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Usability questionnaire for standalone or interactive mobile health applications: a systematic review

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Abstract

Background Mobile health apps (mHealth apps) play important roles in various aspects of disease management, health monitoring, behavioural change, education, and medication adherence. The usability and satisfaction of the app indicate whether the app is favoured and used for its optimal potential. Surveys are among the most commonly used methods and are simple to conduct, and data analysis is easily quantifiable. We aimed to synthesize the evidence from questionnaires available to assess the usability and satisfaction of mHealth apps, both standalone and interactive apps, and to evaluate the validation status of the questionnaire.

Methods An extensive search of the literature published from 2000 to June 2023 was conducted via PubMed, Scopus and Google Scholar. The keywords, MeSH terms, truncation and text words used for the search included "mobile health" or "health" or "mobile app*" or "mhealth" and "patient satisfaction" or "user" or "usability" or "feasibility" and "survey" or "questionnaire". Eligibility was independently assessed by two investigators on the basis of the inclusion and exclusion criteria. Human studies published in English that reported the usability and/or satisfaction of patients or users with mHealth apps with published questionnaires were included. Studies that did not include questions or assessed the usability and/or satisfaction of healthcare providers or experts were excluded. Studies such as questionnaire development and validation, translation studies, qualitative studies, reviews, editorials, brief reports, comments, conference proceedings, letters and wrong outcomes were excluded. The first author, year and country of publication; sample size; demographics of the study population; name and type of mobile health application; assessment tool; validation status; and number of questions, domains and scores were collected from each study. The quality assessment was independently performed by two reviewers via the Joanna Briggs Institute (JBI) critical appraisal checklist for cross-sectional studies.

Results Electronic database searches identified 5703 potentially relevant studies, and 40 studies with a total of 1552 respondents were included. The majority of the studies assessed the usability of standalone apps (62.5%). Half of the studies (50.0%) utilized researcher-developed questionnaires, whereas only 25% of the researcher-developed questionnaires were validated. Nine studies used the System Usability Survey (SUS). The majority of the studies

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(70.0%) used questionnaires that were not validated. When the JBI critical appraisal checklist was used to assess quality, 14 (35.0%) studies were assessed to be poor quality.

Conclusion Researchers have developed questionnaires, and the SUS is the most commonly used method to assess the usability and satisfaction of mobile health applications. Although most questionnaires have not been validated, ensuring the optimal use of mHealth apps via adapted and customized questionnaires is crucial.

Keywords mHealth, Mobile health application, Usability, Satisfaction, Questionnaire

Background

In today's digital era, the use of mobile phones has evolved quickly from being a gadget for communication to being a significant part of daily activities, offering a wide range of accessibilities, especially through the use of mobile applications. Among its various definitions, mobile health (mHealth) can be used to describe the integration of mobile device applications and next-generation technologies in the healthcare sector [1]. MHealth apps have been shown to play important roles in various aspects of disease management, health monitoring, behavioural change, education, and medication adherence [2]. While its uses can range from basic mobile device functions such as voice calls and short message services, it is also capable of more complex functions designed for medical, physical health, and public health purposes [2].

MHealth apps are often designed on the basis of two classifications: type of users and type of mobile apps [3]. The type of user for the app is divided into patients and healthcare providers, and it is determined by their purpose for using the app. When users are patients, they may use the app to maintain, improve, or manage their health, whereas when users are healthcare providers, they may be delivering healthcare services through the app [3]. The next domain, which is the type of mobile app, refers to the nature of the app, whether it is interactive or standalone. Interactive mHealth apps have functions for users to send and receive information from their healthcare providers or communicate with other people, whereas standalone mHealth apps only store, collect and save health information entered by users and do not send data to healthcare providers [3].

