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Abstract

Introduction: Health-promoting lifestyle behaviours are part of the activities of daily living that influence individual happiness, values, and well-being. They play a crucial role in prevention and control of non-communicable diseases (NCDs) among all age groups. Current statistics on mortality, disability, and morbidity associated with NCDs are alarming globally. Use of information and communication technology (ICT) for health-promoting lifestyle behaviour programme enhances effective health behaviour which are important in the prevention and control of both communicable and non-communicable diseases. Our study aims to map evidence on use of information and communication technology (ICT) in comprehensive health-promoting lifestyle behaviour among healthy adults.

Methods: Eleven electronic databases were searched for the study. We included study reporting on healthy adults, ICT and any subscales of the health-promoting lifestyle profile (HPLP). All study designs published in the English language between January 2007 and July 2017. Studies focusing on diseases or disease management that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT or computer games were excluded. Data were summarised numerically and thematically.

Results: All the studies reviewed were conducted in developed countries and reported on physical activity, and findings of one study were on all the subscales of HPLP. Use of ICT for health-promoting lifestyle behaviours was reported to be effective in ensuring health behaviours that can improve physical and mental health.

Conclusion: Our findings showed that there is a dearth of knowledge on comprehensive health-promoting lifestyle behaviour that can be beneficial for the control and prevention of NCDs. There is need to carry out primary studies on use of ICT and comprehensive health-promoting lifestyle, especially among adults in low- and middle-income countries where there are alarming statistics for mortality and disability associated with NCDs.

Systematic review registration: This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568.

Strengths and limitations of this study

- A comprehensive and extensive literature searched on the use of information and communication technology (ICT) in comprehensive health-promoting lifestyle behaviour among healthy adults to identify research gap.
- Rigorous process in searching and selecting the included articles for the study.
- Inclusion of primary research articles in the study were subjected to only Mixed Method Appraisal Tool (MMAT) version 2011
- Only studies published in the English language between January 2007 and July 2017 were included in the study
- The reference lists of the included articles were not examined, and no manual searches were performed. Lastly, only electronic databases were extensively searched for the included studies.

Keywords: health-promoting lifestyle behaviour, nutrition, physical activity, health responsibility, stress management, interpersonal relationship, self-actualization, information and communication technology, healthy adults, systematic scoping review

Introduction

Increase in the prevalence of non-communicable diseases (NCDs) such as chronic cardiovascular diseases, stroke, cancers, chronic respiratory diseases and diabetes mellitus calls for more proactive ways to manage, control and prevent them. Seventy percent of global mortality has been attributed to NCDs [1 2]. Eighty percent of deaths associated with NCDs occur in low- and middle-income countries (LMICs) in the 30 to 60 years age group [2-5]. In 2013, a report showed that (Int$)53.8 billion was spent on NCDs globally [6]. NCDs have been shown to be a major barrier to development and achievement of the millennium development goals [6]. Many NCDs have a strong association with unhealthy lifestyle [2 7 8]. Risk factors for NCDs are tobacco use, food high in saturated and trans-fat, high consumption of sugar and salt, excessive alcohol intake, physical inactivity, poor diet, overweight and obesity, inadequate sleep and rest, stress, and exposure to environmental hazards [9-12].

Health-promoting lifestyle behaviour has been identified as having an essential role in prevention and control of NCDs [13-16]. Health promotion is an umbrella term describing composite of disease prevention and health promotion [3]. Information and communication technology (ICT) has been shown to be beneficial to general population and to individuals as it has made it possible to access health-related information easily [17]. Use of ICT in health promotion and health management is increasingly well recognised because of its cost-effectiveness in the prevention of diseases [18]. Evidence exists that ICT is used in health surveillance for both communicable and non-communicable diseases. ICT paired with monitoring tools can improve physical activity and weight loss [19]. Few individuals adhered to healthy lifestyle behaviour despite the role it plays in chronic disease prevention, and literature showed that web-based interventions are effective in changing behaviour [20]. ICT refers to technology that provides access to information and communication [21] through a wide range of communication tools. In this study, ICT includes internet, cell phones, computers, and websites.

Use of ICT in management and prevention of diseases is on the increase. ICT applications are used in psychotherapeutic intervention [22 23], management and control of medical conditions such as hypertension [24 25], HIV and other sexually transmitted diseases [26], diabetes management, smoking cessation, asthma management, weight loss and physical activity [20 27 28]. ICT applications have also been used for recruitment of one research group or the other. One good example was a study conducted by Bauermeister and his team, where they used a web version of respondent-driven sampling (webRDS) to recruit a sample of young adults (ages 18–24) and examined whether this strategy would result in alcohol and other drug prevalence estimates comparable to national estimates [29]. On health-promoting lifestyle and ICT, several studies have been done, mainly on physical activity, smoking cessation, alcohol intervention and diet for weight control. However, there are other health-promoting lifestyle behaviours such as stress management, interpersonal relationship, health responsibility and self-actualisation that are equally important to disease prevention and health promotion, along with physical activity and nutrition [11].

We are not aware of any review that has reported on use of ICT and comprehensive health-promoting lifestyle behaviour (nutrition, physical activity, stress management, interpersonal relationships, self-actualisation/spiritual growth and health responsibility) among healthy individuals. Comprehensive health-promoting lifestyle behaviours are described for the purpose

of this this study as day-to-day lifestyle practices that can prevent diseases and promote health. The six health-promoting lifestyle behaviours are the subscales of the health-promoting lifestyle profile instrument [30]. Each of these health-promoting lifestyle behaviours is important in the prevention and control of both communicable and non-communicable diseases, as they are part of the activities of daily living that influence individual happiness, values, and well-being [31]. Reports show that there was a lower risk of developing diabetes mellitus, stroke, myocardial infarction and cancers among 23,153 Germans between 35 and 65 years of age that were followed for an average period of 7.8 years on adherence to no smoking, exercise, healthy diet and BMI less than 30kg/m^2. compared to participants that did not engage in these healthy lifestyle practices [20]. There is a possibility that if lifestyle practices such as stress management, interpersonal relationships, health responsibility and self-actualisation were added to the lifestyle this could have led to lower risk for developing other NCDs such as peptic ulcer, mental illnesses, etc. Hence, this study aims to map evidence on use of ICT in health-promoting lifestyle behaviour among healthy individuals to comprehensively assess the current state of knowledge of health-promoting lifestyle behaviour and ICT. The results of this study will help to identify an area that requires meta-analysis and future primary research. This systematic scoping review accordingly seeks to address the following research questions:

- Does use of ICT without hardware monitoring (accelerometer or pedometer) improve and enhance health-promoting lifestyle behaviour?
- Is there any evidence that use of ICT in health-promoting lifestyle activity resulted in good health status (healthy weight, normal blood pressure, normal blood sugar and good mental and physical health)?

Methods/Designs

This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568. The review adopted the five stages Arksey and O'Malley framework (identifying the research question, identifying relevant studies, study selection, charting the data. and collating, summarising and reporting the results) for conducting scoping reviews [32]. The study protocol was published in *BMJ Open* [3]. This review report followed the PRISMA (Preferred Reporting Items for Systematic Review) guidelines) [33].

Search strategy

An extensive search of eligible studies was conducted on the following 11 databases: Academic Search Complete (EBSCO), PsycArticle (EBSCO), PubMed, Medline (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source – Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), PsycINFO (EBSCO), Science Direct, and Google Scholar. We searched for articles published in the English language between 2007 and 2017. The search strategy was focused mainly on the study interventions and the population of interest (Table 1). Boolean operators (AND and OR) separated keywords in the search as follows: health-promoting lifestyle profile OR health-promoting lifestyle behaviour OR wellness OR nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualisation OR spiritual growth AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR the internet AND adult OR workers OR employees. Summary of the search strategy is found in the supplementary file.

Eligibility criteria

Inclusion criteria

- studies reporting on healthy workers, professionals and adults,
- studies published in the English language
- studies published between January 2007 and July 2017
- studies reporting on interventions such as any subscales of the health-promoting lifestyle profile (stress management, interpersonal relationships, nutrition, self-actualisation, health responsibility and physical activity,) and ICT (text messages, SMS, computers, mobile phone, websites and internet)
- all study designs, including cross-sectional studies, quantitative studies, randomised control trial studies, quasi-experimental study designs, cohort studies, qualitative studies, and systematic reviews

Exclusion criteria

- studies which do not report on any form of ICT

- studies on patients, youth, students, diseases/management or children
- studies that do not report on all or any of the subscales of the health-promoting lifestyle profile
- studies that use any form of ICT in recruitment or as a means of collecting data only
- literature published before January 2007 and after July 2017
- studies which do not report on adults
- studies that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT and computer games
- studies reporting on alcoholism, obesity or cigarette smoking
- non-English publications
- study protocols, non-systematic review, and letter to the editors

Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Study selection

The selection process for the included articles involved rigorous exercises in three stages of screening – title, abstract and full-text screening – before data extraction. One reviewer conducted the title screening of the included articles and abstract and full-text screening was undertaken independently by two reviewers. Any disagreement at any level of the screening was discussed until both reviewers reached consensus. Title of an article that was not cleared was included for abstract screening and if abstract of an article was not cleared same was added for the full-text screening. The reviewers developed the screening form before commencement of the screening exercise. The screening forms were developed based on population, interventions, and outcomes [3]. Systematic reviews were included if they met the inclusion criteria. Two independent reviewers screened the included articles full-text, based on the inclusion and exclusion criteria described above, and consensus between the reviewers resolved any disagreement. The degree of agreement between reviewers at the full-text screening stage was estimated using kappa statistic with STATA 13.

Figure I: Flow diagram of the included article

Data extraction

Data extraction criteria were determined, and a self-designed data extraction form was designed by the reviewers before data extraction to aid the process. The primary outcome measured was health-promoting lifestyle behaviours and health status (Table 1). There was no restriction on how to measure the outcome such as whether physiological or self-report. However, use of accelerometer, pedometer or computer games was not included in this study. In order to provide answers to the study questions, data extracted from each of the studies included were as follows: bibliography of the study (author's name and date), location of the study, objective or aim of the study (as reported by authors), study design, study population, study setting, sample size, type of ICT (Table 1), type of health-promoting lifestyle behaviour (Table 1), duration of the study, outcome of the study, results or findings from the study and conclusions of the study.

Quality appraisal of the included studies

Mixed Method Appraisal Tool (MMAT) version 2011 [34] was used to assess the quality of included research articles. MMAT was designed to evaluate articles on primary research using the following study designs: qualitative; quantitative and mixed method. The MMAT enabled us to assess the methodological quality of the included studies. Scores for each study varied between 25% and 100%. For mixed method studies, there were 11 criteria to be met for an article to be rated as high; four criteria each for quantitative (QUANT) section and qualitative (QUAL) section and three for mixed method (MM) section). Mixed method studies were rated as 25% when QUAL=1 and QUAN=1 and MM=0; as 50% when QUAL=2 and QUAN=2 and MM=1; as 75% when QUAL=3 and QUAN=3 and MM=2; and as 100% when QUAL=4 and QUAN=4 and MM=3. A criteria score between 25% and 49% was rated as low quality, a score of 50% to 74% as average quality and a score of 75% to 100% as high quality.

Collating and summarising the findings

Extracted data were summarised numerically and thematically using the following two themes: ICT used in health-promoting lifestyle behaviour and health-promoting lifestyle behaviour outcomes. The authors collectively assessed themes and conducted a critical appraisal of each theme in relation to the research questions. We also examined the meaning of the findings in relation to the aim of the study and their implications for research, practice, and policy.

Patient and public involvement

Patients and public were not involved in the study as it is a systematic review

Results

The literature encompassed a broad scope of studies exploring use of ICT in health-promoting lifestyle behaviour among healthy individuals. Eleven electronic databases searched (figure 1) yielded 9118 potential articles. After screening and duplicates were removed, 20 articles met the study inclusion criteria. The kappa statistics for the degree of agreement showed 74.5% agreement versus 49.8% expected by chance, which constitutes moderate to substantial agreement (Kappa statistic = 0.49, p-value<0.001). McNemar's chi-square statistic suggests that there is not a statistically significant difference in the proportions of yes/no answers by reviewers. The study includes 13 research articles and 7 systematic reviews identified as meeting the inclusion criteria and focused on the specified health-promoting lifestyle behaviours and ICT among healthy adults.

Characteristics of included studies

The characteristics of the included studies are presented in Table 2. Two of the included studies adopted mixed methods designs [35 36], one each was qualitative design [37], quantitative non-randomised design [38], prospective longitudinal cluster-randomised controlled trial [39], retrospective randomised trial design [40] and intervention study [41]. Six studies [18 20 42-45] adopted randomised control trial design. The duration of the intervention studies ranged from 4 weeks to 10 months. One of the main study aims was to determine the effect of proactive dissemination strategy on the reach of the Internet-delivered computer-tailored intervention [41]; study duration commenced with the invitation to participate in the study. Sample sizes of included research articles ranged from 26 to 16,948; sample sizes of included evidence review articles ranged from 11 to 457. Twelve studies focused on males and females [20 35 36 38-41 43-46], one reported on females alone [18], one reported on all study population [47] and six studies (systematic review) did not report study population [17 27 48-51]. Six of the studies reviewed were conducted in the community [38 40 43-46]. Seven were conducted at the workplace: one each among the military [39], nurses [18], university employees [35], municipality employees [45]; two in more than one organisation [20 37]; and one did not describe the workers [36].

Three of the seven systematically reviewed studies [27 48 51] did not report the study country of included articles, one reported 457 articles from 36 countries in Asia, Australia and Oceania, Europe, North America, and South America [47]; one reviewed 34 articles from five countries (Europe, Asia South Korea, USA, New Zealand) [49]; one reviewed 12 articles from three countries (USA, UK and Australia)[17]; and one reviwed 38 articles from the USA alone [50]. In regard to primary research included in this study, three studies were conducted in Australia [38 40 44], three in the United Kingdom [35-37], three in the United States [39 42 43], two in the Netherlands [41 45], one in Israel [20] and one in Taiwan [18]. Not all of the included studies reported on geographical setting of the research and none of the studies was conducted in a low- or middle-income country.

Risk-of-bias assessment

In regard to quality assessment of the included studies, the scores of the 13 articles reviewed for methodological quality ranged from 50% to 100%. Nine of the reviewed articles were rated as high quality, of which three scored 100% [39 43 44] and six scored 75% [18 20 37 40 41 46]. Only four were rated average quality, with two scoring 50% [38 45] and two scoring 67% [35 36]. The overall quality assessment was appraised to be average risk of bias due to the following: no clear description of concealment, withdrawal rate higher than 20% and no consideration given to how findings related to researcher influence.

ICT use in health-promoting lifestyle behaviours

A theme emerging from the study was ICT use in health-promoting lifestyle behaviours and health-promoting lifestyle behaviours targeted by the included studies (Table 3). Various forms of ICT (email, social network sites, websites, short message service (SMS) or text messages, mobile phone app, smartphones, computers and Multimedia Messaging Service (MMS)) were used in the included studies for health-promoting lifestyle behaviours intervention that targeted one form or another of health-promoting behaviours. It is obvious that all the included articles used internet with either phones or computers. However, some authors specifically mentioned use of internet in their reports [41 45 46 49] while computer use was explicitly mentioned by few authors [41 45 50]. All the reviewed studies reported on physical activity, ten reported on nutrition [18 20 36 39 41 45 47 48 50 51], one reported on social connection [36] and one reported on all the subscales of health-promoting lifestyle profile [18].

Use of email and website [38], email, website and SMS [37], smartphone and website [44] and website only [46], was reported only for physical activities behaviour. Two of the reviewed studies reported on a smartphone apps, one in the form of an in-built accelerator [43] and one on smartphone with website [40] for physical activity behaviour. Fanning et al. reported on use of mobile device, mobile software, and SMS for physical activity [27]. Three of the included studies reported on use of more than one form of ICT for more than one health behaviour [39 47 49]. Computer-based information and communication technologies [50] and Internet-delivered computer-tailored lifestyle programme [41 45 51] were reported to be used for more than one health behaviour, including physical activity, nutrition, alcohol use, smoking behaviour, and condom use. Use of website only was reported for nutrition, physical activity, stress management, interpersonal relationship, spiritual growth, and health responsibility [18], and diet, physical activity, and social connection [36]. Social network sites were reported for fitness, sexual health, food safety, smoking and health promotion [17]. Mackenzie et al. reported use of email, software reminder, and Twitter to reduce workplace sitting only [35], while a web-based app was used for nutrition and physical activity only [20]. A comprehensive health-promoting lifestyle behaviour was reported among female nurses only [18].

Use of ICT for health-promoting lifestyle behaviours and health status

Use of any form of ICT increased participants' physical activity behaviour [27 35 38-40 43 44 46], and health behaviour change [17 20 49 50] (Table 3). Use of ICT in health-promoting behaviour was reported to reduce weight [20], but Frank et al. reported no significant difference in participants BMI and waist circumference [39]. People that are likely to participate in the Internet-delivered computer-tailored intervention are older individuals with higher educational level, relative healthier lifestyle and healthy BMI [41]. For efficient use of Internet-delivered computer-tailored lifestyle programme, there should be a preview of new website content to a standard prompt in addition to short prompt timing [45]. Factors to be considered when planning intervention for ICT to be used for health-promoting lifestyle behaviours in the workplace are encouragements in the form of motivation from managers, time management, involvement of stakeholders in the designing of the intervention, and reminders [37]. Use of ICT has been documented to be effective in promoting health behaviours [50]. Comprehensive health-promoting lifestyle behaviours and ICT reduce BMI, and improve physical and mental component summary [18]. There is a need to examine the long-term effectiveness of ICT on health-promoting behaviours [51]. To ascertain the effectiveness of ICT and

comprehensive health-promoting behaviours in the prevention of diseases, there is a need to consider other health assessment parameters such as blood pressure and biochemical parameter instead of BMI alone [18]

Discussion

We conducted a systematic scoping review of the available studies on use of ICT for comprehensive health-promoting behaviours globally. Health-promoting lifestyle behaviours play an essential role in the prevention of diseases and quality of life [12 15]. According to the WHO, to control NCDs, it is important to reduce risk factors associated with them by adopting health-promoting lifestyle behaviours [2]. Our systematic review showed that various forms of ICT such as email, social network sites, websites, SMS or text messages, mobile phone app, smartphones, computers and MMS were used for mainly nutrition, physical activity, smoking cessation and reducing alcohol consumption. There was a paucity of data on stress management, interpersonal relationship, self-actualisation/spiritual belief and health responsibility. However, health-related lifestyle behaviours such as smoking cessation, reduced alcohol consumption, condom use, breast cancer prevention and sexually transmitted diseases prevention were not a primary research study. Furthermore, our systematic review reported that use of ICT for health promotion, improves and enhances health-promoting behaviours. More so, use of ICT for comprehensive health-promoting lifestyle behaviours was reported to result in a healthy BMI and improve physical and mental health. However, BMI was the only physical health parameter assessed by all the included studies. Factors such as time management, motivation and reminder are essential when designing health-promoting lifestyle behaviour for workers. There was only one primary study on use of ICT and comprehensive health-promoting lifestyle behaviour among females. Also, the quality assessment of the primary studies included was of moderate risk. It is of interest to know that no reports on LMICs were found in the included studies. Regarding population size, our systematic review reported large population spreads from 26 to 16,948 across the study locations reported. This review showed that there is a dearth of knowledge on use of ICT for comprehensive health-promoting lifestyle and health status.

