi:10.1521/aeap.2019.31.5.395
33. Li Y, Guo Y, Hong YA, et al. Mechanisms and effects of a WeChat-based intervention on suicide among people living with HIV and depression: path model analysis of a randomized controlled trial. *J Med Internet Res*. 2019;21(11):e14729. doi:10.2196/14729
34. Sarna A, Saraswati LR, Okal J, et al. Cell phone counseling improves retention of mothers with HIV infection in care and infant HIV testing in Kisumu, Kenya: a randomized controlled study. *Glob Health Sci Pract*. 2019;7(2):171–188. doi:10.9745/GHSP-D-18-00241
35. Soni K, Kirschke-Schwartz H, Hightow-Weidman LB, et al. A randomized trial of an online risk reduction intervention for young black MSM. *AIDS Behav*. 2019;23(5):1166–1177. doi:10.1007/s10461-018-2289-9
36. Zhu M, Cai W, Li L, et al. Mediators of intervention effects on depressive symptoms among people living with HIV: secondary analysis of a mobile health randomized controlled trial using latent growth curve modeling. *JMIR mHealth Uhealth*. 2019;7(11):e15489. doi:10.2196/15489
37. Barroso J, Madisetti M, Mueller M, Feasibility A. Study to develop and test a cognitive behavioral stress management mobile health application for HIV-related fatigue. *J Pain Symptom Manage*. 2020;59(2):242–253. doi:10.1016/j.jpainsymman.2019.09.009
38. Carey MP, Dunne EM, Norris A, et al. Telephone-delivered mindfulness training to promote medication adherence and reduce sexual risk behavior among persons living with HIV: an exploratory clinical trial. *AIDS Behav*. 2020;24(6):1912–1928. doi:10.1007/s10461-019-02768-2

39. Fahey CA, Njau PF, Katabaro E, et al. Financial incentives to promote retention in care and viral suppression in adults with HIV initiating antiretroviral therapy in Tanzania: a three-arm randomised controlled trial. *Lancet HIV*. 2020;7(11):e762–e771. doi:10.1016/S2352-3018(20)30230-7
40. Guo Y, Hong YA, Cai W, et al. Effect of a WeChat-based intervention (Run4Love) on depressive symptoms among people living with HIV in China: a randomized controlled trial. *J Med Internet Res*. 2020;22(2):e16715. doi:10.2196/16715
41. Marhefka SL, Lockhart E, Turner D, et al. Social determinants of potential eHealth engagement among people living with HIV receiving Ryan white case management: health equity implications from project TECH. *AIDS Behav*. 2020;24(5):1463–1475. doi:10.1007/s10461-019-02723-1
42. Uhrig Castonguay BJ, Cressman AE, Kuo I, et al. The implementation of a text messaging intervention to improve HIV continuum of care outcomes among persons recently released from correctional facilities: randomized controlled trial. *JMIR mHealth Uhealth*. 2020;8(2):e16220. doi:10.2196/16220
43. Zeng Y, Guo Y, Li L, et al. Relationship between patient engagement and depressive symptoms among people living with HIV in a mobile health intervention: secondary analysis of a randomized controlled trial. *JMIR mHealth Uhealth*. 2020;8(10):e20847. doi:10.2196/20847
44. Li Y, Guo Y, Hong YA, et al. Mediating effects of stigma and depressive symptoms in a social media-based intervention to improve long-term quality of life among people living with HIV: secondary analysis of a randomized controlled trial. *J Med Internet Res*. 2021;23(11):e27897. doi:10.2196/27897
45. Plomer A-S, McCool-Myers M, Apfelbacher C. Exploring real-world experiences of early PrEP adopters in southern Germany. *AIDS Care*. 2021;33(6):754–759. doi:10.1080/09540121.2021.1876835
46. Policarpo S, Machado MV, Cortez-Pinto H. Telemedicine as a tool for dietary intervention in NAFLD-HIV patients during the COVID-19 lockdown: a randomized controlled trial. *Clin Nutr ESPEN*. 2021;43:329–334. doi:10.1016/j.clnesp.2021.03.031
47. Twimukye A, Bwanika Naggirinya A, Parkes-Ratanshi R, et al. Acceptability of a mobile phone support tool (Call for Life Uganda) for promoting adherence to antiretroviral therapy among young adults in a randomized controlled trial: exploratory qualitative study. *JMIR mHealth Uhealth*. 2021;9(6):e17418. doi:10.2196/17418
48. Yelverton V, Qiao S, Weissman S, Olatosi B, Li X. Telehealth for HIV care services in south carolina: utilization, barriers, and promotion strategies during the COVID-19 pandemic. *AIDS Behav*. 2021;25(12):3909–3921. doi:10.1007/s10461-021-03349-y
49. Guo Y, Li Y, Yu C, et al. Long-term effects of a social media-based intervention (run4love) on depressive symptoms of people living with HIV: 3-year follow-up of a randomized controlled trial. *J Med Internet Res*. 2022;24(6):e36809. doi:10.2196/36809
50. Stephenson R, Sullivan SP, Mitchell JW, Johnson BA, Sullvian PS. Efficacy of a telehealth delivered couples' HIV Counseling and Testing (CHTC) intervention to improve formation and adherence to safer sexual agreements among male couples in the US: results from a randomized control trial. *AIDS Behav*. 2022;26(8):2813–2824. doi:10.1007/s10461-022-03619-3
51. Zeng Y, Guo Y, Ho RTH, et al. Positive coping as a mediator of mobile health intervention effects on quality of life among people living with HIV: secondary analysis of the randomized controlled trial run4love. *J Med Internet Res*. 2022;24(2):e25948. doi:10.2196/25948
52. Kruse CS, Betancourt JA, Madrid S, Lindsey CW, Wall V. Leveraging mHealth and wearable sensors to manage alcohol use disorders: a systematic literature review. *Healthcare*. 2022;10(9):1672. doi:10.3390/healthcare10091672
53. Kruse CS, Lee K, Watson JB, Lobo LG, Stoppelmoor AG, Oyibo SE. Measures of effectiveness, efficiency, and quality of telemedicine in the management of alcohol abuse, addiction, and rehabilitation: systematic review. *J Med Internet Res*. 2020;22(1):e13252. doi:10.2196/13252