Although mHealth apps have many benefits, acceptance among users is still related to ease of use, perceived usefulness, accuracy and quality of content, and consumer attitudes [2]. Studies have shown that well-designed mHealth apps have the ability to empower patients, improve medication adherence, and decrease healthcare costs [4–6]. However, a previous study revealed a decrease in usage among mHealth users for several reasons, such as unseen costs, tedious data entry loads and disinterest [7]. An apparent factor to question when such issues surface would be the usability and satisfaction of the app design, as this indicates whether the app is favoured and used to its optimal potential. Therefore, in efforts to enhance mHealth services, there is an increasing demand for research to assess the usability and satisfaction of mHealth apps. This further leads to the need to systematically review the methods used to evaluate these factors.

Surveys are among the methods most commonly used to evaluate usability, as they are simple to conduct and data analysis is easily quantifiable [3]. Validated usability surveys that are readily available and widely used are fundamentally designed for computerized systems and may not cover aspects that are exclusive to mobile apps [3]. On the other hand, while investigator-derived surveys can be tailored specifically for mobile apps, they are often not validated or have insufficient data for reliable psychometric analysis. For example, a review on the usability of a disease-specific management app revealed that the available apps were incomprehensible and unable to cater to specific target populations [8]. The ideal step forward in ensuring optimal use of the app would be a validated usability and satisfaction questionnaire that is designed specifically for mHealth apps and considers the four aspects of its design. This study aimed to synthesize the current evidence on the types of usability and satisfaction questionnaires available, their use for standalone and interactive mHealth apps, and the validation of the questionnaire.

Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [9] and was registered with the National Medical Research Register of Malaysia (NMRR ID-22–02846-I21). This study was exempt from ethical approval, as the data were extracted from previously published studies.

Search strategy

An extensive search of the literature was conducted via electronic databases, namely, PubMed, Scopus, and Google Scholar. The keywords used for the search included ("mobile health (MeSH Terms)") or ("health (MeSH Terms)") or ("mobile app* (MeSH Terms)") and

("patient satisfaction (MeSH Terms)") or ("user (MeSH Terms)") or ("usability (MeSH Terms)") or ("feasibility (MeSH Terms)") and ("survey (MeSH Terms)"). Further title and abstract keyword searches included "mhealth" or "mobile application" and "questionnaire" and "satisfaction" or "usability". In addition, the references of each retrieved study were screened for relevant titles.

Inclusion and exclusion criteria

Only studies published in the English language and conducted with human subjects between 2000 and June 2023 were included in the literature review. Studies reporting the usability and/or satisfaction of patients or users with mHealth apps with published questionnaires were included.

Studies that did not include questions to assess usability and/or satisfaction were excluded. Studies that assessed the usability and/or satisfaction of health care providers or experts were excluded. Studies such as questionnaire development and validation, translation studies, qualitative studies, reviews, editorials, brief reports, comments, conference proceedings, letters and wrong outcomes were excluded.

These criteria were established to filter out non-relevant studies and ensure that the review focused on types of usability and/or satisfaction questionnaires available to assess interactive or standalone mHealth apps.

Study selection and data collection

Initially, potential eligible studies were selected by screening the title and abstract relevance by two investigators (LPC and RR) independently. After the removal of duplications, the full texts were retrieved. Eligibility was independently assessed by two investigators (LPC and LYL) on the basis of the inclusion and exclusion criteria. Decisions to include or exclude the study were compared between the two investigators. When disagreements arose, the other investigators were consulted if the primary reviewers could not reach a consensus.

A data collection sheet was used to extract the data. The following information was collected from each study: first author, year and country of publication, sample size, demographics of the study population, name and type of mobile health application, assessment tool and validation status, number of questions, domains and scoring. The findings were synthesized narratively as heterogeneity in the study methodologies, which included population, assessment tools and mobile health applications.

Quality assessment

The quality of the eligible studies was independently assessed by two reviewers (RR and LPC) via the Joanna Briggs Institute (JBI) critical appraisal checklist for cross-sectional studies [10]. JBI provided permissions to use and publish the JBI critical appraisal checklist for cross sectional studies. The tool consists of eight questions and one overall appraisal to assess the quality of the study methods and determine the possibility of bias in terms of study design, conduct, and analysis. The answers for every question were yes (Y), no (N), unclear (UC), or not applicable (NA).