ICT enhances the success of national health promotion and disease prevention programmes [52]. Our study reported large population size, which demonstrates that public health promotion campaigns can be achieved through use of ICT [53], since large populations can be involved in health promotion

intervention programmes, which will potentially enhance achievement of the sustainable development goal of reducing premature deaths associated with NCDs to one-third by 2030 [2]. However, to reduce attrition rate in ICT use for health-promoting lifestyle behaviour intervention, one of our included studies reported that reminders are critical [37]. Health-promoting lifestyle behaviour is important in the prevention and control of both communicable and non-communicable diseases as they are part of the activities of daily living that influence individual happiness, values, and well-being [31]. In addition, a group of 23,153 Germans between 35 and 65 years of age that were followed for an average period of 7.8 years on adherence to no smoking, exercise, healthy diet, and BMI less than 30kg/m^2 reported lower risk of developing diabetes mellitus, stroke, myocardial infarction and cancers compared to participants that did not engage in the above healthy lifestyle [20]. Much attention has been given to physical activity, nutritional lifestyle behaviours and healthy weight, and this might be the possible reason why these two lifestyle behaviours were more pronounced in our findings. This might also be the reason why only BMI was assessed among all the physical health parameters that could be of importance to control and prevention of NCDs [2]. These findings have implications for the control and prevention of NCDs in the near future.

One of the strengths of this study is the extensive literature searched and the rigorous process in selecting the included studies. Scoping review conducted for this study is an approach that examines the extent, range and nature of research activity in a particular field to identify research gap [32 54]. This is the first article that has examined ICT and comprehensive health-promoting lifestyle behaviours among healthy adults, as the authors are not aware of any such others. We also conducted a methodological quality appraisal of the included primary research. Results in our study did not omit any country, as 'country filter' was not applied during the literature search. All the included articles reported on physical activity and some reported on stress management, spiritual growth health responsibility, and interpersonal relationships. Majority of the included studies that reported on health-related lifestyle behaviours such as smoking cessation, reduced alcohol consumption, condom use, breast cancer prevention and sexually transmitted diseases prevention were systematically reviewed studies. However, none of the included studies reported on blood pressure or blood glucose level. Screening and early detection of NCDs are one way to prevent and control this demon called NCDs [2]. In the next 30 years, there will be a 3.5-fold increase in deaths due to cardiovascular diseases globally [55] which is the leading cause of mortality and

morbidity among all the NCDs [1-3]. Highest premature deaths associated with NCDs are recorded in the LMICs [1 2 56]. However, our scoping review showed scarcity in use of ICT for comprehensive health-promoting lifestyle behaviours research among healthy adults from these regions.

Some limitations of this study were, first, inclusion of studies published in the English language between January 2007 and July 2017. Secondly, the reference lists of the included articles were not examined, and no manual searches were performed. Lastly, only electronic databases were extensively searched for the included studies.

Health-promoting lifestyle behaviour remains a crucial means of curbing the menace associated with NCDs [3 14-16]. Nevertheless, 'healthy' individuals prefer to be busy with other issues of life than to engage in health-promoting lifestyle behaviour [14 37]. Few individuals adhered to healthy lifestyle behaviour despite the role it plays in chronic diseases prevention [14 35]. There is need to explore other means of encouraging people to practice health-promoting lifestyle behaviours because it is a fact that prevention is better than cure. Literature showed that web-based interventions are effective in changing behaviour [20]. With the increase in the burden of NCDs in LMICs [56], use of ICT to promote health behaviour lifestyle is the key determinant in the control and prevention of NCDs [53]. There is an urgent need to assess the nature and form of ICT that can be effective in promoting health behaviours among healthy adults in LMICs, and in Africa in particular. In addition, there is need to explore use of ICT and comprehensive health-promoting lifestyle behaviours among healthy adults in LMICs where there is a gap in the primary study of these issues.

Conclusion

The findings from our study showed that ICT enhances health-promoting lifestyle behaviour and promotes physical and mental health. The physical parameter assessed by all the included studies was BMI, but factors such as time management, motivation and reminders are also important when designing health-promoting lifestyle behaviour for the worker. None of the included studies reported on LMICs. There is a dearth of knowledge on a comprehensive health-promoting behaviour that can be beneficial in the control and prevention of NCDs. There is need to carry out primary studies on use of ICT for a comprehensive health-promoting lifestyle, especially among

'healthy' adults in LMICs where there are alarming statistics on the mortality and disability associated with NCDs.

List of abbreviations

- NCDs -Non-communicable diseases
- HPLP – Health-promoting lifestyle profile
- ICT- information and communication technology
- LMICs- Low and Middle-income countries
- SMS - short message service
- MMS- and Multimedia Messaging Service
- WHO- World Health Organisation
- BMI- body mass index

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Data sharing statement

The data for the study is available either in the manuscript or as a supplementary file accompanying this manuscript. However further request of any data should be directed to the corresponding author, who will gladly share it.

Competing Interest

The authors declare that they have no competing interests.

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Author Contribution

Mrs Elizabeth M Joseph-Shehu conceptualised, designed the protocol and prepare the draft of the manuscript under the supervision of Professor BP Ncama. Ms. Nomaxabiso Mooi and Dr Tivani Mashamba-Thompson contributed to the methodology and data collection. All authors critically reviewed the draft version of the manuscript and gave approval for submission

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Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Criteria	Determinants
Population	Healthy adults, workers, well individuals. Patients, children, students, adolescents (youth was excluded from this study)
Interventions	Health-promoting lifestyle profile (nutrition, physical activity, interpersonal relationship, health responsibility, stress management, self-actualisation or spiritual growth) and information and communication technologies (ICT, mobile phone, text messages, SMS, internet, computers, websites)
Comparison	Health-promoting lifestyle profile intervention without ICT
Outcomes	Effective and sustaining health-promoting lifestyle practices and health status (normal weight, normal blood pressure, normal blood sugar and good mental and physical health)
Study setting	Focus on low- and middle-income countries

Adopted from the study protocol [3]

Table Error! No text of specified style in document. Characteristics of included studies

Author and date	Country	Income level of country	Aim of the study	Study design	Study population	Study setting	Sample size	Duration of study
Research articles								
Ammann et al. (2012)	Australia	High	To evaluate a website- delivered computer-tailored physical activity intervention, with a specific focus on differences in tailored advice acceptability, website usability, and physical activity change between three age groups.	Quantitative non-randomised design	Male and Female;	Community	863	1 Month
Bardus et al. (2014)	United Kingdom	High	To investigate the reason for participating and not participating in an eHealth workplace physical activity intervention.	Qualitative study	Male and female	Workplace	62	Not specified
Carr et al. (2013)	United States	High	The goals of these focus groups were to identify Internet features rated as "useful for improving PA".	Randomised controlled trial (RCT) design	Male and female;	Community	53	6 months
Frank et al. (2016)	United States		To determine if a telehealth coaching initiative is superior to a one-time nutrition and fitness education class regarding: (a) dietary contributions to bone health and (b) exercise contributions to bone health, assessed before and after deployment.	prospective, longitudinal, cluster-randomised, controlled trial	Male and female	Workplace	158	9 months
Guertler et al. (2015)	Australia	High	The aims of this study were to (1) examine the engagement with the freely available physical activity promotion program 10,000 Steps, (2) examine how use of a smartphone app may be helpful in increasing engagement with the intervention and in decreasing non-usage attrition, and (3) identify socio-demographic and engagement-related determinants of nonusage attrition.	Retrospective randomised trial	Male and female	Community	16,948	9 months

King et al. (2016)	United States	High	This study provided an initial 8-week evaluation of three different customised physical activity-sedentary behaviour apps drawn from conceptually distinct motivational frames in comparison with a commercially available control app.	Controlled experimental design	Men and women	Community	95	8 weeks
Kirwan et al. (2012)	Australia	High	To measure the potential of a newly developed smartphone application to improve health behaviours in existing members of a website-delivered physical activity program (10,000 Steps, Australia).	2-arm matched case–control trial	Men and women	Community	200	3 months
Lara et al. (2016)	UK	High	We report a pilot randomised controlled trial (RCT) of a web-based platform (Living, Eating, Activity and Planning through retirement; LEAP) promoting healthy eating (based on a Mediterranean diet (MD), physical activity (PA) and meaningful social roles.	Mixed method design	Men and women	Workplace	70	8 weeks
Mackenzie et al. (2015)	UK	High	To explore the acceptability and feasibility of a low-cost, co-produced, multi-modal intervention to reduce workplace sitting.	Mixed method design	Men and women	Workplace	26	Over 4 weeks
Naimark et al. (2015)	Israel	High	Our aim was to compare people receiving a new Web-based app with people who got an introductory lecture alone on healthy lifestyle, weight change, nutritional knowledge, and physical activity, and to identify predictors of success for maintaining a health.	RCT	Male and female	Workplace	85	14 weeks
Schneider et al. (2013)	Netherlands	High	This study investigated the influence of content and timing of a single email prompt on re-use of an Internet-delivered computer-tailored (CT) lifestyle program.	RCT	Male and female	Workplace	200	6 weeks

Schneider et al. (2013)	Netherlands	High	This study aimed to determine the effect of proactive dissemination strategy on reach of the Internet-delivered computer-tailored intervention.	Intervention study	Male and female	Community	5168	10 months
Tsai et al. (2015)	Taiwan	High	This study aimed to evaluate health-promoting effects of an eHealth intervention among nurses compared with conventional handbook learning.	Randomised control	Female Nurses	Workplace	105	12 weeks
Review evidence articles								
Bardus et al. (2015)	36 countries in Asian, Australia & Oceania; Europe, North and South America	High	To provide an up-to-date, comprehensive map of the literature discussing use of mobile phone and Web 2.0 apps for influencing behaviours related to weight management (i.e., diet, physical activity [PA], weight control, etc.)	Review	All population group	Not specified	457 articles	8 months
Bert et al. (2014)	Not specified	High	to describe use of smartphones by health professionals and patients in the field of health promotion.	Review	Not specified	Not specified	21 articles	1 Month
Buhi et al. (2013)	Europe, Asia South Korea, USA, New Zealand	High	To perform a systematic review of the literature concerning behavioural mobile health (mHealth) and summarise points related to heath topic, use of theory, audience, purpose, design, intervention components, and principal results that can inform future health education applications.	Review	Not specified	Not specified	34 articles	4 weeks to 1 year
Fanning et al. (2012)	Not specified	Not specified	The aims of this review were to: (1) examine the efficacy of mobile devices in the physical activity setting, (2) explore and discuss implementation of device features across studies, and (3) make recommendations for future intervention development.	Review	Not specified	Not specified	11articles	11 months

Hou et al. (2014)	USA	High	This review examines Internet interventions aiming to change health behaviours in the general population.	Review	Not specified	Not specified	38 articles	NA
Kohl et al. (2013)	Not specified	Not specified	The aim of this paper is to (1) review the current literature on online prevention aimed at lifestyle behaviours, and (2) identify research gaps regarding reach, effectiveness, and use.	Review	Not specified	Not specified	41 articles	NA
Laranjo et al. (2014)	UK, USA, Australia	High	Our aim was to evaluate use and effectiveness of interventions using social networking sites (SNSs) to change health behaviours.	Review	Not specified	Not specified	12 articles	varied from 21 days-18 months

Table 3 Health-promoting lifestyle behaviours and ICT

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Ammann et al. (2012)	Email, website	Physical activity	Physical activity and BMI	No significant differences between the age groups were found with regard to BMI and physical activity level at baseline. All age groups increased their weekly total physical activity minutes and the number of total physical activity sessions significantly over time from baseline to 1-month follow-up. Old-age group increased physical activity more than the other two age groups.	The study suggests that website-delivered physical activity interventions can be suitable and effective for older aged adults.
Bardus et al. (2014)	Website, email and text messaging (SMS)	Physical activity (PA)	Physical activity	Reasons for participation included a need to be more active, increase motivation to engage in PA, and better weight management. Employees were attracted by the perceived ease of use of the programme and by the promise of receiving reminders. Many felt encouraged to enrol by managers or peers. Reported reasons for non-participation are lack of time, loss of interest toward the programme, or a lack of reminders to complete enrolment.	In developing workplace physical activity interventions, it is important to identify salient motivators and barriers to participation through formative research with the target population. Programme enrolment procedures should be simple and not time consuming, so that burden on participants is reduced and early attrition is minimised. It is also important that employers find ways to actively promote workplace health promotion programmes (WHPPs) to their staff while also maintaining confidentiality and individual rights on employees, so that larger segments of the workforce can be reached.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Bardus et al. (2015)	Mobile phone and Web 2.0 technologies	PA, Diet and weight loss management	Diet and Physical activity	This review categorised the identified articles into two overarching themes, which described use of technologies for either (1) promoting behaviour change (309/457, 67.6%) or (2) measuring behaviour (103/457, 22.5%). The remaining articles were overviews of apps and social media content (33/457, 7.2%) or covered a combination of these three themes (12/457, 2.6%).	Limited evidence exists on use of social media for behaviour change, but a segment of studies deals with content analyses of social media. Future research should analyse mobile phone and Web 2.0 technologies together by combining the evaluation of content and design aspects with usability, feasibility, and efficacy/effectiveness for behaviour change, in order to understand which technological components and features are likely to result in effective interventions.
Bert et al. (2014)	smart phones	Nutrition lifestyles, physical activity, health in elderly, prevention of sexually transmitted diseases	Nutrition and physical activity	Out of 21 articles identified as specifically centred on health promotion, the nutrition field have applications that allow to count calories and keep a food diary or more specific platforms for people with food allergies. While in the physical activity many applications suggest exercises with measurement of sports statistics and some applications deal with lifestyles suggestions and tips. .	The promotion of healthy lifestyles, adequate nutrition and physical activity are all possible and desirable through use of smartphones but it is important to underline the crucial role of health care providers in the management of the patient while using these tools. There is also a need to analyse the usefulness, quality and accuracy of smartphones applications in the field of preventive medicine.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Buhi et al. (2013)	SMS, MMS, Internet	Breast cancer prevention, diabetes management, weight loss or obesity prevention, smoking cessation, asthma self-management and physical activity	physical activity and breast cancer prevention	One journal assessed physical activity promotion and breast cancer prevention respectively. Twenty interventions (59%) were evaluated using experimental designs, and most resulted in statistically significant health behavioural changes.	Consideration should be given for the deployment of mHealth applications to combat coronary heart disease, HIV/AIDS, and other high-priority problems contributing to high mortality. A mobile video-based modality, using sight and sound, may show even greater promise in health behaviour change interventions.
Carr et al. (2013)	Internet website	Physical activity	Physical activity	The enhanced internet (EI) arm increased PA in relation to the standard internet (SI) arm at 3 months but between-groups differences were not observed at 6 months. EI participants-maintained PA from 3 to 6 months. This result suggests that a non-face-to-face, user- and theory-guided Internet PA program is more efficacious for producing immediate increases in PA among sedentary adults than what is currently available to the public.	The EI program was efficacious at improving PA levels in relation to publicly available Websites initially, but differences in PA levels were not maintained at 6 months. Future research should identify Internet features that promote long-term maintenance.
Fanning et al. (2012)	Mobile device, mobile software, SMS	Physical activity	Physical activity	Four studies were of “good” quality and seven of “fair” quality. In total, 1351 individuals participated in 11 unique studies. This study suggests that mobile devices are effective means for influencing physical activity behaviour.	Our focus must be on the best possible use of these tools to measure and understand behaviour. Therefore, theoretically grounded behaviour changes interventions that recognise and act on the potential of smartphone technology could provide investigators with an effective tool for increasing physical activity.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Frank et al. (2016)	Website, email	exercise, nutrition, bone health	Physical activity, nutrition, waist circumference, BMI	There were no significant differences found in the BMI and waist circumference of soldiers in both control and intervention group over the course of study. There were significant increases in body fat, osteocalcin, and sports index for the telehealth group.	A 9-month deployment to Afghanistan increased body fat, bone turnover, and physical activity among soldiers randomised to receive telehealth strategies to build bone with nutrition and exercise. This study indicates that diet and exercise coaching via telehealth methods to deployed soldiers is feasible but limited in its effectiveness for short-term overseas deployments.
Guertler et al. (2015)	Smartphone app and website	Physical activity	Physical activity	Compared to other freely accessible Web-based health behaviour interventions, the 10,000 Steps program showed high engagement.	Use of an app alone or in addition to the website can enhance program engagement and reduce risk of attrition.
Hou et al. (2014)	Computer-based information and communication technology	Tobacco prevention, alcohol prevention, weight loss, Physical activity, nutrition, HIV and chronic diseases	Physical activity and nutrition	There were seven studies focused primarily on increasing PA, and additionally five studies also examined related factors, such as nutrition and binge eating. Two studies were categorised as nutrition only interventions, with one focused on folic acid intake and the other targeted fruit juice and vegetable (FJV) consumptions.	Findings from the current review study indicated that, overall, Internet or web-based interventions (WIs) produce favourable results and are effective in producing and increasing targeted health or behavioural outcomes.
King et al. (2016)	Smartphone's built-in accelerometer	Physical activity	Physical activity behaviour	Over the 8-week period, the social app users showed significantly greater overall increases in weekly accelerometery-derived moderate to vigorous physical activity relative to the other three arms. Participants reported that the apps helped remind and motivate them to increase their physical activity levels as well as sit less throughout the day.	The results provide initial support for use of a smartphone-delivered social frame in the early induction of both physical activity and sedentary behaviour changes. The information obtained also sets the stage for further investigation of subgroups that might particularly benefit from different motivationally framed apps in these two key health promotion areas.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Kirwan et al. (2012)	Smartphone, website	Physical activity	Physical activity	Over the study period (90 days), the intervention group logged steps on an average of 62 days, compared with 41 days in the matched group. Use of the application was associated with an increased likelihood to log steps daily during the intervention period compared with those not using the application.	Using a smartphone application as an additional delivery method to a website-delivered physical activity intervention may assist in maintaining participant engagement and behaviour change.
Kohl et al. (2013)	Internet-delivered intervention	Dietary behaviours, physical activity, alcohol use, smoking, and condom use	Dietary behaviours and physical activity	According to health priorities, interventions are largely targeted at weight-related behaviours, such as physical activity and dietary behaviour. Eleven studies targeted weight management and they were on dietary behaviours and physical activity. The main aimed of these studies were weight loss five reviews also included interventions on weight maintenance. Six studies included 3 or more behaviours. The other groups included studies aimed at physical activity, 5 reviews were on smoking and alcohol respectively. Four papers combined alcohol and smoking while three were on dietary behaviours. An additional manual search showed one study on condom use.	More research is needed on effective elements instead of effective interventions, with special attention to long-term effectiveness. The reach and use of interventions need more scientific input to increase the public health impact of Internet-delivered Interventions.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Lara et al. (2016)	Web-based platform	Diet, Physical activity, social connection and anthropometric status	Diet, Physical activity, social connection, BMI and waist circumference	'Eating well' and 'being social' were the most visited modules. At interview, participants reported that diet and PA modules were important and acceptable within the context of healthy ageing.	The trial procedures and the LEAP (Living, Eating, Activity and Planning through retirement) intervention proved feasible and acceptable. Overall participants reported that the LEAP domains of 'eating well', were important for their health and well-being in retirement.
Laranjo et al. (2014)	Social network sites	Fitness, sexual health, food safety, smoking and health promotion	Fitness (physical activity)	The study found a statistically significant positive effect of SNS interventions on behaviour change, boosting encouragement for future research in this area.	The study showed a positive effect of SNS interventions on health behaviour-related outcomes, but there was considerable heterogeneity.
Mackenzie et al. (2015)	Email, reminder software, twitter	Reduced workplace sitting	Increased Physical activity	Therefore, "completers" demonstrated a range of levels of physical activity. In addition, "completers" generally demonstrated positive health behaviours with 0 % being smokers, over 50 % eating five fruits or vegetables/day and almost 25 % not drinking alcohol.	Evaluation of this intervention provides useful information to support participatory approaches during intervention development and the potential for more sustainable low-cost interventions.
Naimark et al. (2015)	Web-based app	Nutrition and Physical activity	Nutrition, Physical activity, BMI and waist circumference	The app group increased their weekly duration of physical activity to the healthy range of more than 150 minutes a week, which may afford substantial health benefits, they lost more weight and had increased nutritional knowledge compare to the control group.	We showed a positive impact of a newly developed Web-based app on lifestyle indicators during an intervention of 14 weeks. These results are promising in the app's potential to promote a healthy lifestyle, although larger and longer duration studies are needed to achieve more definitive conclusions.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Schneider et al. (2013)	Internet-delivered Computer-tailored lifestyle program	Physical activity, Fruit and vegetable consumption, smoking status, alcohol consumption	Physical activity, Fruit and vegetable consumption	Sending prompt 2 weeks after the first visit was more effective compared with using a longer time period, adding a preview of new website content to a standard prompt increased its effectiveness in persuading people to log in to the program and sending a prompt with additional content after a 2-week period significantly increased program log-ins compared to using a reactive approach in which no additional prompts were used.	The key findings suggest that boosting revisits to a CT program benefits most from relatively short prompt timing. Furthermore, a preview of new website content may be added to a standard prompt to further increase its effectiveness in persuading people to log in to the program.
Schneider et al. (2013)	Internet-delivered computer-tailored intervention.	Physical activity, fruit and vegetable intake, alcohol consumption and smoking behaviour	Physical activity, fruit and vegetable intake, BMI, mental health status	Approximately 50% of all participants had a healthy body weight, 35% were overweight, and 10% were obese. In term of physical activity, 21% with a minimum of 150 minutes exercise per week, whereas 46% and 69% were not adhering to the Dutch guidelines of fruit and vegetable intake respectively. More than one-third (36%) complied with three lifestyle guidelines while 1% of the respondents complied with none of these guidelines. Older and respondents with a higher educational degree, as well as respondents with relatively healthier lifestyle and a healthy BMI, were more likely to participate in the intervention.	The study concluded that there is need to put additional effort to ensure that at-risk individuals (low socio-economic status and unhealthy lifestyle) have increase interest in a lifestyle intervention and they should also be encouraged to employ lifestyle intervention.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Tsai et al. (2015)	Website	Health-promoting lifestyle profile (HPLP)	Health-promoting lifestyle profile (HPLP), BMI, physical and mental component summary	The eHealth education intervention had the effect of significantly increasing nurses' post-intervention Health-Promoting Lifestyle Profile total scores, physical component summary (PCS), mental component summary (MCS) and decreases in BMI.	Tailored eHealth education is an effective and accessible intervention for enhancing health-promoting behaviour among nurses.

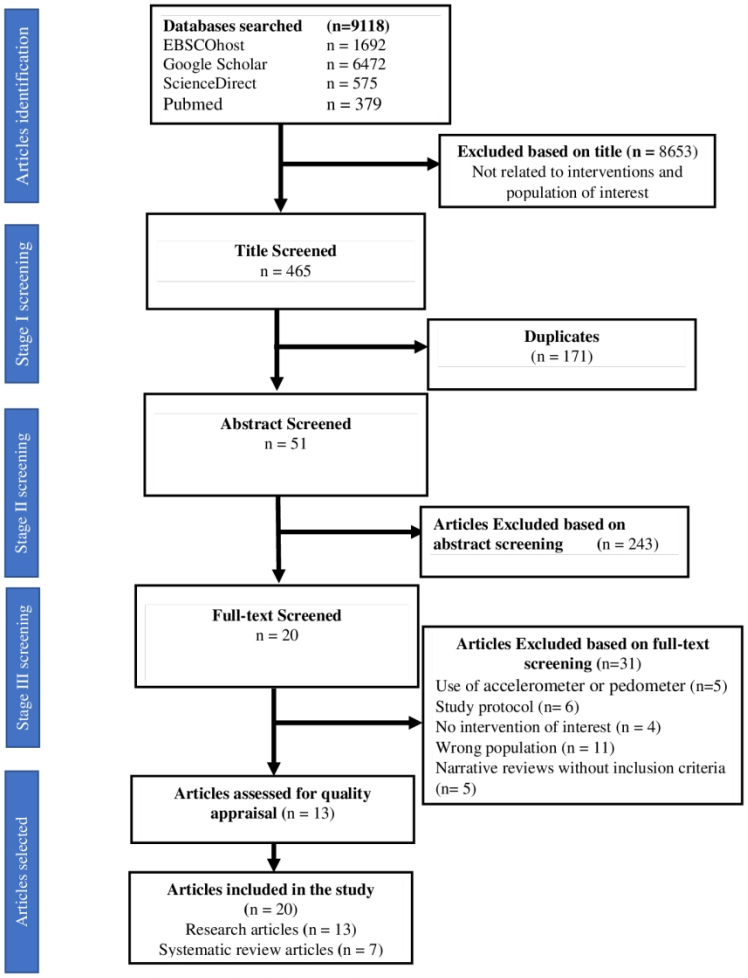

Figure I: flow diagram of the included articles

Figure I: flow diagram of the included articles

143x186mm (300 x 300 DPI)

Supplementary file: Search strategy to identify articles that use ICTs to promote healthy lifestyle behaviour

Search engine	Keywords searched	No of publications retrieved
PsycArticle (EBSCO), PsycINFO (EBSCO), Academic Search Complete (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source – Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), and Medline (EBSCO)	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet AND Adults OR workers OR employees	1,692
Google Scholar	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR internet AND Adults	4301
Google Scholar	Health- promoting lifestyle behaviour OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health OR internet	1054
Google Scholar	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR e-health OR m-health OR text messages OR SMS OR internet	1117
Science direct,	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet AND adult	575
PubMed	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet AND adult	379

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 3-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 9

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Page 9
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 8 and Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 10 and Supplementary file 1
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Page 10-11
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Supplementary file 1 and 2
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 9-12
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Page 12-14
Limitations	20	Discuss the limitations of the scoping review process.	Page 14-15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 15
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 16

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. ;169:467–473. doi: 10.7326/M18-0850

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The use of information and communication technologies to promote healthy lifestyle behaviour: A systematic scoping review

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Abstract

Introduction: Health-promoting lifestyle behaviours are part of the activities of daily living that influence individual happiness, values, and well-being. They play a crucial role in prevention and control of noncommunicable diseases (NCDs) among all age groups. Current statistics on mortality, disability, and morbidity associated with NCDs are alarming globally. Use of information and communication technology (ICT) for a health-promoting lifestyle behaviour programme enhances health behaviours that are important in the prevention and control of both communicable and noncommunicable diseases. Our study aims to map evidence on use of ICT in comprehensive health-promoting lifestyle behaviour among healthy adults.

Methods: Eleven electronic databases were searched for the study. We included studies published in English between January 2007 and December 2017 reporting on healthy adults, ICT and any subscales of the health-promoting lifestyle profile (HPLP). Studies focusing on diseases or disease management, and studies that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT or computer games were excluded. Data were summarised numerically and thematically.

Results: All the studies reviewed were conducted in developed countries. Most of the studies reported on physical activity, and findings of one study covered all the subscales of HPLP. Use of ICT for health-promoting lifestyle behaviours was reported to be effective in ensuring health behaviours that can improve physical and mental health.

Conclusion: Our findings showed that there is a dearth of knowledge on comprehensive health-promoting lifestyle behaviour that can be beneficial for the control and prevention of NCDs. There is need to carry out primary studies on use of ICT and comprehensive health-promoting lifestyle, especially among adults in low- and middle-income countries where there are alarming statistics for mortality and disability associated with NCDs.

Systematic review registration: This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568.

Strengths and limitations of this study

- A comprehensive and extensive literature search on the use of information and communication technology (ICT) in comprehensive health-promoting lifestyle behaviour among healthy adults was done to identify research gap.
- Rigorous process was followed in searching and selecting the included articles for the study.
- Inclusion of primary research articles in the study was subjected only to Mixed Method Appraisal Tool (MMAT) version 2011.
- Only studies published in English between January 2007 and December 2017 were included in the study.
- The reference lists of the included articles were not examined, and no manual searches were performed. Lastly, only electronic databases were extensively searched for the included studies.

Keywords: health-promoting lifestyle behaviour, nutrition, physical activity, health responsibility, stress management, interpersonal relationship, self-actualisation, information and communication technology, healthy adults, systematic scoping review

Introduction

Increase in the prevalence of noncommunicable diseases (NCDs) such as chronic cardiovascular diseases, stroke, cancers, chronic respiratory diseases and diabetes mellitus calls for more proactive ways to manage, control and prevent them. Seventy per cent of global mortality has been attributed to NCDs [1 2]. Eighty per cent of deaths associated with NCDs occur in low- and middle-income countries (LMICs) in the 30 to 60 years age group [2-5]. In 2013, a report showed that (Int$) 53.8 billion was spent on NCDs globally [6]. NCDs have been shown to be a major barrier to development and achievement of the millennium development goals [6]. Many NCDs have a strong association with unhealthy lifestyle [2 7 8]. Risk factors for NCDs are tobacco use, food high in saturated and trans-fat, high consumption of sugar and salt, excessive alcohol intake, physical inactivity, poor diet, overweight and obesity, inadequate sleep and rest, stress, and exposure to environmental hazards [9-12].

Health-promoting lifestyle behaviour has been identified as having an essential role in prevention and control of NCDs [13-16]. Health promotion is an umbrella term describing a composite of disease prevention and health promotion [3]. Information and communication technology (ICT) has been shown to be beneficial as it has made it possible to access health-related information easily [17]. Use of ICT in health promotion and health management is increasingly well recognised because of its cost-effectiveness in the prevention of diseases [18]. Evidence exists that ICT is used in health surveillance for both communicable and noncommunicable diseases. ICT paired with monitoring tools can improve physical activity and weight loss [19]. Few individuals adhere to healthy lifestyle behaviour despite the role it plays in chronic disease prevention, and literature has shown that web-based interventions are effective in changing behaviour [20]. ICT refers to technology that provides access to information and communication [21] through a wide range of communication tools. In this study, ICT includes internet, cell phones, computers, and websites.

Use of ICT in management and prevention of diseases is on the increase. ICT applications are used in psychotherapeutic intervention [22 23], management and control of medical conditions such as hypertension [24 25], HIV and other sexually transmitted diseases [26], diabetes management, smoking cessation, asthma management, weight loss and physical activity [20 27 28]. ICT applications have also been used for recruitment of particular research groups. One good example was a study conducted by Bauermeister and his team, where they used a Web version of respondent-driven sampling (webRDS) to recruit a sample of young adults (ages 18–24) and examined whether this strategy would result in alcohol and other drug prevalence estimates comparable to national estimates [29]. On health-promoting lifestyle and ICT, several studies have been done, mainly on physical activity, smoking cessation, alcohol intervention and diet for weight control. However, there are other health-promoting lifestyle behaviours such as stress management, interpersonal relationship, health responsibility and self-actualisation that are equally important to disease prevention and health promotion, along with physical activity and nutrition [11].

We are not aware of any review that has reported on use of ICT and the six domains of comprehensive health-promoting lifestyle behaviour (nutrition, physical activity, stress management, interpersonal relationships, self-actualisation/spiritual growth and health responsibility) among healthy individuals. Comprehensive health-promoting lifestyle behaviours are described for the purpose of this study as day-to-day lifestyle practices that can prevent

diseases and promote health. The six health-promoting lifestyle behaviours are the subscales of the health-promoting lifestyle profile instrument [30]. Joseph-Shehu et al. [31] describe the HPLP subscales as follows: (i) nutrition signifies an individual's eating habits and food choices; (ii) physical activity signifies actions engaged in by an individual that make him/her active and not sedentary; (iii) health responsibility signifies knowing how to act in ways that improve one's own health; (iv) stress management signifies the ability to identify factors that affect one's stress level and being able to manage such factors; (v) self-actualisation is the ability to achieve one's life goals by adopting a positive approach and drawing upon one's talents and creativity; (vi) spiritual growth is not specific to any particular religion; rather, it signifies ability to harness inner resources to connect with oneself and with others and having purpose in life that leads one to excel and develop in attaining life goals and possible fulfilment; (vii) interpersonal relations signifies achieving meaningful and sustainable relationships with people through any form of communication [31].

Each of these health-promoting lifestyle behaviours is important in the prevention and control of both communicable and noncommunicable diseases, as they are part of the activities of daily living that influence individual happiness, values, and well-being [32]. Reports show that there was a lower risk of developing diabetes mellitus, stroke, myocardial infarction and cancers among 23,153 Germans between 35 and 65 years of age that were followed for an average period of 7.8 years on adherence to no smoking, exercise, healthy diet and BMI less than 30kg/m^2 compared to participants that did not engage in these healthy lifestyle practices [20]. There is a possibility that if lifestyle practices such as stress management, interpersonal relationships, health responsibility and self-actualisation were added to the lifestyle this could have led to lower risk for developing other NCDs such as peptic ulcer, mental illnesses, etc. Hence, this study aims to map evidence on use of ICT in health-promoting lifestyle behaviour among healthy individuals to comprehensively assess the current state of knowledge on health-promoting lifestyle behaviour and ICT. The results of this study will help to identify an area that requires meta-analysis and future primary research. This systematic scoping review accordingly seeks to address the following research questions:

- Does use of ICT improve and enhance health-promoting lifestyle behaviour?

- Is there any evidence that use of ICT in health-promoting lifestyle activity resulted in good health status (healthy weight, normal blood pressure, normal blood sugar and good mental and physical health)?

Methods/Designs

This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568. The review adopted the five stages Arksey and O'Malley framework (identifying the research question, identifying relevant studies, study selection, charting the data, and collating, summarising and reporting the results) for conducting scoping reviews [33]. The study protocol was published in BMJ Open [3]. This review report was guided by PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews)[34].

Search strategy

An extensive search of eligible studies was conducted on the following 11 databases: Academic Search Complete (EBSCO), PsycArticle (EBSCO), PubMed, Medline (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source: Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), PsycINFO (EBSCO), Science Direct, and Google Scholar. We searched for articles published in the English language between January 2007 and December 2017. This time frame was selected to assess work that has been done on using ICT in comprehensive health-promoting lifestyle behaviour among healthy adults over one decade. The search strategy was focused mainly on the study interventions and the population of interest (Table 1). Boolean operators (AND and OR) separated keywords in the search as follows: health-promoting lifestyle profile OR health-promoting lifestyle behaviour OR wellness OR nutrition OR diet OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualisation OR spiritual growth AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR the internet AND adult OR workers OR employees. Summary of the search strategy is found in the supplementary file.

Eligibility criteria

Inclusion criteria

- studies reporting on healthy workers, professionals and adults
- studies published in the English language
- studies published between January 2007 and December 2017
- studies reporting on interventions such as one or more subscale(s) of the health-promoting lifestyle profile (stress management, interpersonal relationships, nutrition, self-actualisation/spiritual growth, health responsibility and physical activity) and ICT (text messages, SMS, computers, mobile phone, websites and internet)
- all study designs, including cross-sectional studies, quantitative studies, randomised control trial studies, quasi-experimental study designs, cohort studies, qualitative studies, and systematic reviews

Exclusion criteria

- studies which do not report on any form of ICT
- studies on patients, youth, students, diseases/management or children
- studies that do not report on all or any of the subscales of the health-promoting lifestyle profile
- studies that do not report on outcome of interest (Table 1)
- studies that use any form of ICT in recruitment or as a means of collecting data only
- literature published before January 2007 and after December 2017
- studies which do not report on adults
- studies that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT and computer games
- studies reporting on alcoholism, obesity or cigarette smoking
- non-English publications
- study protocols, non-systematic review, book chapters, dissertation and letter to the editors

Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Study selection

The selection process for the included articles involved rigorous exercises in three stages of screening – title, abstract and full-text screening – before data extraction. One reviewer conducted the title screening of the included articles and abstract and full-text screening was undertaken independently by two reviewers. Any disagreement at any level of the screening was discussed until both reviewers reached consensus. Title of an article that was not cleared was included for abstract screening, and if abstract of an article was not cleared same was added for the full-text screening. The reviewers developed the screening form before commencement of the screening exercise. The screening forms were developed based on population, interventions, and outcomes [3]. Systematic reviews were included if they met the inclusion criteria. Two independent reviewers screened the included articles full-text, based on the inclusion and exclusion criteria described above, and consensus between the reviewers resolved any disagreement. The degree of agreement between reviewers at the full-text screening stage was estimated using kappa statistic with STATA 13.