Results

The study screening and selection process are shown in Fig. 1. Electronic database searches identified 5703 potentially relevant studies, of which 1964 studies were removed because of duplication. The titles and abstracts were screened, and 3200 studies were found to be irrelevant. The remaining 539 studies underwent full-text review, and 40 studies [11–50] met the inclusion criteria.

The study screening and selection process are shown in Fig. 1.

The studies included originated from the United States of America ($n=13$), Asia ($n=12$), Europe ($n=7$), Australia ($n=4$), Canada ($n=2$) and Brazil ($n=2$). A total of 1552 patients or users, the majority of whom were females (38 studies, 63.2%), were assessed for the usability and satisfaction of mHealth apps through cross-sectional studies. Eight studies were conducted among adolescents [18, 19, 27, 42, 45, 47, 48, 50]. Moreover, three studies assessed the usability and satisfaction of females only, as the mHealth apps were designed for pregnancy [13, 15] and breast cancer [16]. A total of 633 Likert scale questions, 10 open-ended questions and 23 interview questions were identified. The studies are summarized in Table 1. The majority of the mHealth apps (62.5%) were standalone applications.

Usability and satisfaction assessment tools and scoring

Assessment tools

The usability assessment tools are shown in Table 2. Half of the studies (50%) utilized researcher-developed questionnaires, and only 25% of the researcher-developed questionnaires were validated.

The most commonly used existing questionnaire was the System Usability Scale (SUS) [53], with 9 studies [15, 16, 19, 27, 32, 33, 35, 37, 41] using this questionnaire to assess the usability of mHealth apps. Additionally, four studies [14, 23, 29, 34] used a researcher-developed questionnaire that was developed on the basis of the SUS [53]. Few studies [39, 48] have adapted questions from the Post-Study System Usability Questionnaire (PSSUQ) [54] and a study [24] from the Technology Acceptance Model (TAM) [56]. Several researchers have developed questionnaires [25, 29, 34, 42] on the basis of the TAM [56]. Other questionnaires [13, 30, 32, 47] utilized for usability