Figure I: Flow diagram of the included article

Data extraction

Data extraction criteria were determined, and a self-designed data extraction form was designed by the reviewers before data extraction to aid the process. The primary outcome measured was health-promoting lifestyle behaviours and health status (Table 1). There was no restriction on how to measure the outcome such as whether physiological or self-report. However, use of accelerometer, pedometer or computer games was not included in this study. In order to provide answers to the study questions, data extracted from each of the studies included were as follows: bibliography of the study (author's name and date), location of the study, objective or aim of the study (as reported by authors), study design, study population, study setting, sample size, type of ICT (Table 1), type of health-promoting lifestyle behaviour (Table 1), duration of the study, outcome of the study, results or findings from the study and conclusions of the study.

Quality appraisal of the included studies

Mixed Method Appraisal Tool (MMAT) version 2011 [35] was used to assess the quality of included research articles. MMAT was designed to evaluate articles on primary research using the following study designs: qualitative; quantitative and mixed method. The MMAT enabled us to assess the methodological quality of the included studies. Scores for each study varied between 25% and 100%. For mixed method studies, there were 11 criteria to be met for an article to be rated as high; four criteria each for quantitative (QUANT) section and qualitative (QUAL) section and three for mixed method (MM) section). Mixed method studies were rated as 25% when QUAL=1 and QUAN=1 and MM=0; as 50% when QUAL=2 and QUAN=2 and MM=1; as 75% when QUAL=3 and QUAN=3 and MM=2; and as 100% when QUAL=4 and QUAN=4 and MM=3. A criterion score between 25% and 49% was rated as low quality, a score of 50% to 74% as average quality and a score of 75% to 100% as high quality.

Collating and summarising the findings

Extracted data were summarised numerically and thematically using the following two themes: ICT used in health-promoting lifestyle behaviour, and health-promoting lifestyle behaviour outcomes. The authors collectively assessed themes and conducted a critical appraisal of each theme in relation to the research questions. We also examined the meaning of the findings in relation to the aim of the study and their implications for research, practice, and policy.

Patient and public involvement

Patients and public were not involved in the study as it is a systematic scoping review

Results

The literature encompassed a broad scope of studies exploring use of ICT in health-promoting lifestyle behaviour among healthy individuals. Eleven electronic databases searched (Figure 1) yielded 9429 potential articles. After screening and duplicates were removed, 22 articles met the study inclusion criteria. The kappa statistics for the degree of agreement showed 74.5% agreement versus 49.8% expected by chance, which constitutes moderate to substantial agreement (Kappa

statistic = 0.49, p-value<0.001). McNemar's chi-square statistic suggests that there is not a statistically significant difference in the proportions of yes/no answers by reviewers. The study includes 13 research articles and 9 systematic reviews identified as meeting the inclusion criteria and focused on the specified health-promoting lifestyle behaviours and ICT among healthy adults.

Characteristics of included studies in this scoping review

The characteristics of the included studies are presented in Table 2. Two of the included studies adopted mixed methods designs [36 37]; one study in each case adopted qualitative design [38], quantitative non-randomised design [39], prospective longitudinal cluster-randomised controlled trial [40], retrospective randomised trial design [41] and intervention study [42]. Six studies [18 20 43-46] adopted randomised control trial design. The duration of the intervention studies ranged from 4 weeks to 10 months. One of the main study aims was to determine the effect of proactive dissemination strategy on the reach of the internet-delivered computer-tailored intervention [42]; study duration commenced with the invitation to participate in the study. Sample sizes of included research articles ranged from 26 to 16,948; sample sizes of included evidence review articles ranged from 11 to 457. Twelve studies focused on males and females [20 36 37 39-42 44-47], one reported on females alone [18], one reported on all study population [48], one reported on employees [49] and seven studies (systematic review) did not report study population [17 27 50-54]. Six of the studies reviewed were conducted in the community [39 41 44-47]. Seven were conducted at the workplace: one each among the military [40], nurses [18], university employees [36], municipality employees [46]; two in more than one organisation [20 38]; and two did not describe the workers [37 49].

Five of the nine systematically reviewed studies [27 49 50 53 54] did not report the study country of included articles; one reported 457 articles from 36 countries in Asia, Australia and Oceania, Europe, North America, and South America [48]; one reviewed 34 articles from five countries (Europe, Asia, South Korea, USA, New Zealand) [51]; one reviewed 12 articles from three countries (USA, UK and Australia)[17]; and one reviewed 38 articles from the USA alone [52]. In regard to primary research included in this study, three studies were conducted in Australia [39 41 45], three in the United Kingdom [36-38], three in the United States [40 43 44], two in the Netherlands [42 46], one in

Israel [20] and one in Taiwan [18]. Not all of the included studies reported on geographical setting of the research and none of the studies was conducted in a low- or middle-income country.

Risk-of-bias assessment

In regard to quality assessment of the included studies, the scores of the 13 articles reviewed for methodological quality ranged from 50% to 100%. Nine of the reviewed articles were rated as high quality, of which three scored 100% [40 44 45] and six scored 75% [18 20 38 41 42 47]. Only four were rated average quality, with two scoring 50% [39 46] and two scoring 67% [36 37]. The overall quality assessment was appraised to be average risk of bias due to the following: no clear description of concealment, withdrawal rate higher than 20% and no consideration given to how findings related to researcher influence.

ICT use in health-promoting lifestyle behaviours

A theme emerging from the study was ICT use in health-promoting lifestyle behaviours, and health-promoting lifestyle behaviours targeted by the included studies (Table 3). Various forms of ICT (email, social network sites, websites, Short Messaging Service (SMS) or text messages, mobile phone app, smartphones, computers, and Multimedia Messaging Service (MMS)) were used in the included studies for health-promoting lifestyle behaviours intervention that targeted one form or another of health-promoting behaviours. In all the included articles the Internet was obviously used via either phones or computers. However, some authors specifically mentioned use of internet in their reports [42 46 47 51 54], and a few authors explicitly mentioned computer use [42 46 52]. All the reviewed studies except one [49] reported on physical activity, 11 reported on nutrition [18 20 37 40 42 46 48 50 52-54], one reported on social connection [37], one reported on stress management [49] and one reported on all the subscales of health-promoting lifestyle profile [18].

Use of email and website [39], email, website and SMS [38], smartphone and website [45 49] and website only [47 49 54], was reported only for physical activities behaviour. Two of the reviewed studies reported on smartphone apps, one in the form of an in-built accelerator [44] and one on smartphone with website [41] for physical activity behaviour. Fanning et al. reported on use of mobile device, mobile software, and SMS for physical activity [27]. Websites, smartphone and tablet apps were reported to be used for cognitive behavioural therapy (CBT), stress management, and mindfulness-based approaches [49]. Three of the included studies reported on use of more than one form of ICT

for more than one health behaviour [40 48 51]. Computer-based information and communication technologies [52] and internet-delivered computer-tailored lifestyle programme [42 46 53] were reported to be used for more than one health behaviour, including physical activity, nutrition, alcohol use, smoking behaviour, and condom use. Use of website only was reported for nutrition, physical activity, stress management, interpersonal relationship, spiritual growth, and health responsibility [18], and diet, physical activity, and social connection [37]. Social network sites were reported for fitness, sexual health, food safety, smoking and health promotion [17], and for diet, physical activity, alcohol and tobacco use, mental health intervention, disease management, and sexual health [54]. Mackenzie et al. reported use of email, software reminder, and Twitter to reduce workplace sitting only [36], while a Web-based app was used for nutrition and physical activity only [20]. A comprehensive health-promoting lifestyle behaviour was reported among female nurses only [18].

Use of ICT for health-promoting lifestyle behaviours and health status

Use of any form of ICT increased participants' physical activity behaviour [27 36 39-41 44 45 47], and health behaviour change [17 20 51 52] (Table 3). Use of ICT in health-promoting behaviour was reported to reduce weight [20 54], but Frank et al. reported no significant difference in participants BMI and waist circumference [40]. People that are likely to participate in an internet-delivered computer-tailored intervention are older individuals with higher educational level, relative healthier lifestyle and healthy BMI [42]. For efficient use of internet-delivered computer-tailored lifestyle programme a preview of new website content should be included in a standard prompt in addition to short prompt timing [46]. Factors to be considered when planning intervention for ICT to be used for health-promoting lifestyle behaviours in the workplace are encouragements in the form of motivation from managers, time management, involvement of stakeholders in the designing of the intervention, and reminders [38]. Use of ICT has been documented to be effective in promoting health behaviours [49 52 54]. Comprehensive health-promoting lifestyle behaviours and ICT reduce BMI, and improve physical and mental component summary [18]. There is a need to examine the long-term effectiveness of ICT on health-promoting behaviours [53]. To ascertain the effectiveness of ICT and comprehensive health-promoting behaviours in the prevention of diseases, there is a need to consider other health assessment parameters such as blood pressure and biochemical parameter instead of BMI alone [18]

Discussion

We conducted a systematic scoping review of the available studies on use of ICT for stress management, interpersonal relations, nutrition, self-actualisation/spiritual growth, health responsibility and physical activity lifestyle behaviours globally. Health-promoting lifestyle behaviours play an essential role in the prevention of diseases and quality of life [12 15]. According to the WHO, to control NCDs it is important to reduce risk factors associated with them by adopting health-promoting lifestyle behaviours [2]. Our systematic scoping review showed that various forms of ICT such as email, social network sites, websites, SMS or text messages, mobile phone app, smartphones, computers and MMS were used for a range of health-promoting lifestyle behaviours such as nutrition, physical activity, stress management, smoking cessation and reducing alcohol consumption. There was a paucity of data on interpersonal relationship, self-actualisation/spiritual belief and health responsibility. However, health-related lifestyle behaviours such as stress management, condom use, breast cancer prevention and sexually transmitted diseases prevention that could have incorporated health responsibility lifestyle behaviour were not a primary research study.

Furthermore, our study reported that use of ICT for health promotion improves and enhances health-promoting behaviours. More particularly, use of ICT for comprehensive health-promoting lifestyle behaviours was reported to result in a healthy BMI and to improve physical and mental health. However, BMI was the only physical health assessment parameter reported by the included studies. Factors such as time management, motivation and reminders are essential when designing health-promoting lifestyle behaviour for workers. There was only one primary study on use of ICT and comprehensive health-promoting lifestyle behaviour among females. Also, the quality assessment of the primary studies included was of moderate risk. It is of interest to know that no reports on LMICs were found in the included studies. Regarding population size, our systematic review reported wide population spreads from 26 to 16,948 across the study locations reported. This review showed that there is a dearth of knowledge on use of ICT for comprehensive health-promoting lifestyle and health status.

ICT enhances the success of national health promotion and disease prevention programmes [55]. Our study reported large population sizes, which demonstrates that public health promotion campaigns can be achieved through use of ICT [56] since large populations can be involved in health promotion

intervention programmes, which will potentially enhance achievement of the sustainable development goal of reducing premature deaths associated with NCDs to one-third by 2030 [2]. However, to reduce attrition rate in ICT use for health-promoting lifestyle behaviour intervention, one of our included studies reported that reminders are critical [38]. Much attention has been given to physical activity, nutritional lifestyle behaviours and healthy weight, and this might be the possible reason why these two lifestyle behaviours were more pronounced in our findings. This might also be the reason why only BMI was assessed among all the physical health parameters that could be of importance to control and prevention of NCDs [2]. These findings have implications for the control and prevention of NCDs in the near future.

One of the strengths of this study is the extensive literature searched and the rigorous process in selecting the included studies. Scoping review as conducted for this study is an approach that examines the extent, range and nature of research activity in a particular field to identify research gap [33 57]. This is the first article that has examined ICT and comprehensive health-promoting lifestyle behaviours among healthy adults, as the authors are not aware of any such others. We also conducted a methodological quality appraisal of the included primary research. Results in our study did not omit any country, as 'country filter' was not applied during the literature search. All the included articles reported on physical activity except one that reported only on stress management. Also, some articles reported on stress management, spiritual growth health responsibility, and interpersonal relationships. Most of the included studies that reported on health-related lifestyle behaviours such as stress management and other lifestyle behaviours that are related to health responsibility such as smoking cessation, reduced alcohol consumption, condom use, breast cancer prevention and sexually transmitted diseases prevention were systematically reviewed studies. However, none of the included studies reported on blood pressure or blood glucose level. Screening and early detection of NCDs are one way to prevent and control this demon called NCDs [2]. In the next 30 years there will be a 3.5-fold increase globally in deaths due to cardiovascular diseases [58], which are the leading cause of mortality and morbidity among all the NCDs [1-3]. Highest premature deaths associated with NCDs are recorded in the LMICs [1 2 59]. However, our scoping review showed scarcity in use of ICT for comprehensive health-promoting lifestyle behaviours research among healthy adults from these regions.

Some limitations of this study were as follows: firstly, inclusion of studies published in the English language between January 2007 and December 2017; secondly, the reference lists of the included articles were not examined, and no manual searches were performed; lastly, only electronic databases were extensively searched for the included studies.

Health-promoting lifestyle behaviour remains a crucial means of curbing the menace associated with NCDs [3 14-16]. However, some people prefer to be busy with other issues of life rather than engaging in health-promoting lifestyle behaviour [14 38]. Hence, only a few individuals adhere to healthy lifestyle behaviour despite the role it plays in chronic diseases prevention [14 36]. There is need to explore other means of encouraging people to practice health-promoting lifestyle behaviours because it is a fact that prevention is better than cure. Literature showed that web-based interventions are effective in changing behaviour [20]. With the increase in the burden of NCDs in LMICs [59], use of ICT to promote health behaviour lifestyle is the key determinant in the control and prevention of NCDs [56]. There is an urgent need to assess the nature and form of ICT that can be effective in promoting health behaviours among healthy adults in LMICs, and in Africa in particular. In addition, there is need to explore use of ICT and comprehensive health-promoting lifestyle behaviours among healthy adults in LMICs where there is a gap in the primary study of these issues.

Conclusion

The findings from our study showed that ICT in relation to health-promoting lifestyle behaviour enhances health-promoting lifestyle behaviour and promotes physical and mental health. Physical activity was assessed by all the included studies except for one that examined stress management. BMI was the only physical health parameter reported by one of the included studies. Factors such as time management, motivation and reminders are important when designing health-promoting lifestyle behaviour for the worker. None of the included studies reported on LMICs. There is a dearth of knowledge on a comprehensive health-promoting behaviour that can be beneficial in the control and prevention of NCDs. There is need to carry out primary studies on use of ICT for a comprehensive health-promoting lifestyle, especially among 'healthy' adults in LMICs where there are alarming statistics on the mortality and disability associated with NCDs.

List of abbreviations

- BMI body mass index
- HPLP health-promoting lifestyle profile
- ICT information and communication technology
- LMICs low and middle-income countries
- MMS multimedia messaging service
- NCDs noncommunicable diseases
- SMS short message service
- WHO World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Data sharing statement

The data for the study is available either in the manuscript or as a supplementary file accompanying this manuscript. However, further request of any data should be directed to the corresponding author, who will gladly share it.

Competing interest

The authors declare that they have no competing interests.

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Author contribution

Dr Elizabeth M Joseph-Shehu conceptualised, designed the protocol and prepared the draft of the manuscript under the supervision of Professor BP Ncama. Ms. Nomaxabiso Mooi and Dr Tivani Mashamba-Thompson contributed to the methodology and data collection. All authors critically reviewed the draft version of the manuscript and gave approval for submission

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Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Criteria	**Determinants**
Population	Healthy adults, workers and well individuals
Interventions	Health-promoting lifestyle profile (nutrition, physical activity, interpersonal relationship, health responsibility, stress management, self-actualisation or spiritual growth) and information and communication technologies (ICT, mobile phone, text messages, SMS, internet, computers, websites)
Comparison	Health-promoting lifestyle profile intervention without ICT
Outcomes	Effective and sustaining health-promoting lifestyle practices (nutrition, physical activity, interpersonal relationship, health responsibility, stress management, self-actualisation or spiritual growth) and health status (normal weight, normal blood pressure, normal blood sugar and good mental and physical health)
Study setting	Focus on low- and middle-income countries

Adopted from the study protocol [3]

Table Error! No text of specified style in document. Characteristics of included studies

Author and date	Country	Income level of country	Aim of the study	Study design	Study population	Study setting	Sample size	Duration of study
Research articles								
Ammann et al. (2012)	Australia	High	To evaluate a website- delivered computer-tailored physical activity intervention, with a specific focus on differences in tailored advice acceptability, website usability, and physical activity change between three age groups.	Quantitative non-randomised design	Male and Female;	Community	863	1 Month
Bardus et al. (2014)	United Kingdom	High	To investigate the reason for participating and not participating in an eHealth workplace physical activity intervention.	Qualitative study	Male and female	Workplace	62	Not specified
Carr et al. (2013)	United States	High	The goals of these focus groups were to identify internet features rated as "useful for improving PA".	Randomised controlled trial (RCT) design	Male and female;	Community	53	6 months
Frank et al. (2016)	United States		To determine if a telehealth coaching initiative is superior to a one-time nutrition and fitness education class regarding: (a) dietary contributions to bone health and (b) exercise contributions to bone health, assessed before and after deployment.	Prospective, longitudinal, cluster-randomised, controlled trial	Male and female	Workplace	158	9 months
Guertler et al. (2015)	Australia	High	The aims of this study were to (1) examine the engagement with the freely available physical activity promotion program 10,000 Steps, (2) examine how use of a smartphone app may be helpful in increasing engagement with the intervention and in decreasing non-usage attrition, and (3) identify sociodemographic and engagement-related determinants of nonusage attrition.	Retrospective randomised trial	Male and female	Community	16,948	9 months

King et al. (2016)	United States	High	This study provided an initial 8-week evaluation of three different customised physical activity-sedentary behaviour apps drawn from conceptually distinct motivational frames in comparison with a commercially available control app.	Controlled experimental design	Men and women	Community	95	8 weeks
Kirwan et al. (2012)	Australia	High	To measure the potential of a newly developed smartphone application to improve health behaviours in existing members of a website-delivered physical activity program (10,000 Steps, Australia).	2-arm matched case–control trial	Men and women	Community	200	3 months
Lara et al. (2016)	UK	High	We report a pilot randomised controlled trial (RCT) of a web-based platform (Living, Eating, Activity and Planning through retirement; LEAP) promoting healthy eating (based on a Mediterranean diet (MD), physical activity (PA) and meaningful social roles.	Mixed method design	Men and women	Workplace	70	8 weeks
Mackenzie et al. (2015)	UK	High	To explore the acceptability and feasibility of a low-cost, co-produced, multi-modal intervention to reduce workplace sitting.	Mixed method design	Men and women	Workplace	26	Over 4 weeks
Naimark et al. (2015)	Israel	High	Our aim was to compare people receiving a new Web-based app with people who got an introductory lecture alone on healthy lifestyle, weight change, nutritional knowledge, and physical activity, and to identify predictors of success for maintaining a health.	RCT	Male and female	Workplace	85	14 weeks
Schneider et al. (2013)	Netherlands	High	This study investigated the influence of content and timing of a single email prompt on re-use of an internet-delivered computer-tailored (CT) lifestyle program.	RCT	Male and female	Workplace	200	6 weeks

Schneider et al. (2013)	Netherlands	High	This study aimed to determine the effect of proactive dissemination strategy on reach of the internet-delivered computer-tailored intervention.	Intervention study	Male and female	Community	5168	10 months
Tsai et al. (2015)	Taiwan	High	This study aimed to evaluate health-promoting effects of an eHealth intervention among nurses compared with conventional handbook learning.	Randomised control	Female Nurses	Workplace	105	12 weeks
Review evidence articles								
Bardus et al. (2015)	36 countries in Asian, Australia & Oceania; Europe, North and South America	High	To provide an up-to-date, comprehensive map of the literature discussing use of mobile phone and Web 2.0 apps for influencing behaviours related to weight management (i.e., diet, physical activity [PA], weight control, etc.)	Review	All population group	Not specified	457 articles	NA
Bert et al. (2014)	Not specified	High	to describe use of smartphones by health professionals and patients in the field of health promotion.	Review	Not specified	Not specified	21 articles	NA
Buhi et al. (2013)	Europe, Asia South Korea, USA, New Zealand	High	To perform a systematic review of the literature concerning behavioural mobile health (mHealth) and summarise points related to heath topic, use of theory, audience, purpose, design, intervention components, and principal results that can inform future health education applications.	Review	Not specified	Not specified	34 articles	NA
Fanning et al. (2012)	Not specified	Not specified	The aims of this review were to: (1) examine the efficacy of mobile devices in the physical activity setting, (2) explore and discuss implementation of device features across studies, and (3) make recommendations for future intervention development.	Review	Not specified	Not specified	11articles	NA

Hou et al. (2014)	USA	High	This review examines internet interventions aiming to change health behaviours in the general population.	Review	Not specified	Not specified	38 articles	NA
Kohl et al. (2013)	Not specified	Not specified	The aim of this paper is to (1) review the current literature on online prevention aimed at lifestyle behaviours, and (2) identify research gaps regarding reach, effectiveness, and use.	Review	Not specified	Not specified	41 articles	NA
Laranjo et al. (2014)	UK, USA, Australia	High	Our aim was to evaluate use and effectiveness of interventions using social networking sites (SNSs) to change health behaviours.	Review	Not specified	Not specified	12 articles	NA
Rogers et al. (2017)	Not specified	Not specified	The aims of this study were to (1) discover the range of health-related topics that were addressed through internet-delivered interventions, (2) generate a list of current websites used in the trials which demonstrated a health benefit and (3) identify gaps in the research that may have indered dissemination.	Review	Not specified	Not specified	71 articles	NA
Stratton et al. (2017)	Not specified	Not specified	The aim of this paper is to conduct the first comprehensive systematic review and meta-analysis evaluating the evidence for the effectiveness and examine the relative efficacy of different types of eHealth interventions for employees.	Review	Employee	Workplace	23 articles	NA

Table 3 Health-promoting lifestyle behaviours and ICT

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Ammann et al. (2012)	Email, website	Physical activity	Physical activity and BMI	No significant differences between the age groups were found with regard to BMI and physical activity level at baseline. All age groups increased their weekly total physical activity minutes and the number of total physical activity sessions significantly over time from baseline to 1-month follow-up. Old-age group increased physical activity more than the other two age groups.	The study suggests that website-delivered physical activity interventions can be suitable and effective for older aged adults.
Bardus et al. (2014)	Website, email and text messaging (SMS)	Physical activity (PA)	Physical activity	Reasons for participation included a need to be more active, increase motivation to engage in PA, and better weight management. Employees were attracted by the perceived ease of use of the programme and by the promise of receiving reminders. Many felt encouraged to enrol by managers or peers. Reported reasons for non-participation are lack of time, loss of interest toward the programme, or a lack of reminders to complete enrolment.	In developing workplace physical activity interventions, it is important to identify salient motivators and barriers to participation through formative research with the target population. Programme enrolment procedures should be simple and not time consuming, so that burden on participants is reduced and early attrition is minimised. It is also important that employers find ways to actively promote workplace health promotion programmes (WHPPs) to their staff while also maintaining confidentiality and individual rights on employees, so that larger segments of the workforce can be reached.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Bardus et al. (2015)	Mobile phone and Web 2.0 technologies	PA, Diet and weight loss management	Diet and Physical activity	This review categorised the identified articles into two overarching themes, which described use of technologies for either (1) promoting behaviour change (309/457, 67.6%) or (2) measuring behaviour (103/457, 22.5%). The remaining articles were overviews of apps and social media content (33/457, 7.2%) or covered a combination of these three themes (12/457, 2.6%).	Limited evidence exists on use of social media for behaviour change, but a segment of studies deals with content analyses of social media. Future research should analyse mobile phone and Web 2.0 technologies together by combining the evaluation of content and design aspects with usability, feasibility, and efficacy/effectiveness for behaviour change, in order to understand which technological components and features are likely to result in effective interventions.
Bert et al. (2014)	smart phones	Nutrition lifestyles, physical activity, health in elderly, prevention of sexually transmitted diseases	Nutrition and physical activity	Out of 21 articles identified as specifically centred on health promotion, the nutrition field have applications that allow to count calories and keep a food diary or more specific platforms for people with food allergies. While in the physical activity many applications suggest exercises with measurement of sports statistics and some applications deal with lifestyles suggestions and tips..	The promotion of healthy lifestyles, adequate nutrition and physical activity are all possible and desirable through use of smartphones but it is important to underline the crucial role of health care providers in the management of the patient while using these tools. There is also a need to analyse the usefulness, quality and accuracy of smartphones applications in the field of preventive medicine.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Buhi et al. (2013)	SMS, MMS, Internet	Breast cancer prevention, diabetes management, weight loss or obesity prevention, smoking cessation, asthma self-management and physical activity	physical activity and breast cancer prevention	One journal assessed physical activity promotion and breast cancer prevention respectively. Twenty interventions (59%) were evaluated using experimental designs, and most resulted in statistically significant health behavioural changes.	Consideration should be given for the deployment of mHealth applications to combat coronary heart disease, HIV/AIDS, and other high-priority problems contributing to high mortality. A mobile video-based modality, using sight and sound, may show even greater promise in health behaviour change interventions.
Carr et al. (2013)	Internet website	Physical activity	Physical activity	The enhanced internet (EI) arm increased PA in relation to the standard internet (SI) arm at 3 months but between-groups differences were not observed at 6 months. EI participants-maintained PA from 3 to 6 months. This result suggests that a non-face-to-face, user- and theory-guided internet PA program is more efficacious for producing immediate increases in PA among sedentary adults than what is currently available to the public.	The EI program was efficacious at improving PA levels in relation to publicly available Websites initially, but differences in PA levels were not maintained at 6 months. Future research should identify internet features that promote long-term maintenance.
Fanning et al. (2012)	Mobile device, mobile software, SMS	Physical activity	Physical activity	Four studies were of “good” quality and seven of “fair” quality. In total, 1351 individuals participated in 11 unique studies. This study suggests that mobile devices are effective means for influencing physical activity behaviour.	Our focus must be on the best possible use of these tools to measure and understand behaviour. Therefore, theoretically grounded behaviour changes interventions that recognise and act on the potential of smartphone technology could provide investigators with an effective tool for increasing physical activity.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Frank et al. (2016)	Website, email	exercise, nutrition, bone health	Physical activity, nutrition, waist circumference, BMI	There were no significant differences found in the BMI and waist circumference of soldiers in both control and intervention group over the course of study. There were significant increases in body fat, osteocalcin, and sports index for the telehealth group.	A 9-month deployment to Afghanistan increased body fat, bone turnover, and physical activity among soldiers randomised to receive telehealth strategies to build bone with nutrition and exercise. This study indicates that diet and exercise coaching via telehealth methods to deployed soldiers is feasible but limited in its effectiveness for short-term overseas deployments.
Guertler et al. (2015)	Smartphone app and website	Physical activity	Physical activity	Compared to other freely accessible Web-based health behaviour interventions, the 10,000 Steps program showed high engagement.	Use of an app alone or in addition to the website can enhance program engagement and reduce risk of attrition.
Hou et al. (2014)	Computer-based information and communication technology	Tobacco prevention, alcohol prevention, weight loss, Physical activity, nutrition, HIV and chronic diseases	Physical activity and nutrition	There were seven studies focused primarily on increasing PA, and additionally five studies also examined related factors, such as nutrition and binge eating. Two studies were categorised as nutrition only interventions, with one focused on folic acid intake and the other targeted fruit juice and vegetable (FJV) consumptions.	Findings from the current review study indicated that, overall, internet or web-based interventions (WIs) produce favourable results and are effective in producing and increasing targeted health or behavioural outcomes.
King et al. (2016)	Smartphone's built-in accelerometer	Physical activity	Physical activity behaviour	Over the 8-week period, the social app users showed significantly greater overall increases in weekly accelerometery-derived moderate to vigorous physical activity relative to the other three arms. Participants reported that the apps helped remind and motivate them to increase their physical activity levels as well as sit less throughout the day.	The results provide initial support for use of a smartphone-delivered social frame in the early induction of both physical activity and sedentary behaviour changes. The information obtained also sets the stage for further investigation of subgroups that might particularly benefit from different motivationally framed apps in these two key health promotion areas.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Kirwan et al. (2012)	Smartphone, website	Physical activity	Physical activity	Over the study period (90 days), the intervention group logged steps on an average of 62 days, compared with 41 days in the matched group. Use of the application was associated with an increased likelihood to log steps daily during the intervention period compared with those not using the application.	Using a smartphone application as an additional delivery method to a website-delivered physical activity intervention may assist in maintaining participant engagement and behaviour change.
Kohl et al. (2013)	Internet-delivered intervention	Dietary behaviours, physical activity, alcohol use, smoking, and condom use	Dietary behaviours and physical activity	According to health priorities, interventions are largely targeted at weight-related behaviours, such as physical activity and dietary behaviour. Eleven studies targeted weight management and they were on dietary behaviours and physical activity. The main aimed of these studies were weight loss five reviews also included interventions on weight maintenance. Six studies included 3 or more behaviours. The other groups included studies aimed at physical activity, 5 reviews were on smoking and alcohol respectively. Four papers combined alcohol and smoking while three were on dietary behaviours. An additional manual search showed one study on condom use.	More research is needed on effective elements instead of effective interventions, with special attention to long-term effectiveness. The reach and use of interventions need more scientific input to increase the public health impact of internet-delivered Interventions.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Lara et al. (2016)	Web-based platform	Diet, Physical activity, social connection and anthropometric status	Diet, Physical activity, social connection, BMI and waist circumference	'Eating well' and 'being social' were the most visited modules. At interview, participants reported that diet and PA modules were important and acceptable within the context of healthy ageing.	The trial procedures and the LEAP (Living, Eating, Activity and Planning through retirement) intervention proved feasible and acceptable. Overall participants reported that the LEAP domains of 'eating well', were important for their health and well-being in retirement.
Laranjo et al. (2014)	Social network sites	Fitness, sexual health, food safety, smoking and health promotion	Fitness (physical activity)	The study found a statistically significant positive effect of SNS interventions on behaviour change, boosting encouragement for future research in this area.	The study showed a positive effect of SNS interventions on health behaviour-related outcomes, but there was considerable heterogeneity.
Mackenzie et al. (2015)	Email, reminder software, twitter	Reduced workplace sitting	Increased Physical activity	Therefore, "completers" demonstrated a range of levels of physical activity. In addition, "completers" generally demonstrated positive health behaviours with 0 % being smokers, over 50 % eating five fruits or vegetables/day and almost 25 % not drinking alcohol.	Evaluation of this intervention provides useful information to support participatory approaches during intervention development and the potential for more sustainable low-cost interventions.
Naimark et al. (2015)	Web-based app	Nutrition and Physical activity	Nutrition, Physical activity, BMI and waist circumference	The app group increased their weekly duration of physical activity to the healthy range of more than 150 minutes a week, which may afford substantial health benefits, they lost more weight and had increased nutritional knowledge compare to the control group.	We showed a positive impact of a newly developed Web-based app on lifestyle indicators during an intervention of 14 weeks. These results are promising in the app's potential to promote a healthy lifestyle, although larger and longer duration studies are needed to achieve more definitive conclusions.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Rogers et al. (2017)	Website Internet-delivered Intervention	Diet, Physical activity, Alcohol and tobacco use, Mental health intervention, Disease management, Sexual health	Diet and Physical activity	The efficacy of the interventions for diet and physical activity, although significant, was modest (e.g., 2.1 kg mean weight reduction compared with a 0.4 kg increase in controls). People who completed the internet intervention reduced their waist circumference by 2.6 cm, whereas people who did not complete the intervention added 0.3 cm to their waist circumference.	A wide range of evidence-based internet programs are currently available for health-related behaviours, as well as disease prevention and treatment. However, the majority of internet-delivered health interventions found to be efficacious in RCTs do not have websites for general use. Increased efforts to provide mechanisms to host "interventions that work" on the Web and to assist the public in locating these sites are necessary.
Schneider et al. (2013)	Internet-delivered Computer-tailored lifestyle program	Physical activity, Fruit and vegetable consumption, smoking status, alcohol consumption	Physical activity, Fruit and vegetable consumption	Sending prompt 2 weeks after the first visit was more effective compared with using a longer time period, adding a preview of new website content to a standard prompt increased its effectiveness in persuading people to log in to the program and sending a prompt with additional content after a 2-week period significantly increased program log-ins compared to using a reactive approach in which no additional prompts were used.	The key findings suggest that boosting revisits to a CT program benefits most from relatively short prompt timing. Furthermore, a preview of new website content may be added to a standard prompt to further increase its effectiveness in persuading people to log in to the program.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Schneider et al. (2013)	Internet-delivered computer-tailored intervention.	Physical activity, fruit and vegetable intake, alcohol consumption and smoking behaviour	Physical activity, fruit and vegetable intake, BMI, mental health status	Approximately 50% of all participants had a healthy body weight, 35% were overweight, and 10% were obese. In term of physical activity, 21% with a minimum of 150 minutes exercise per week, whereas 46% and 69% were not adhering to the Dutch guidelines of fruit and vegetable intake respectively. More than one-third (36%) complied with three lifestyle guidelines while 1% of the respondents complied with none of these guidelines. Older and respondents with a higher educational degree, as well as respondents with relatively healthier lifestyle and a healthy BMI, were more likely to participate in the intervention.	The study concluded that there is need to put additional effort to ensure that at-risk individuals (low socioeconomic status and unhealthy lifestyle) have increase interest in a lifestyle intervention and they should also be encouraged to employ lifestyle intervention.
Stratton et al. (2017)	Websites, smartphone and tablet apps.	Cognitive behavioural therapy, Stress management, Mindfulness-based approaches,	Stress management	The stress management interventions differed by whether delivered to universal or targeted groups with a moderately large effect size at both post-intervention (g = 0.64, 95% CI 0.54 to 0.85) and follow-up (g = 0.69, 95% CI 0.06 to 1.33) in targeted groups, but no effect in unselected groups.	There is reasonable evidence that eHealth interventions delivered to employees may reduce mental health and stress symptoms post intervention and still have a benefit, although reduced at follow-up.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Tsai et al. (2015)	Website	Health-promoting lifestyle profile (HPLP)	Health-promoting lifestyle profile (HPLP), BMI, physical and mental component summary	The eHealth education intervention had the effect of significantly increasing nurses' post-intervention Health-Promoting Lifestyle Profile total scores, physical component summary (PCS), mental component summary (MCS) and decreases in BMI.	Tailored eHealth education is an effective and accessible intervention for enhancing health-promoting behaviour among nurses.