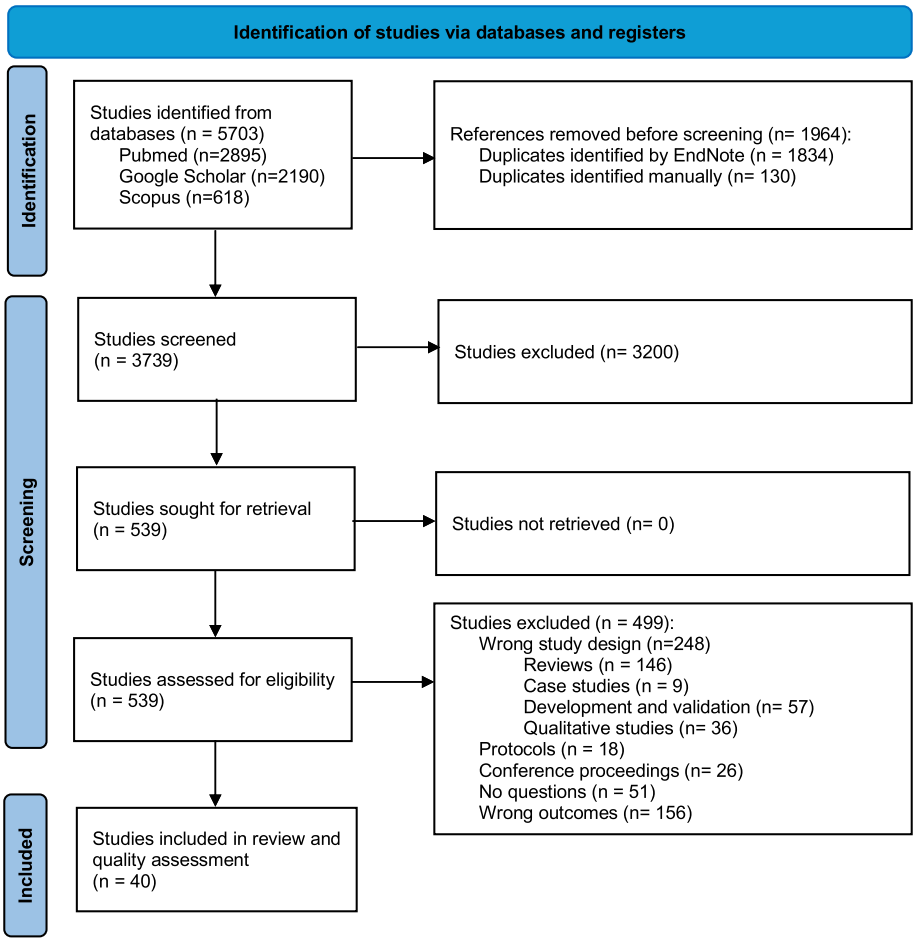

Fig. 1 Flow chart for study screening and selection according to PRISMA guidelines

assessment include the mHealth App Usability Questionnaire (MAUQ) [3] and the Usefulness, Satisfaction and Ease of Use (USE) questionnaire [55].

Fifteen studies [11–25] used interactive mHealth apps, eight studies assessed usability via a researcher-developed questionnaire, and three studies used the SUS [53] (Table 2). Nevertheless, only eight studies that utilized interactive apps had questions related to the connection between patients or users and healthcare providers [11–13, 17, 21–23] or the same community [18]. Although the other seven studies used interactive apps, the usability questionnaire focused on usefulness, ease of use, interface and satisfaction.

Only 30% of the studies validated the questionnaire. The validation status of the questionnaire is summarized in Fig. 2.

Scoring

Among the questionnaires, only the SUS [53], Smartphone Usability Questionnaire (SURE) [59] and Health Information Technology Usability Survey (Health-ITUES) [58] elaborated on the scoring. In the SUS [53], odd questions are positive, whereas even questions are negative. A new number was formed by subtracting one from the response for odd questions and five for even questions. The total number of new numbers was added and multiplied by 2.5 to convert to a total ranging from 0 to 100. Good usability was considered when the score was above 68 [27]. On the other hand, the total score for SURE was 124 points. If the total score was 80 or above, the respondents agreed with the usability of the scale [36]. Moreover, the total score for Health-ITUES ranges from 20 to 100, with a higher score indicating better usability [28].

Quality assessment

When the JBI critical appraisal checklist was used to assess quality, 14 (35%) studies were assessed as poor quality (Table 3). However, all studies were included. Only studies conducted by Jaffar et al. [13], Chen et al. [28], and Everett et al. [41] received yes for every question for the quality assessment. A total of 95% of the

Table 1 Summary of study characteristics, mHealth apps, assessment tools and validation status