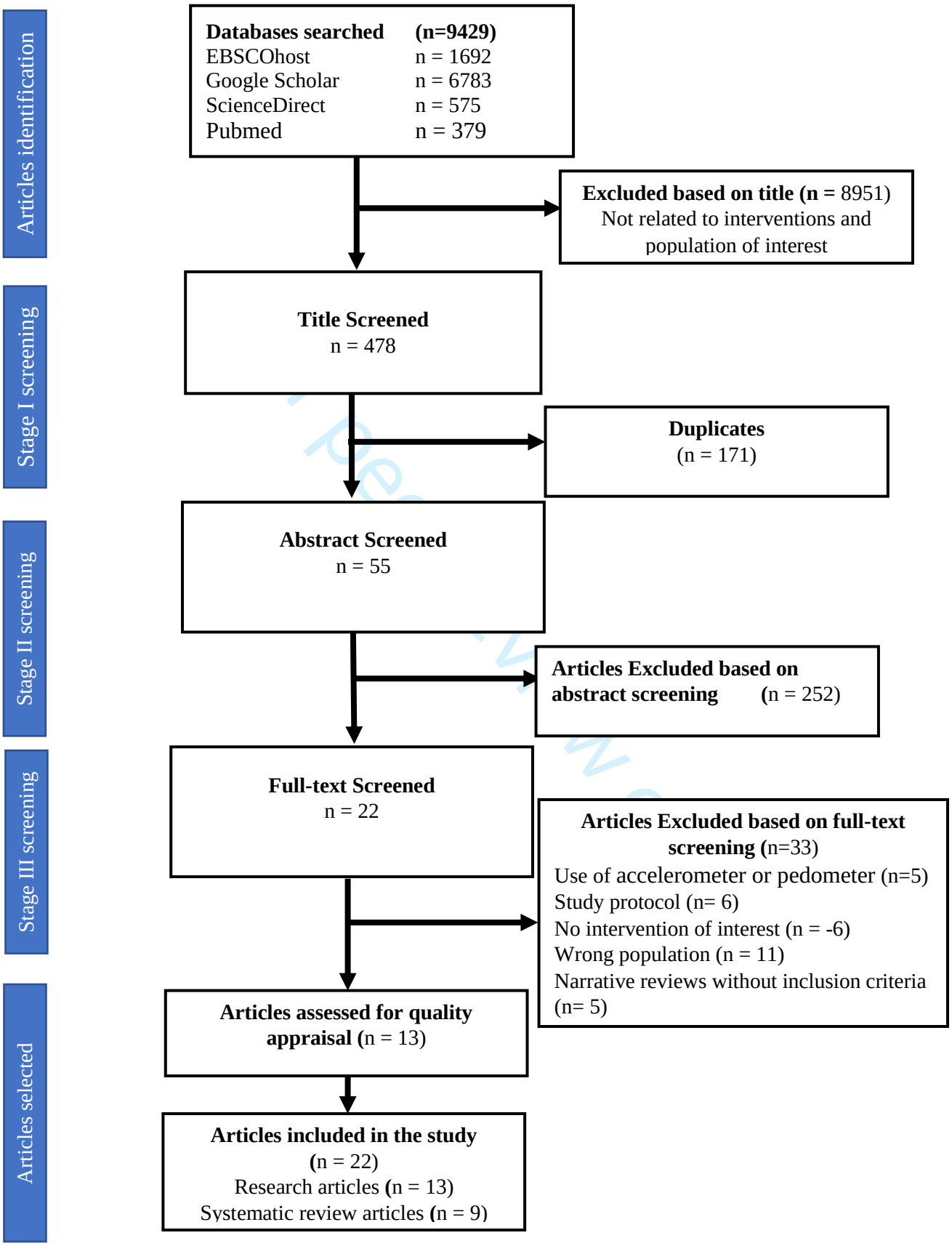

Figure I: flow diagram of the included articles

Supplementary file: Search strategy to identify articles that use ICTs to promote healthy lifestyle behaviour

Search engine	Keywords searched	No of publications retrieved
PsycArticle (EBSCO), PsycINFO (EBSCO), Academic Search Complete (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source – Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), and Medline (EBSCO)	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND Adults OR workers OR employees	1,692
Google Scholar	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR diet OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR internet AND Adults OR workers OR employees	4612
Google Scholar	Health- promoting lifestyle behaviour OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health OR internet	1054
Google Scholar	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR e-health OR m-health OR text messages OR SMS OR internet	1117
Science direct,	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND adult	575
PubMed	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND adult	379

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 3-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 9
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Page 9

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 8 and Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 10 and Table 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Page 11
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Table 2 and Table 3
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 9-12
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Page 13-14
Limitations	20	Discuss the limitations of the scoping review process.	Page 14-15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 15
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 16

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. ;169:467–473. doi: 10.7326/M18-0850

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The use of information and communication technologies to promote healthy lifestyle behaviour: A systematic scoping review

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The use of information and communication technologies to promote healthy lifestyle behaviour: A systematic scoping review

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Abstract

Introduction: Health-promoting lifestyle behaviours are part of the activities of daily living that influence individual happiness, values, and well-being. They play a crucial role in prevention and control of noncommunicable diseases (NCDs) among all age groups. Current statistics on mortality, disability, and morbidity associated with NCDs are alarming globally. Use of information and communication technology (ICT) for a health-promoting lifestyle behaviour programme enhances health behaviours that are important in the prevention and control of both communicable and noncommunicable diseases. Our study aims to map evidence on use of ICT in comprehensive health-promoting lifestyle behaviour among healthy adults.

Methods: Eleven electronic databases were searched for the study. We included studies published in English between January 2007 and December 2018 reporting on healthy adults, ICT and any subscales of the health-promoting lifestyle profile (HPLP). Studies focusing on diseases or disease management, and studies that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT or computer games were excluded. Data were summarised numerically and thematically.

Results: All the studies reviewed were conducted in developed countries. Most of the studies reported on physical activity, and findings of one study covered all the subscales of HPLP. Use of ICT for health-promoting lifestyle behaviours was reported to be effective in ensuring health behaviours that can improve physical and mental health.

Conclusion: Our findings showed that there is a dearth of knowledge on comprehensive health-promoting lifestyle behaviour that can be beneficial for the control and prevention of NCDs. There is need to carry out primary studies on use of ICT and comprehensive health-promoting lifestyle, especially among adults in low- and middle-income countries where there are alarming statistics for mortality and disability associated with NCDs.

Systematic review registration: This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568.

Strengths and limitations of this study

- A comprehensive and extensive literature search on the use of information and communication technology (ICT) in comprehensive health-promoting lifestyle behaviour among healthy adults was done to identify research gap.
- Rigorous process was followed in searching and selecting the included articles for the study.
- Inclusion of primary research articles in the study was subjected only to Mixed Method Appraisal Tool (MMAT) version 2011.
- Only studies published in English between January 2007 and December 2018 were included in the study.
- The reference lists of the included articles were not examined, and no manual searches were performed. Lastly, only electronic databases were extensively searched for the included studies.

Keywords: health-promoting lifestyle behaviour, nutrition, physical activity, health responsibility, stress management, interpersonal relationship, self-actualisation, information and communication technology, healthy adults, systematic scoping review

Introduction

Increase in the prevalence of noncommunicable diseases (NCDs) such as chronic cardiovascular diseases, stroke, cancers, chronic respiratory diseases and diabetes mellitus calls for more proactive ways to manage, control and prevent them. Seventy per cent of global mortality has been attributed to NCDs [1 2]. Eighty per cent of deaths associated with NCDs occur in low- and middle-income countries (LMICs) in the 30 to 60 years age group [2-5]. In 2013, a report showed that (Int$) 53.8 billion was spent on NCDs globally [6]. NCDs have been shown to be a major barrier to development and achievement of the millennium development goals [6]. Many NCDs have a strong association with unhealthy lifestyle [2 7 8]. Risk factors for NCDs are tobacco use, food high in saturated and trans-fat, high consumption of sugar and salt, excessive alcohol intake, physical inactivity, poor diet, overweight and obesity, inadequate sleep and rest, stress, and exposure to environmental hazards [9-12].

Health-promoting lifestyle behaviour has been identified as having an essential role in prevention and control of NCDs [13-16]. Health promotion is an umbrella term describing a composite of disease prevention and health promotion [3]. Information and communication technology (ICT) has been shown to be beneficial as it has made it possible to access health-related information easily [17]. Use of ICT in health promotion and health management is increasingly well recognised because of its cost-effectiveness in the prevention of diseases [18]. Evidence exists that ICT is used in health surveillance for both communicable and noncommunicable diseases. ICT paired with monitoring tools can improve physical activity and weight loss [19]. Few individuals adhere to healthy lifestyle behaviour despite the role it plays in chronic disease prevention, and literature has shown that web-based interventions are effective in changing behaviour [20]. ICT refers to technology that provides access to information and communication [21] through a wide range of communication tools. In this study, ICT includes internet, cell phones, computers, and websites.

Use of ICT in management and prevention of diseases is on the increase. ICT applications are used in psychotherapeutic intervention [22 23], management and control of medical conditions such as hypertension [24 25], HIV and other sexually transmitted diseases [26], diabetes management, smoking cessation, asthma management, weight loss and physical activity [20 27 28]. ICT applications have also been used for recruitment of particular research groups. One good example was a study conducted by Bauermeister and his team, where they used a Web version of respondent-driven sampling (webRDS) to recruit a sample of young adults (ages 18–24) and examined whether this strategy would result in alcohol and other drug prevalence estimates comparable to national estimates [29]. On health-promoting lifestyle and ICT, several studies have been done, mainly on physical activity, smoking cessation, alcohol intervention and diet for weight control. However, there are other health-promoting lifestyle behaviours such as stress management, interpersonal relationship, health responsibility and self-actualisation that are equally important to disease prevention and health promotion, along with physical activity and nutrition [11].

We are not aware of any review that has reported on use of ICT and the six domains of comprehensive health-promoting lifestyle behaviour (nutrition, physical activity, stress management, interpersonal relationships, self-actualisation/spiritual growth and health responsibility) among healthy individuals. Comprehensive health-promoting lifestyle behaviours are described for the purpose of this study as day-to-day lifestyle practices that can prevent

diseases and promote health. The six health-promoting lifestyle behaviours are the subscales of the health-promoting lifestyle profile instrument [30]. Joseph-Shehu et al. [31] describe the HPLP subscales as follows: (i) nutrition signifies an individual's eating habits and food choices; (ii) physical activity signifies actions engaged in by an individual that make him/her active and not sedentary; (iii) health responsibility signifies knowing how to act in ways that improve one's own health; (iv) stress management signifies the ability to identify factors that affect one's stress level and being able to manage such factors; (v) self-actualisation is the ability to achieve one's life goals by adopting a positive approach and drawing upon one's talents and creativity; (vi) spiritual growth is not specific to any particular religion; rather, it signifies ability to harness inner resources to connect with oneself and with others and having purpose in life that leads one to excel and develop in attaining life goals and possible fulfilment; (vii) interpersonal relations signifies achieving meaningful and sustainable relationships with people through any form of communication [31].

Each of these health-promoting lifestyle behaviours is important in the prevention and control of both communicable and noncommunicable diseases, as they are part of the activities of daily living that influence individual happiness, values, and well-being [32]. Reports show that there was a lower risk of developing diabetes mellitus, stroke, myocardial infarction and cancers among 23,153 Germans between 35 and 65 years of age that were followed for an average period of 7.8 years on adherence to no smoking, exercise, healthy diet and BMI less than 30kg/m^2 compared to participants that did not engage in these healthy lifestyle practices [20]. There is a possibility that if lifestyle practices such as stress management, interpersonal relationships, health responsibility and self-actualisation were added to the lifestyle this could have led to lower risk for developing other NCDs such as peptic ulcer, mental illnesses, etc. Hence, this study aims to map evidence on use of ICT in health-promoting lifestyle behaviour among healthy individuals to comprehensively assess the current state of knowledge on health-promoting lifestyle behaviour and ICT. The results of this study will help to identify an area that requires meta-analysis and future primary research. This systematic scoping review accordingly seeks to address the following research questions:

- Does use of ICT improve and enhance health-promoting lifestyle behaviour?

- Is there any evidence that use of ICT in health-promoting lifestyle activity resulted in good health status (healthy weight, normal blood pressure, normal blood sugar and good mental and physical health)?

Methods/Designs

This systematic scoping study was registered with PROSPERO (the International Prospective Register of Systematic Reviews): registration number CRD42016042568. The review adopted the five stages Arksey and O'Malley framework (identifying the research question, identifying relevant studies, study selection, charting the data, and collating, summarising and reporting the results) for conducting scoping reviews [33]. The study protocol was published in BMJ Open [3]. This review report was guided by PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews)[34].

Search strategy

An extensive search of eligible studies was conducted on the following 11 databases: Academic Search Complete (EBSCO), PsycArticle (EBSCO), PubMed, Medline (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source: Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), PsycINFO (EBSCO), Science Direct, and Google Scholar. We searched for articles published in the English language between January 2007 and December 2018. This time frame was selected to assess work that has been done on using ICT in comprehensive health-promoting lifestyle behaviour among healthy adults over one decade. The search strategy was focused mainly on the study interventions and the population of interest (Table 1). Boolean operators (AND and OR) separated keywords in the search as follows: health promoting lifestyle profile OR health-promoting lifestyle profile OR health-promoting lifestyle behaviour OR wellness OR nutrition OR diet OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualisation OR spiritual growth AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR the internet AND adult OR workers OR employees. Summary of the search strategy is found in the supplementary file.

Eligibility criteria

Inclusion criteria

- studies reporting on healthy workers, professionals and adults
- studies published in the English language
- studies published between January 2007 and December 2018
- studies reporting on interventions such as one or more subscale(s) of the health-promoting lifestyle profile (stress management, interpersonal relationships, nutrition, self-actualisation/spiritual growth, health responsibility and physical activity) and ICT (text messages, SMS, computers, mobile phone, websites and internet)
- all study designs, including cross-sectional studies, quantitative studies, randomised control trial studies, quasi-experimental study designs, cohort studies, qualitative studies, and systematic reviews

Exclusion criteria

- studies which do not report on any form of ICT
- studies on patients, youth, students, diseases/management or children
- studies that do not report on all or any of the subscales of the health-promoting lifestyle profile
- studies that do not report on outcome of interest (Table 1)
- studies that use any form of ICT in recruitment or as a means of collecting data only
- literature published before January 2007 and after December 2018
- studies which do not report on adults
- studies that combine monitoring tools in the form of hardware (accelerometer or pedometer) with ICT and computer games
- studies reporting on alcoholism, obesity or cigarette smoking
- non-English publications
- study protocols, non-systematic review, book chapters, dissertation and letter to the editors

Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Study selection

The selection process for the included articles involved rigorous exercises in three stages of screening – title, abstract and full-text screening – before data extraction. One reviewer conducted the title screening of the included articles and abstract and full-text screening was undertaken independently by two reviewers. Any disagreement at any level of the screening was discussed until both reviewers reached consensus. Title of an article that was not cleared was included for abstract screening, and if abstract of an article was not cleared same was added for the full-text screening. The reviewers developed the screening form before commencement of the screening exercise. The screening forms were developed based on population, interventions, and outcomes [3]. Systematic reviews were included if they met the inclusion criteria. Two independent reviewers screened the included articles full-text, based on the inclusion and exclusion criteria described above, and consensus between the reviewers resolved any disagreement. The degree of agreement between reviewers at the full-text screening stage was estimated using kappa statistic with STATA 13.

Figure I: Flow diagram of the included article

Data extraction

Data extraction criteria were determined, and a self-designed data extraction form was designed by the reviewers before data extraction to aid the process. The primary outcome measured was health-promoting lifestyle behaviours and health status (Table 1). There was no restriction on how to measure the outcome such as whether physiological or self-report. However, use of accelerometer, pedometer or computer games was not included in this study. In order to provide answers to the study questions, data extracted from each of the studies included were as follows: bibliography of the study (author's name and date), location of the study, objective or aim of the study (as reported by authors), study design, study population, study setting, sample size, type of ICT (Table 1), type of health-promoting lifestyle behaviour (Table 1), duration of the study, outcome of the study, results or findings from the study and conclusions of the study.

Quality appraisal of the included studies

Mixed Method Appraisal Tool (MMAT) version 2011 [35] was used to assess the quality of included research articles. MMAT was designed to evaluate articles on primary research using the following study designs: qualitative; quantitative and mixed method. The MMAT enabled us to assess the methodological quality of the included studies. Scores for each study varied between 25% and 100%. For mixed method studies, there were 11 criteria to be met for an article to be rated as high; four criteria each for quantitative (QUANT) section and qualitative (QUAL) section and three for mixed method (MM) section). Mixed method studies were rated as 25% when QUAL=1 and QUAN=1 and MM=0; as 50% when QUAL=2 and QUAN=2 and MM=1; as 75% when QUAL=3 and QUAN=3 and MM=2; and as 100% when QUAL=4 and QUAN=4 and MM=3. A criterion score between 25% and 49% was rated as low quality, a score of 50% to 74% as average quality and a score of 75% to 100% as high quality.

Collating and summarising the findings

Extracted data were summarised numerically and thematically using the following two themes: ICT used in health-promoting lifestyle behaviour, and health-promoting lifestyle behaviour outcomes. The authors collectively assessed themes and conducted a critical appraisal of each theme in relation to the research questions. We also examined the meaning of the findings in relation to the aim of the study and their implications for research, practice, and policy.

Patient and public involvement

Patients and public were not involved in the study as it is a systematic scoping review

Results

The literature encompassed a broad scope of studies exploring use of ICT in health-promoting lifestyle behaviour among healthy individuals. Eleven electronic databases searched (Figure 1) yielded 10,858 potential articles. After screening and duplicates were removed, 24 articles met the study inclusion criteria. The kappa statistics for the degree of agreement showed 74.5% agreement versus 49.8% expected by chance, which constitutes moderate to substantial agreement (Kappa

statistic = 0.49, p-value<0.001). McNemar's chi-square statistic suggests that there is not a statistically significant difference in the proportions of yes/no answers by reviewers. The study includes 13 research articles and 11 systematic reviews identified as meeting the inclusion criteria and focused on the specified health-promoting lifestyle behaviours and ICT among healthy adults.

Characteristics of included studies in this scoping review

The characteristics of the included studies are presented in Table 2. Two of the included studies adopted mixed methods designs [36 37]; one study in each case adopted qualitative design [38], quantitative non-randomised design [39], prospective longitudinal cluster-randomised controlled trial [40], retrospective randomised trial design [41] and intervention study [42]. Six studies [18 20 43-46] adopted randomised control trial design. The duration of the intervention studies ranged from 4 weeks to 10 months. One of the main study aims was to determine the effect of proactive dissemination strategy on the reach of the internet-delivered computer-tailored intervention [42]; study duration commenced with the invitation to participate in the study. Sample sizes of included research articles ranged from 26 to 16,948; sample sizes of included evidence review articles ranged from 11 to 457. [47] Twelve studies focused on males and females [20 36-42 44-46 48], one reported on females alone [18], one reported on all study population [49], one reported on employees [50] and nine studies (systematic review) did not report study population [17 27 47 51-56]. Seven of the studies reviewed were conducted in the community [39 41 44-46 48 56]. Eight were conducted at the workplace: one each among the military [40], nurses [18], university employees [36], municipality employees [46]; two in more than one organisation [20 38 47]; and two did not describe the workers [37 50].

Five of the eleven systematically reviewed studies [27 50 51 54 55] did not report the study country of included articles; one reported 457 articles from 36 countries in Asia, Australia and Oceania, Europe, North America, and South America [49]; one reviewed 34 articles from five countries (Europe, Asia, South Korea, USA, New Zealand) [52]; 12 articles from three countries (USA, UK and Australia)[17]; 12 articles from nine countries (US., Denmark, England, Ireland, Canada, Australia, South Korea, Israel, and Singapore)[56], 22 articles from eight countries (USA, Australia, Netherlands, UK, Sweden, Japan, Norway and Singapore) [47] and 38 articles from the USA alone [53]. In regard to primary research included in this study, three studies were conducted in Australia

[39 41 45], three in the United Kingdom [36-38], three in the United States [40 43 44], two in the Netherlands [42 46], one in Israel [20] and one in Taiwan [18]. Not all of the included studies reported on geographical setting of the research and none of the studies was conducted in a low- or middle-income country.