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Interactive apps					
Chiang et al. [11], (2023), Taiwan	$n=20$, convenient sampling	Mean age 21.1 ± 2.51 years	Healthcare CEO application catered to the needs of type 1 diabetes patients transitioning from adolescent to young adulthood	7th Edition of the Questionnaire for User Interaction Satisfaction (QUIS). 19 questions, 5-point Likert scale. 7 domains- overall user response (5), interface (2), learning (2), multimedia (3), content (5), system performance (1) and online consultation (1). Additional one open ended questions	No
Bosse et al.[12], (2022), United States	$n=31$, convenient sampling	55% female, mean age 42.2 years (range 22–69 years)	Boulder Care. To provide patient centred tele-health to opioid use disorder patients	Researchers developed questionnaire. 24 questions, Likert scale 1 (not) to 5 (completely) and another one 0 (not at all) to 10 (extremely). 5 dimensions- comfort, interest and recommendation (3), usability, appeal and lifestyle fit (3), helpfulness of current app features (6),usefulness of proposed app features (5), likeliness of using proposed features (7). Researcher developed interview guide, 7 questions	No
Jaffar et al. [13], (2022), Malaysia	$n=10$, convenient sampling	100% female, mean age 28.9 ± 3.1 years	Kegel exercise pregnancy training (KEPT) app to empower pregnant women to adhere to pelvic floor muscle training to improve urinary incontinence	Validated forward and backwards translation to Malay version of mHealth Application Usability Questionnaire (MAUQ) interactive version. 21 questions Likert scale of 1 to 7. 3 domains- ease of use and satisfaction (8), system information arrangement (6) and usefulness (7)	Yes
Jiang et al. [14], (2022), China	$n=15$, convenient sampling	53% female, mean age 42.3 ± 17.4 years	Alfafa app to provide warfarin dose adjustment remotely	Researcher developed questionnaire based on System Usability Scale (SUS) in Chinese version. 14 questions, Likert scale of 1 to 5. 3 domains- demographic (4), usability (8), learnability (2)	No
Lee et al. [15], (2022), South Korea	$n=31$, convenient sampling, 83.8% (initial 37)	100% female, mean age 32.94 ± 3.2 years	SPWW app to provide prenatal education and enhance self-care practice for Korean pregnant women at work	Validated SUS. 10 questions, Likert scale of 1 (strongly disagree) to 5 (strongly agree) and 4 open-ended questions	Unclear

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Rezaee et al. [16], (2022), Iran	*n* = 25, convenient sampling	100% female	CaRA app to educate breast cancer patients to improve their resilience	SUS. 10 questions, Likert scale of 1 (strongly disagree) to 5 (strongly agree)	No
Kooij et al. [17], (2021), Netherlands	*N* = 39, convenient sampling, 94.9%	77% female, mean age 62.2 ± 6.7 years	COPD app. 8-week health and self-management program	Total 21 questions, 18 questions using Likert scale 1 (totally disagree) to 7 (totally agree), 1 multiple answers questions, 1 open ended question and 1 overall satisfaction question on a scale of 1 (not satisfied) to 10 (very satisfied). 5 domains- usability (2), lung attack action plan (3), information (10), overall satisfaction and improvement (2), video consultation (4)	Unclear
Francis et al. [18], (2020), Australia	*n* = 22, convenient sampling, 37% (initial 59)	50% female, aged 12 to 18 years	CyFi Space. To support social connectedness (interact with peers via LIveWire chatroom) and well-being of young people living with cystic fibrosis	Validated questionnaire adapted from Cai et al. [51] and Wood et al. [52]. 16 questions, Likert scale 1 (strongly disagree) to 7 (strongly agree). 2 domains-usability (7) and acceptability (9). Mixed method with interview via online on use of the app, positive and negative experiences using the app and recommendation to improve the app	Yes
Rudolf et al. [19], (2019), Germany	*N* = 27, convenient sampling, 74.1%	14 female, 11 male, mean age 16 ± 3 years	KiOAPP app. Self-management app for cystic fibrosis in adolescent and young adults	SUS translated from English to German and self-developed questionnaire on application usage and satisfaction. 10 questions from SUS, Likert scale 1 (decline very much) to 5 (agree very much) and 15 questions (4 questions on frequency, 2 questions on free text, 9 questions using likert scale 1 (agree) to 4 (do not know)	Unclear
Støme et al. [20], (2019), Norway	*N* = 12, convenient sampling, 91.7%	83.3% female, mean age 65 years (ranging from 61 to 70 years)	Vett app. Behavioural change and habit formation to achieve goal for osteoarthritis patients	User satisfaction questions. 10 questions, Likert scale 0 (complete disagreement) to 100 (complete agreement). 2 domains- technical feasibility (usability) (4) and user satisfaction (utility) (6)	No