Risk-of-bias assessment

In regard to quality assessment of the included studies, the scores of the 13 articles reviewed for methodological quality ranged from 50% to 100%. Nine of the reviewed articles were rated as high quality, of which three scored 100% [40 44 45] and six scored 75% [18 20 38 41 42 48]. Only four were rated average quality, with two scoring 50% [39 46] and two scoring 67% [36 37]. The overall quality assessment was appraised to be average risk of bias due to the following: no clear description of concealment, withdrawal rate higher than 20% and no consideration given to how findings related to researcher influence.

ICT use in health-promoting lifestyle behaviours

A theme emerging from the study was ICT use in health-promoting lifestyle behaviours, and health-promoting lifestyle behaviours targeted by the included studies (Table 3). Various forms of ICT (email, social network sites, websites, Short Messaging Service (SMS) or text messages, mobile phone app, smartphones, computers, and Multimedia Messaging Service (MMS)) were used in the included studies for health-promoting lifestyle behaviours intervention that targeted one form or another of health-promoting behaviours. In all the included articles the Internet was obviously used via either phones or computers. However, some authors specifically mentioned use of internet in their reports [42 46-48 52 55], and a few authors explicitly mentioned computer use [42 46 53]. All the reviewed studies except one [50] reported on physical activity, 13 reported on nutrition [18 20 37 40 42 46 47 49 51 53-56], one reported on social connection [37], three reported on stress management [47 50 56] and one reported on all the subscales of health-promoting lifestyle profile [18].

Use of email and website [39], email, website and SMS [38], smartphone and website [45 50] and website only [48 50 55], was reported only for physical activities behaviour. Three of the reviewed studies reported on smartphone apps, one in the form of an in-built accelerator [44] and one on smartphone with website for physical activity behaviour [41] Fanning et al. reported on use of mobile device, mobile software, and SMS for physical activity [27]. Websites, smartphone and tablet apps were reported to be used for cognitive behavioural therapy (CBT), stress management, and mindfulness-

based approaches [50]. five of the included studies reported on use of more than one form of ICT for more than one health behaviour [40 47 49 52 56]. Computer-based information and communication technologies [53] and internet-delivered computer-tailored lifestyle programme [42 46 54] were reported to be used for more than one health behaviour, including physical activity, nutrition, alcohol use, smoking behaviour, and condom use. Use of website only was reported for nutrition, physical activity, stress management, interpersonal relationship, spiritual growth, and health responsibility [18], and diet, physical activity, and social connection [37].

Social network sites were reported for fitness, sexual health, food safety, smoking and health promotion [17], and for diet, physical activity, alcohol and tobacco use, mental health intervention, disease management, and sexual health [55]. A specific software programs aimed at reducing sedentary behaviour in the work place [47]. Mackenzie et al. reported use of email, software reminder, and Twitter to reduce workplace sitting only [36], while a Web-based app was used for nutrition and physical activity only [20]. A comprehensive health-promoting lifestyle behaviour was reported among female nurses only [18].

Use of ICT for health-promoting lifestyle behaviours and health status

Use of any form of ICT increased participants' physical activity behaviour [27 36 39-41 44 45 48], and health behaviour change [17 20 47 52 53 56] (Table 3). Use of ICT in health-promoting behaviour was reported to reduce weight [20 55 56], but Frank et al. reported no significant difference in participants BMI and waist circumference [40]. People that are likely to participate in an internet-delivered computer-tailored intervention are older individuals with higher educational level, relative healthier lifestyle and healthy BMI [42]. For efficient use of internet-delivered computer-tailored lifestyle programme a preview of new website content should be included in a standard prompt in addition to short prompt timing [46]. Factors to be considered when planning intervention for ICT to be used for health-promoting lifestyle behaviours in the workplace are encouragements in the form of motivation from managers, time management, involvement of stakeholders in the designing of the intervention, and reminders [38]. Use of ICT has been documented to be effective in promoting health behaviours [50 53 55]. Comprehensive health-promoting lifestyle behaviours and ICT reduce BMI, and improve physical and mental component summary [18]. There is a need to examine the long-term effectiveness of ICT on health-promoting behaviours [54]. To ascertain the effectiveness of ICT and comprehensive health-promoting behaviours in the prevention of diseases, there is a

need to consider other health assessment parameters such as blood pressure and biochemical parameter instead of BMI alone [18]

Discussion

We conducted a systematic scoping review of the available studies on use of ICT for stress management, interpersonal relations, nutrition, self-actualisation/spiritual growth, health responsibility and physical activity lifestyle behaviours globally. Health-promoting lifestyle behaviours play an essential role in the prevention of diseases and quality of life [12 15]. According to the WHO, to control NCDs it is important to reduce risk factors associated with them by adopting health-promoting lifestyle behaviours [2]. Our systematic scoping review showed that various forms of ICT such as email, social network sites, websites, SMS or text messages, mobile phone app, smartphones, computers and MMS were used for a range of health-promoting lifestyle behaviours such as nutrition, physical activity, stress management, smoking cessation and reducing alcohol consumption. There was a paucity of data on interpersonal relationship, self-actualisation/spiritual belief, stress management and health responsibility. However, health-related lifestyle behaviours such as condom use, breast cancer prevention and sexually transmitted diseases prevention that could have incorporated into health responsibility lifestyle behaviour were not a primary research article.

Furthermore, our study reported that use of ICT for health promotion improves and enhances health-promoting behaviours. More particularly, use of ICT for comprehensive health-promoting lifestyle behaviours was reported to result in a healthy BMI and to improve physical and mental health. However, BMI was the only physical health assessment parameter reported by the included studies. Factors such as time management, motivation and reminders are essential when designing health-promoting lifestyle behaviour for workers. There was only one primary study on use of ICT and comprehensive health-promoting lifestyle behaviour among females. Also, the quality assessment of the primary studies included was of moderate risk. It is of interest to know that no reports on LMICs were found in the included studies. Regarding population size, our systematic review reported wide population spreads from 26 to 16,948 across the study locations reported. This review showed that there is a dearth of knowledge on use of ICT for comprehensive health-promoting lifestyle and health status.

ICT enhances the success of national health promotion and disease prevention programmes [57]. Our study reported large population sizes, which demonstrates that public health promotion campaigns can be achieved through use of ICT [58] since large populations can be involved in health promotion intervention programmes, which will potentially enhance achievement of the sustainable development goal of reducing premature deaths associated with NCDs to one-third by 2030 [2]. However, to reduce attrition rate in ICT use for health-promoting lifestyle behaviour intervention, one of our included studies reported that reminders are critical [38]. Much attention has been given to physical activity, nutritional lifestyle behaviours and healthy weight, and this might be the possible reason why these two lifestyle behaviours were more pronounced in our findings. This might also be the reason why only BMI was assessed among all the physical health parameters that could be of importance to control and prevention of NCDs [2]. These findings have implications for the control and prevention of NCDs in the near future.

One of the strengths of this study is the extensive literature searched and the rigorous process in selecting the included studies. Scoping review as conducted for this study is an approach that examines the extent, range and nature of research activity in a particular field to identify research gap [33 59]. This is the first article that has examined ICT and comprehensive health-promoting lifestyle behaviours among healthy adults, as the authors are not aware of any such others. We also conducted a methodological quality appraisal of the included primary research. Results in our study did not omit any country, as 'country filter' was not applied during the literature search. All the included articles reported on physical activity except one that reported only on stress management. Also, some articles reported on stress management, spiritual growth health responsibility, and interpersonal relationships. Most of the included studies that reported on health responsibility related lifestyle behaviours such as smoking cessation, reduced alcohol consumption, condom use, breast cancer prevention and sexually transmitted diseases prevention were systematically reviewed studies. However, none of the included studies reported on blood pressure or blood glucose level. Screening and early detection of NCDs are one way to prevent and control this demon called NCDs [2]. In the next 30 years there will be a 3.5-fold increase globally in deaths due to cardiovascular diseases [60], which are the leading cause of mortality and morbidity among all the NCDs [1-3]. Highest premature deaths associated with NCDs are recorded in the LMICs [1 2 61]. However, our scoping review showed scarcity in use of ICT for comprehensive health-promoting lifestyle behaviours research among healthy adults from these regions.

Some limitations of this study were as follows: firstly, inclusion of studies published in the English language between January 2007 and December 2018; secondly, the reference lists of the included articles were not examined, and no manual searches were performed; lastly, only electronic databases were extensively searched for the included studies.

Health-promoting lifestyle behaviour remains a crucial means of curbing the menace associated with NCDs [3 14-16]. However, some people prefer to be busy with other issues of life rather than engaging in health-promoting lifestyle behaviour [14 38]. Hence, only a few individuals adhere to healthy lifestyle behaviour despite the role it plays in chronic diseases prevention [14 36]. There is need to explore other means of encouraging people to practice health-promoting lifestyle behaviours because it is a fact that prevention is better than cure. Literature showed that web-based interventions are effective in changing behaviour [20]. With the increase in the burden of NCDs in LMICs [61], use of ICT to promote health behaviour lifestyle is the key determinant in the control and prevention of NCDs [58]. There is an urgent need to assess the nature and form of ICT that can be effective in promoting health behaviours among healthy adults in LMICs, and in Africa in particular. In addition, there is need to explore use of ICT and comprehensive health-promoting lifestyle behaviours among healthy adults in LMICs where there is a gap in the primary study of these issues.

Conclusion

The findings from our study showed that ICT in relation to health-promoting lifestyle behaviour enhances health-promoting lifestyle behaviour and promotes physical and mental health. Physical activity was assessed by all the included studies except for one that examined stress management. BMI was the only physical health parameter reported by one of the included studies. Factors such as time management, motivation and reminders are important when designing health-promoting lifestyle behaviour for the worker. None of the included studies reported on LMICs. There is a dearth of knowledge on a comprehensive health-promoting behaviour that can be beneficial in the control and prevention of NCDs. There is need to carry out primary studies on use of ICT for a comprehensive health-promoting lifestyle, especially among 'healthy' adults in LMICs where there are alarming statistics on the mortality and disability associated with NCDs.

List of abbreviations

- BMI body mass index
- HPLP health-promoting lifestyle profile
- ICT information and communication technology
- LMICs low and middle-income countries
- MMS multimedia messaging service
- NCDs noncommunicable diseases
- SMS short message service
- WHO World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Data sharing statement

The data for the study is available either in the manuscript or as a supplementary file accompanying this manuscript. However, further request of any data should be directed to the corresponding author, who will gladly share it.

Competing interest

The authors declare that they have no competing interests.

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Author contribution

Dr Elizabeth M Joseph-Shehu conceptualised, designed the protocol and prepared the draft of the manuscript under the supervision of Professor BP Ncama. Ms. Nomaxabiso Mooi and Dr Tivani Mashamba-Thompson contributed to the methodology and data collection. All authors critically reviewed the draft version of the manuscript and gave approval for submission

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Table 1: Population, Interventions, Comparison, Outcome and Study setting (PICOS) framework for determination of the eligibility of the review questions

Criteria	**Determinants**
Population	Healthy adults, workers and well individuals
Interventions	Health-promoting lifestyle profile (nutrition, physical activity, interpersonal relationship, health responsibility, stress management, self-actualisation or spiritual growth) and information and communication technologies (ICT, mobile phone, text messages, SMS, internet, computers, websites)
Comparison	Health-promoting lifestyle profile intervention without ICT
Outcomes	Effective and sustaining health-promoting lifestyle practices (nutrition, physical activity, interpersonal relationship, health responsibility, stress management, self-actualisation or spiritual growth) and health status (normal weight, normal blood pressure, normal blood sugar and good mental and physical health)
Study setting	Focus on low- and middle-income countries

Adopted from the study protocol [3]

Table Error! No text of specified style in document. Characteristics of included studies

Author and date	Country	Income level of country	Aim of the study	Study design	Study population	Study setting	Sample size	Duration of study
Research articles								
Ammann et al. (2012)	Australia	High	To evaluate a website- delivered computer-tailored physical activity intervention, with a specific focus on differences in tailored advice acceptability, website usability, and physical activity change between three age groups.	Quantitative non-randomised design	Male and Female;	Community	863	1 Month
Bardus et al. (2014)	United Kingdom	High	To investigate the reason for participating and not participating in an eHealth workplace physical activity intervention.	Qualitative study	Male and female	Workplace	62	Not specified
Carr et al. (2013)	United States	High	The goals of these focus groups were to identify internet features rated as "useful for improving PA".	Randomised controlled trial (RCT) design	Male and female;	Community	53	6 months
Frank et al. (2016)	United States		To determine if a telehealth coaching initiative is superior to a one-time nutrition and fitness education class regarding: (a) dietary contributions to bone health and (b) exercise contributions to bone health, assessed before and after deployment.	Prospective, longitudinal, cluster-randomised, controlled trial	Male and female	Workplace	158	9 months
Guertler et al. (2015)	Australia	High	The aims of this study were to (1) examine the engagement with the freely available physical activity promotion program 10,000 Steps, (2) examine how use of a smartphone app may be helpful in increasing engagement with the intervention and in decreasing non-usage attrition, and (3) identify sociodemographic and engagement-related determinants of nonusage attrition.	Retrospective randomised trial	Male and female	Community	16,948	9 months

King et al. (2016)	United States	High	This study provided an initial 8-week evaluation of three different customised physical activity-sedentary behaviour apps drawn from conceptually distinct motivational frames in comparison with a commercially available control app.	Controlled experimental design	Men and women	Community	95	8 weeks
Kirwan et al. (2012)	Australia	High	To measure the potential of a newly developed smartphone application to improve health behaviours in existing members of a website-delivered physical activity program (10,000 Steps, Australia).	2-arm matched case–control trial	Men and women	Community	200	3 months
Lara et al. (2016)	UK	High	We report a pilot randomised controlled trial (RCT) of a web-based platform (Living, Eating, Activity and Planning through retirement; LEAP) promoting healthy eating (based on a Mediterranean diet (MD), physical activity (PA) and meaningful social roles.	Mixed method design	Men and women	Workplace	70	8 weeks
Mackenzie et al. (2015)	UK	High	To explore the acceptability and feasibility of a low-cost, co-produced, multi-modal intervention to reduce workplace sitting.	Mixed method design	Men and women	Workplace	26	Over 4 weeks
Naimark et al. (2015)	Israel	High	Our aim was to compare people receiving a new Web-based app with people who got an introductory lecture alone on healthy lifestyle, weight change, nutritional knowledge, and physical activity, and to identify predictors of success for maintaining a health.	RCT	Male and female	Workplace	85	14 weeks
Schneider et al. (2013)	Netherlands	High	This study investigated the influence of content and timing of a single email prompt on re-use of an internet-delivered computer-tailored (CT) lifestyle program.	RCT	Male and female	Workplace	200	6 weeks

Schneider et al. (2013)	Netherlands	High	This study aimed to determine the effect of proactive dissemination strategy on reach of the internet-delivered computer-tailored intervention.	Intervention study	Male and female	Community	5168	10 months
Tsai et al. (2015)	Taiwan	High	This study aimed to evaluate health-promoting effects of an eHealth intervention among nurses compared with conventional handbook learning.	Randomised control	Female Nurses	Workplace	105	12 weeks
Review evidence articles								
Bardus et al. (2015)	36 countries in Asian, Australia & Oceania; Europe, North and South America	High	To provide an up-to-date, comprehensive map of the literature discussing use of mobile phone and Web 2.0 apps for influencing behaviours related to weight management (i.e., diet, physical activity [PA], weight control, etc.)	Review	All population group	Not specified	457 articles	NA
Bert et al. (2014)	Not specified	High	to describe use of smartphones by health professionals and patients in the field of health promotion.	Review	Not specified	Not specified	21 articles	NA
Buhi et al. (2013)	Europe, Asia South Korea, USA, New Zealand	High	To perform a systematic review of the literature concerning behavioural mobile health (mHealth) and summarise points related to heath topic, use of theory, audience, purpose, design, intervention components, and principal results that can inform future health education applications.	Review	Not specified	Not specified	34 articles	NA
Fanning et al. (2012)	Not specified	Not specified	The aims of this review were to: (1) examine the efficacy of mobile devices in the physical activity setting, (2) explore and discuss implementation of device features across studies, and (3) make recommendations for future intervention development.	Review	Not specified	Not specified	11articles	NA

Howarth et al (2018)	Not specified	Not specified	The aim of this systematic review was to assess the impact of pure digital health interventions in the workplace on health-related outcomes.	Review	Not specified	Not specified	22 articles	NA
Hou et al. (2014)	USA	High	This review examines internet interventions aiming to change health behaviours in the general population.	Review	Not specified	Not specified	38 articles	NA
Kohl et al. (2013)	Not specified	Not specified	The aim of this paper is to (1) review the current literature on online prevention aimed at lifestyle behaviours, and (2) identify research gaps regarding reach, effectiveness, and use.	Review	Not specified	Not specified	41 articles	NA
Laranjo et al. (2014)	UK, USA, Australia	High	Our aim was to evaluate use and effectiveness of interventions using social networking sites (SNSs) to change health behaviours.	Review	Not specified	Not specified	12 articles	NA
Lee et al (2018)			the objective of this study was to investigate the content and usefulness of mobile app programs for the general adult population.	Review	Not specified	Not specified	12 articles	NA
Rogers et al. (2017)	Not specified	Not specified	The aims of this study were to (1) discover the range of health-related topics that were addressed through internet-delivered interventions, (2) generate a list of current websites used in the trials which demonstrated a health benefit and (3) identify gaps in the research that may have indered dissemination.	Review	Not specified	Not specified	71 articles	NA
Stratton et al. (2017)	Not specified	Not specified	The aim of this paper is to conduct the first comprehensive systematic review and meta-analysis evaluating the evidence for the effectiveness and examine the relative efficacy of different types of eHealth interventions for employees.	Review	Employee	Workplace	23 articles	NA