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Bauer et al. [21], (2018), United States	$n=18$, convenient sampling, 94.4%	59% female. 35% aged 25–34 years	Ginger.iO app. Collaborative care program for people with depression and anxiety	Developer's product feedback survey, 20 questions, 7 questions using Likert scale 6-point from strongly disagree to strongly agree and 13 questions to measure technology obtrusiveness using Likert scale 7-point	No
Casida et al. [22], (2018), United States	$n=18$, convenience sampling, 88.9%	Patients, 100% male and caregivers, 87.5% female	VAD Care app. Self-management for left ventricular assist device	Researcher developed App Evaluation Questionnaire, 14 questions using Likert scale 1 (strongly disagree) to 5 (strongly agree) and 1 open ended question. 3 domains—acceptability (5), usability (6), competency (3)	No
Liu et al. [23], (2018), United States	$N=16$, convenient sampling, 100%	Median age 58 (IQR 36–80) years	eCO app. Management of hypertension and diarrhoea among ovarian cancer patients	Derived from SUS and validated using cognitive interview, 17 questions, Likert scale 1 (strongly disagree) to 4 (strongly agree). 3 domains- usability, usability of the features, how eCo made in relation to the trial	Yes
Chen et al. [24], (2017), Malaysia	$n=28$, purposive sampling, 100%	University students, 89.3% female, mean age 22.0 ± 0.9 years	Food app. Food diary mobile application	Modified the validated TAM, 29 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree). 8 domains—perceived ease of use, perceived usefulness, perceived enjoyment, attitude towards food app, social influence, intention to use, system quality, and smartphone experience and 2 open ended questions for problems or issues encountered and recommendation to improvise the app	No
Al Ayubi et al. [25], (2014), United States	$N=14$, convenient sampling, 92.9%	76.9% females, age range from 24 to 45 years	PersonA app. Physical activity promotion app	Questionnaire adapted from TAM, PSSUQ and Nielsen's attribute of usability, 11 questions, Likert scale 1 (totally disagree) to 5 (totally agree), 5 domains- learnability, efficiency, memorability, error recovery, and satisfaction	No

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Standalone Apps					
Alali et al. [26], (2022), Saudi Arabia	$n=146$, snowball random sampling	92.5% female, 80.2% age < 40 years	Mawid app.For users to book, cancel and/or reschedule appointments at primary healthcare centres and referral appointments, COVID-19 risk assessment tool	Researchers developed questionnaire. Validated by 3 experts and reliability test with 5 participants. 5 questions, Likert scale 1 (difficult) to 5 (very easy). 1 domain- ease of use	Yes
Akmal Muhammad et al. [27], (2021), Malaysia	$n=10$, convenient sampling, 100%	Parents of 4 to 6 years old children. 100% female, mean age 37.1 ± 3.45 years	Gigiku Sihat, diet and oral health application for parents or guardians of preschool children	'*Skala Kebolehgunaan Aplikasi Mudah Alih*' (SKAMA), the translated and validated Malay version of the SUS questionnaire, 10 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree). 3 domains- effectiveness, efficiency and user satisfaction	Yes
Chen et al. [28], (2021), China	$n=88$, convenient sampling	28% female, mean age 60 ± 9.9 years	iCARE app to facilitate behavioural modification and medication adherence among patients with coronary heart disease	Modified Health Information Technology Usability Evaluation Scale (Health-ITUES). 20 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree). 4 domains- impact (3), perceived usefulness (9), perceived ease of use (5), user control (3)	Yes
Chulasai et al. [29], (2021), Thailand	$n=19$, purposive sampling	31.6% female, mean age 20.42 ± 1.46 years	Quit with US app to provide smoking cessation assistance to young adults aged 18 to 24 years	Developed based on Technology Acceptance Model (TAM) and SUS. 28 questions, Likert scale 1 (the lowest) to 5 (the highest). 3 domains- satisfaction of design (9), satisfaction of content (11) and confidence (8)	Yes
Chumkasian et al. [30], (2021), Australia	$n=94$, convenient sampling, 79% (initial $n=119$)	53.2% female, 49.31 ± 18.08 years	Eye Donor Aust App for eye donation among Australians, to provide person-centred and high quality information to empower people to register as an eye donor	Adapted and validated Mobile Health App Usability Questionnaire (m-MAUQ). 15 questions, Likert scale 1 (strongly disagree) to 7 (strongly agree). 3 domains- ease of use and satisfaction (9), usefulness in obtaining information (3) and system information arrangement (3)	Yes

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Hsia et al. [31], (2021), United States	$n=30$, convenient sampling	86.7% female, mean age 42.8 ± 14.4 years	ASTHMAXcel mobile application to provide education and personalized approach in managing asthma patients	Adapted standardized questionnaire. 8 questions, Likert scale of 1 (strongly disagree) to 5 (strongly agree). 6 domains- understanding of information, comprehensiveness, comfort level, general satisfaction and ease of use and technology specific (2)	No
Tonga et al. [32], (2021), Turkey	$N=20$, convenient sampling, 85%	94.1% female, median age 48 (IQR 39–61) years	MarHand TherapyApp. Hand exercise prescription form for rheumatoid arthritis patients	SUS and adapted Usefulness, Satisfaction and Ease to Use Questionnaire (USE) Questionnaire, 10 questions for SUS, Likert scale 1 (strongly disagree) to 5 (strongly agree). 10 questions for USE, Likert scale 1 (strongly disagree) to 5 (strongly agree). 2 domains- ease of use (5) and satisfaction (5). Mixed method as interview for qualitative, 12 questions	No
Valente et al. [33], (2021), Brazil	$n=36$, rational choice sampling	55.5% female, mean age 51 years (range from 22–69)	GlaucoCheck app to provide education to improve knowledge and facilitate treatment for patients with glaucoma	SUS. 10 questions, Likert scale of 1 (completely disagree) to 5 (completely agree)	No
Adu et al. [34], (2020), Australia	$n=50$, convenient sampling, 82%	39% female, mean age 49.29 ± 12.74 years	My Care Hub (MCH) app, evidence-based support and education to promote self-management behavioural change in Type 1 and Type 2 diabetes patients	Adapted from USE, TAM and SUS,18 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree). 3 domains- ease of use/intelligibility/satisfaction (7), value (7) and intention for use and recommendation (4). Mixed method. Researcher developed interview guide	No
Ji et al. [35], (2020), Canada	$N=102$, random sampling, 70.6%	65.3% female. Mean age 38.5 ± 16.7 years	Keenoa app. Artificial intelligence image based dietary assessment app and food journal	SUS, 10 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree) and additional 3 questions	Unclear
Marques et al. [36], (2020), Brazil	$N=15$, convenient sampling, 100%	60% female, mean age 50.8 ± 14.4 years	PedCare app. Foot care app for diabetes patients	Smartphone Usability Questionnaire (SURE), 31 questions, Likert scale 1 (inadequate) to 4 (totally adequate) and not applicable (NA)	Unclear
Sung et al. [37], (2020), South Korea	$N=70$, convenient sampling, 62.9%	83% female	App to inform medical record changes	Modified SUS, 10 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree)	No