Table 3 Health-promoting lifestyle behaviours and ICT

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Ammann et al. (2012)	Email, website	Physical activity	Physical activity and BMI	No significant differences between the age groups were found with regard to BMI and physical activity level at baseline. All age groups increased their weekly total physical activity minutes and the number of total physical activity sessions significantly over time from baseline to 1-month follow-up. Old-age group increased physical activity more than the other two age groups.	The study suggests that website-delivered physical activity interventions can be suitable and effective for older aged adults.
Bardus et al. (2014)	Website, email and text messaging (SMS)	Physical activity (PA)	Physical activity	Reasons for participation included a need to be more active, increase motivation to engage in PA, and better weight management. Employees were attracted by the perceived ease of use of the programme and by the promise of receiving reminders. Many felt encouraged to enrol by managers or peers. Reported reasons for non-participation are lack of time, loss of interest toward the programme, or a lack of reminders to complete enrolment.	In developing workplace physical activity interventions, it is important to identify salient motivators and barriers to participation through formative research with the target population. Programme enrolment procedures should be simple and not time consuming, so that burden on participants is reduced and early attrition is minimised. It is also important that employers find ways to actively promote workplace health promotion programmes (WHPPs) to their staff while also maintaining confidentiality and individual rights on employees, so that larger segments of the workforce can be reached.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Bardus et al. (2015)	Mobile phone and Web 2.0 technologies	PA, Diet and weight loss management	Diet and Physical activity	This review categorised the identified articles into two overarching themes, which described use of technologies for either (1) promoting behaviour change (309/457, 67.6%) or (2) measuring behaviour (103/457, 22.5%). The remaining articles were overviews of apps and social media content (33/457, 7.2%) or covered a combination of these three themes (12/457, 2.6%).	Limited evidence exists on use of social media for behaviour change, but a segment of studies deals with content analyses of social media. Future research should analyse mobile phone and Web 2.0 technologies together by combining the evaluation of content and design aspects with usability, feasibility, and efficacy/effectiveness for behaviour change, in order to understand which technological components and features are likely to result in effective interventions.
Bert et al. (2014)	smart phones	Nutrition lifestyles, physical activity, health in elderly, prevention of sexually transmitted diseases	Nutrition and physical activity	Out of 21 articles identified as specifically centred on health promotion, the nutrition field have applications that allow to count calories and keep a food diary or more specific platforms for people with food allergies. While in the physical activity many applications suggest exercises with measurement of sports statistics and some applications deal with lifestyles suggestions and tips..	The promotion of healthy lifestyles, adequate nutrition and physical activity are all possible and desirable through use of smartphones but it is important to underline the crucial role of health care providers in the management of the patient while using these tools. There is also a need to analyse the usefulness, quality and accuracy of smartphones applications in the field of preventive medicine.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Buhi et al. (2013)	SMS, MMS, Internet	Breast cancer prevention, diabetes management, weight loss or obesity prevention, smoking cessation, asthma self-management and physical activity	physical activity and breast cancer prevention	One journal assessed physical activity promotion and breast cancer prevention respectively. Twenty interventions (59%) were evaluated using experimental designs, and most resulted in statistically significant health behavioural changes.	Consideration should be given for the deployment of mHealth applications to combat coronary heart disease, HIV/AIDS, and other high-priority problems contributing to high mortality. A mobile video-based modality, using sight and sound, may show even greater promise in health behaviour change interventions.
Carr et al. (2013)	Internet website	Physical activity	Physical activity	The enhanced internet (EI) arm increased PA in relation to the standard internet (SI) arm at 3 months but between-groups differences were not observed at 6 months. EI participants-maintained PA from 3 to 6 months. This result suggests that a non-face-to-face, user- and theory-guided internet PA program is more efficacious for producing immediate increases in PA among sedentary adults than what is currently available to the public.	The EI program was efficacious at improving PA levels in relation to publicly available Websites initially, but differences in PA levels were not maintained at 6 months. Future research should identify internet features that promote long-term maintenance.
Fanning et al. (2012)	Mobile device, mobile software, SMS	Physical activity	Physical activity	Four studies were of “good” quality and seven of “fair” quality. In total, 1351 individuals participated in 11 unique studies. This study suggests that mobile devices are effective means for influencing physical activity behaviour.	Our focus must be on the best possible use of these tools to measure and understand behaviour. Therefore, theoretically grounded behaviour changes interventions that recognise and act on the potential of smartphone technology could provide investigators with an effective tool for increasing physical activity.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Frank et al. (2016)	Website, email	exercise, nutrition, bone health	Physical activity, nutrition, waist circumference, BMI	There were no significant differences found in the BMI and waist circumference of soldiers in both control and intervention group over the course of study. There were significant increases in body fat, osteocalcin, and sports index for the telehealth group.	A 9-month deployment to Afghanistan increased body fat, bone turnover, and physical activity among soldiers randomised to receive telehealth strategies to build bone with nutrition and exercise. This study indicates that diet and exercise coaching via telehealth methods to deployed soldiers is feasible but limited in its effectiveness for short-term overseas deployments.
Guertler et al. (2015)	Smartphone app and website	Physical activity	Physical activity	Compared to other freely accessible Web-based health behaviour interventions, the 10,000 Steps program showed high engagement.	Use of an app alone or in addition to the website can enhance program engagement and reduce risk of attrition.
Hou et al. (2014)	Computer-based information and communication technology	Tobacco prevention, alcohol prevention, weight loss, Physical activity, nutrition, HIV and chronic diseases	Physical activity and nutrition	There were seven studies focused primarily on increasing PA, and additionally five studies also examined related factors, such as nutrition and binge eating. Two studies were categorised as nutrition only interventions, with one focused on folic acid intake and the other targeted fruit juice and vegetable (FJV) consumptions.	Findings from the current review study indicated that, overall, internet or web-based interventions (WIs) produce favourable results and are effective in producing and increasing targeted health or behavioural outcomes.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Howarth et al (2018)	Smart-phone, email, either as a website, app or download-able software.	self-reported measures of sleep, physical activity levels and healthy lifestyle rating, mental health	Blood pressure and body mass index (BMI), physical activity, mental health	there was a high level of heterogeneity across these studies, significant improvements were found for a broad range of outcomes such as sleep, mental health, sedentary behaviours and physical activity levels. Standardized measures were not always used to quantify intervention impact. All but one study resulted in at least one significantly improved health-related outcome, but attrition rates ranged widely, suggesting sustaining engagement was an issue.	This review found modest evidence that digital-only interventions have a positive impact on health-related outcomes in the workplace. High heterogeneity impacted the ability to confirm what interventions might work best for which health outcomes, although less complex health outcomes appeared to be more likely to be impacted. A focus on engage-ment along with the use of standardized measures and reporting of active intervention components would be helpful in future evaluations.
King et al. (2016)	Smartphone's built-in accelerometer	Physical activity	Physical activity behaviour	Over the 8-week period, the social app users showed significantly greater overall increases in weekly accelerometery-derived moderate to vigorous physical activity relative to the other three arms. Participants reported that the apps helped remind and motivate them to increase their physical activity levels as well as sit less throughout the day.	The results provide initial support for use of a smartphone-delivered social frame in the early induction of both physical activity and sedentary behaviour changes. The information obtained also sets the stage for further investigation of subgroups that might particularly benefit from different motivationally framed apps in these two key health promotion areas.
Kirwan et al. (2012)	Smartphone, website	Physical activity	Physical activity	Over the study period (90 days), the intervention group logged steps on an average of 62 days, compared with 41 days in the matched group. Use of the application was associated with an increased likelihood to log steps daily during the intervention period compared with those not using the application.	Using a smartphone application as an additional delivery method to a website-delivered physical activity intervention may assist in maintaining participant engagement and behaviour change.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Kohl et al. (2013)	Internet-delivered intervention	Dietary behaviours, physical activity, alcohol use, smoking, and condom use	Dietary behaviours and physical activity	According to health priorities, interventions are largely targeted at weight-related behaviours, such as physical activity and dietary behaviour. Eleven studies targeted weight management and they were on dietary behaviours and physical activity. The main aimed of these studies were weight loss five reviews also included interventions on weight maintenance. Six studies included 3 or more behaviours. The other groups included studies aimed at physical activity, 5 reviews were on smoking and alcohol respectively. Four papers combined alcohol and smoking while three were on dietary behaviours. An additional manual search showed one study on condom use.	More research is needed on effective elements instead of effective interventions, with special attention to long-term effectiveness. The reach and use of interventions need more scientific input to increase the public health impact of internet-delivered Interventions.
Lara et al. (2016)	Web-based platform	Diet, Physical activity, social connection and anthropometric status	Diet, Physical activity, social connection, BMI and waist circumference	'Eating well' and 'being social' were the most visited modules. At interview, participants reported that diet and PA modules were important and acceptable within the context of healthy ageing.	The trial procedures and the LEAP (Living, Eating, Activity and Planning through retirement) intervention proved feasible and acceptable. Overall participants reported that the LEAP domains of 'eating well', were important for their health and well-being in retirement.
Laranjo et al. (2014)	Social network sites	Fitness, sexual health, food safety, smoking and health promotion	Fitness (physical activity)	The study found a statistically significant positive effect of SNS interventions on behaviour change, boosting encouragement for future research in this area.	The study showed a positive effect of SNS interventions on health behaviour-related outcomes, but there was considerable heterogeneity.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Lee et al. (2018)	mobile apps	Diet, physical activity and overall healthy lifestyle improvement	Diet, physical activity and overall healthy lifestyle improvement	Across all studies, health outcomes were shown to be better for mobile app users compared to non-users. Mobile app-based health interventions may be an effective strategy for improving health promotion behaviours in the general population without diseases	This study suggests that mobile app use is becoming commonplace for a variety of health-promoting behaviours in addition to physical activity and weight control. Future research should address the feasibility and effectiveness of using mobile apps for health promotion in developing countries.
Mackenzie et al. (2015)	Email, reminder software, twitter	Reduced workplace sitting	Increased Physical activity	Therefore, "completers" demonstrated a range of levels of physical activity. In addition, "completers" generally demonstrated positive health behaviours with 0 % being smokers, over 50 % eating five fruits or vegetables/day and almost 25 % not drinking alcohol.	Evaluation of this intervention provides useful information to support participatory approaches during intervention development and the potential for more sustainable low-cost interventions.
Naimark et al. (2015)	Web-based app	Nutrition and Physical activity	Nutrition, Physical activity, BMI and waist circumference	The app group increased their weekly duration of physical activity to the healthy range of more than 150 minutes a week, which may afford substantial health benefits, they lost more weight and had increased nutritional knowledge compare to the control group.	We showed a positive impact of a newly developed Web-based app on lifestyle indicators during an intervention of 14 weeks. These results are promising in the app's potential to promote a healthy lifestyle, although larger and longer duration studies are needed to achieve more definitive conclusions.
Rogers et al. (2017)	Website Internet-delivered Intervention	Diet, Physical activity, Alcohol and tobacco use, Mental health intervention, Disease management, Sexual health	Diet and Physical activity	The efficacy of the interventions for diet and physical activity, although significant, was modest (e.g., 2.1 kg mean weight reduction compared with a 0.4 kg increase in controls). People who completed the internet intervention reduced their waist circumference by 2.6 cm, whereas people who did not complete the intervention added 0.3 cm to their waist circumference.	A wide range of evidence-based internet programs are currently available for health-related behaviours, as well as disease prevention and treatment. However, the majority of internet-delivered health interventions found to be efficacious in RCTs do not have websites for general use. Increased efforts to provide mechanisms to host "interventions that work" on the Web and to assist the public in locating these sites are necessary.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Schneider et al. (2013)	Internet-delivered Computer-tailored lifestyle program	Physical activity, Fruit and vegetable consumption, smoking status, alcohol consumption	Physical activity, Fruit and vegetable consumption	Sending prompt 2 weeks after the first visit was more effective compared with using a longer time period, adding a preview of new website content to a standard prompt increased its effectiveness in persuading people to log in to the program and sending a prompt with additional content after a 2-week period significantly increased program log-ins compared to using a reactive approach in which no additional prompts were used.	The key findings suggest that boosting revisits to a CT program benefits most from relatively short prompt timing. Furthermore, a preview of new website content may be added to a standard prompt to further increase its effectiveness in persuading people to log in to the program.
Schneider et al. (2013)	Internet-delivered computer-tailored intervention.	Physical activity, fruit and vegetable intake, alcohol consumption and smoking behaviour	Physical activity, fruit and vegetable intake, BMI, mental health status	Approximately 50% of all participants had a healthy body weight, 35% were overweight, and 10% were obese. In term of physical activity, 21% with a minimum of 150 minutes exercise per week, whereas 46% and 69% were not adhering to the Dutch guidelines of fruit and vegetable intake respectively. More than one-third (36%) complied with three lifestyle guidelines while 1% of the respondents complied with none of these guidelines. Older and respondents with a higher educational degree, as well as respondents with relatively healthier lifestyle and a healthy BMI, were more likely to participate in the intervention.	The study concluded that there is need to put additional effort to ensure that at-risk individuals (low socioeconomic status and unhealthy lifestyle) have increase interest in a lifestyle intervention and they should also be encouraged to employ lifestyle intervention.

Author and date	ICT employed	Health promoting-lifestyle behaviour	Outcome of interest	Findings	Conclusion
Stratton et al. (2017)	Websites, smartphone and tablet apps.	Cognitive behavioural therapy, Stress management, Mindfulness-based approaches,	Stress management	The stress management interventions differed by whether delivered to universal or targeted groups with a moderately large effect size at both post-intervention (g = 0.64, 95% CI 0.54 to 0.85) and follow-up (g = 0.69, 95% CI 0.06 to 1.33) in targeted groups, but no effect in unselected groups.	There is reasonable evidence that eHealth interventions delivered to employees may reduce mental health and stress symptoms post intervention and still have a benefit, although reduced at follow-up.
Tsai et al. (2015)	Website	Health-promoting lifestyle profile (HPLP)	Health-promoting lifestyle profile (HPLP), BMI, physical and mental component summary	The eHealth education intervention had the effect of significantly increasing nurses' post-intervention Health-Promoting Lifestyle Profile total scores, physical component summary (PCS), mental component summary (MCS) and decreases in BMI.	Tailored eHealth education is an effective and accessible intervention for enhancing health-promoting behaviour among nurses.

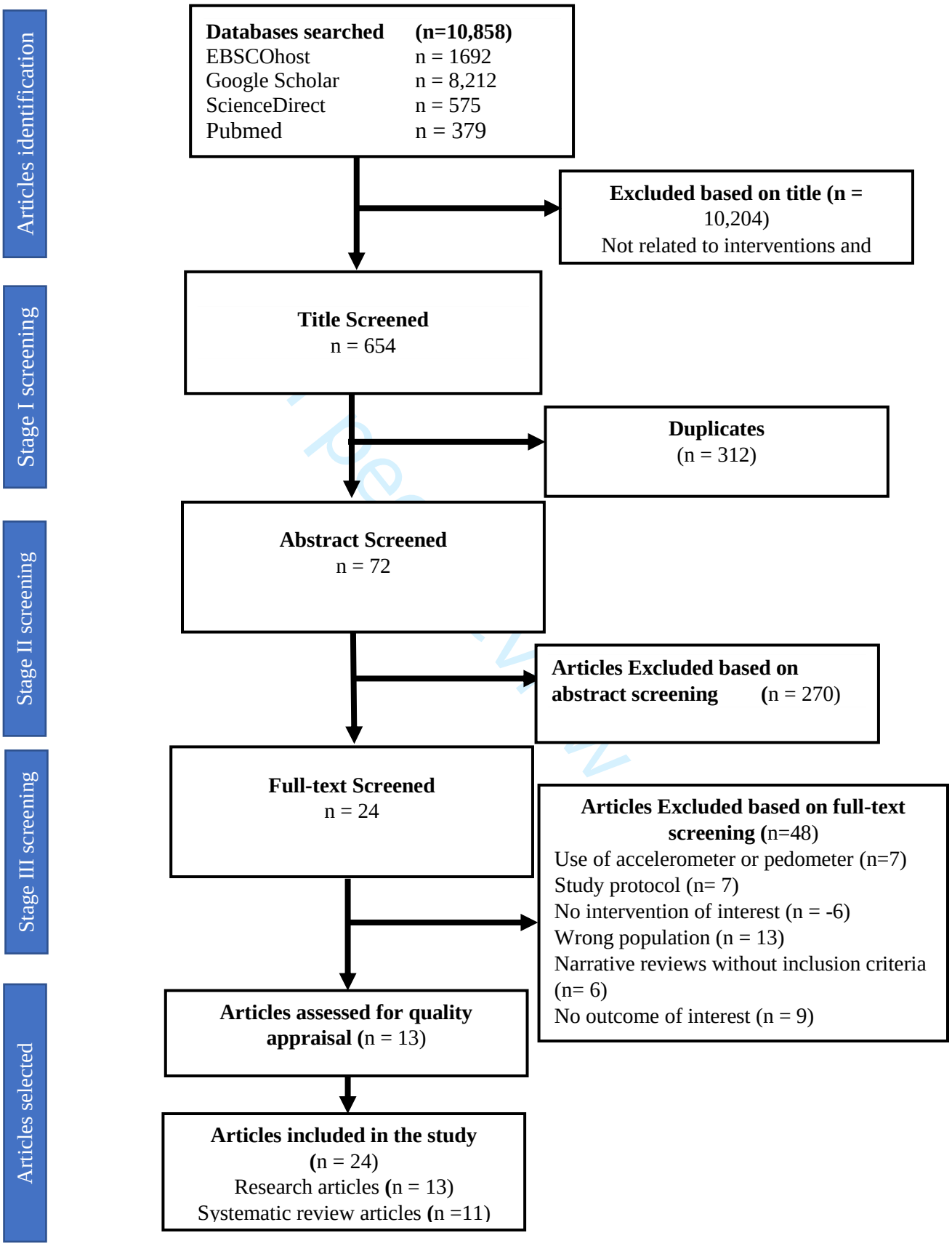

Figure I: flow diagram of the included articles

Supplementary file: Search strategy to identify articles that use ICTs to promote healthy lifestyle behaviour

Search engine	Keywords searched	No of publications retrieved
PsycArticle (EBSCO), PsycINFO (EBSCO), Academic Search Complete (EBSCO), CINAHL (EBSCO), Educational Source (EBSCO), Health Source – Consumer Edition (EBSCO), Health Source: Nursing Academic Edition (EBSCO), and Medline (EBSCO)	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND Adults OR workers OR employees	1,692
Google Scholar	health promoting lifestyle profile OR health-promoting behaviour OR physical activity OR health responsibility OR nutrition OR diet OR interpersonal relation, OR stress management OR self-actualization OR spiritual growth OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR e-health OR m-health OR internet AND Adults OR workers OR employees	6041
Google Scholar	Health- promoting lifestyle behaviour OR wellness AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health OR internet	1054
Google Scholar	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR e-health OR m-health OR text messages OR SMS OR internet	1117
Science direct,	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND adult	575
PubMed	Nutrition OR physical activity OR interpersonal relationships OR health responsibility OR stress management OR self-actualization AND information and communication technology OR ICT OR mobile phone OR text messages OR SMS OR internet OR e-health OR m-health AND adult	379

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 3-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 8
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 9
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Page 9

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 8 and Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 10 and Table 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Page 11
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Table 2 and Table 3
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 9-12
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Page 13-14
Limitations	20	Discuss the limitations of the scoping review process.	Page 14-15
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 15
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 16

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. ;169:467–473. doi: 10.7326/M18-0850