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Battineni et al. [38], (2019), Italy	Phase 1, $n=13$; phase 2, $n=15$, convenient sampling, 100%	Phase 1: staffs and university students Phase 2 seafarers	Wellness on ship (WOS) app. Physical education for seafarers	Researcher designed survey, 9 questions. Likert scale 0 (very unsatisfied) to 5 (very satisfied). 3 domains- usability (3), feasibility (4) and satisfaction (2)	No
Zhou et al. [39], (2019), United States	$N=15$, randomly selected from 104 patients who expressed interest	46.7% female, mean age 35.3 ± 15.24 years	PittPHR app. Personal health record app to manage personal health data	Post-Study System Usability Questionnaire (PSSUQ), 19 questions, Likert scale 1 (strongly agree) to 7 (strongly disagree)	No
Ambrosini et al. [40], (2018), Australia	$n=68$, convenient sampling, 73.5%	82% female, mean age 31 years	Easy Diet Diary app., dietary assessment tool	Experience using the app, 10 questions using Likert scale (strongly disagree, disagree, undecided, agree or strongly agree) and 2 open-ended questions. 4 domains- ease of use, learnability, convenience, and perceived accuracy	No
Everett et al. [41], (2018), United States	$N=55$, convenient sampling, 85.4%	60% female, mean age 55.0 ± 10.6 years	Sweetch app. For prediabetes to promote adherence to physical activity and weight reduction	Adapted and validated SUS, 10 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree)	Yes
Wu et al. [42], (2018), United States	$N=32$, convenient sampling, 72% ($n=23$) completed the study	$N=23$, 39% female, mean age 19.7 ± 4.3 years	Dosecast app. Medication reminder to promote oral medication adherence among adolescent and young adult cancer patients	Researcher-developed smartphone application acceptability questionnaire adapted from TAM, reliability test done, 13 questions, Likert scale 1 (not at all easy) to 5 (very easy). 2 domains—perceived ease of use (6), perceived usefulness (7)	Yes
Boisseau et al. [43], (2017), United States	$N=21$, convenient sampling, 71.4%	76.2% female, mean age 36.6 ± 10.9 years	LiveOCDFree app. For obsessive compulsive disorder to conduct exposure and response prevention program	Investigators created acceptability questionnaire, 8 questions, Likert scale 1 (very difficult to use) to 7 (very easy to use) and several open-ended questions. 5 domains—overall usability (1), rate the component of the apps (4), usefulness of the apps to manage symptom (1), recommend the app to friend (1), continue use the app (1)	No
Boushey et al. [44], (2017), United States	$n=45$, convenient sampling, 83.3% (initial $n=54$)	66.7% female, mean age 33 ± 12 years	Mobile food record (mFR) application to assess dietary intake. Capture the food with mobile phone camera to estimate the energy and nutrient intake	19 questions, results presented in strongly agree or agree, neither agree or disagree and disagree or strongly disagree	No

Table 1 (continued)

Author, (publication year), country	Sample size, sampling method, response rate	Population characteristics	mhealth app	Assessment tool, number of questions, type of domains (number of questions, n)	Validation
Lee et al. [45], (2017), South Korea	$N=33$, convenient sampling, 63.6%	72.7% female, mean age of male 16.9 ± 0.3 years and mean age of female 17.4 ± 0.6 years	Diet-A app. Dietary intake monitoring among adolescents	Adopted questions from previous studies, 21 questions, Likert scale 1 (totally disagree) to 5 (totally agree). 3 domains- satisfaction, convenience and efficiency	No
Prada et al. [46], (2017), Switzerland	$n=16$, convenient sampling, 75% (12 responded)	100% female, mean age 30.5 ± 9.3 years	EMOTEO app to help borderline personality disorder patients to regulate their emotion especially when their therapist was not reachable	Researcher developed questionnaire. 16 questions, likert scale of 1 (I don't agree) to 5 (I agree)	Yes
Stoll et al. [47], (2017), United States	$n=132$, convenient sampling	63% female, mean age 9.65 ± 0.82 years	REACH app to provide support, prevent and early intervention to anxiety among the youth	Adapted from USE and the Reactions to Program Scale (RPS). 26 questions, Likert scale 1 (not at all) to 10 (very much). 5 domains- ease of use (11), quality of support information (3), ease of learning (4), satisfaction (4) and social acceptability (4)	Yes
Shellmer et al. [48], (2016), United States	$N=7$ adolescents, $n=9$ caregivers, purposive sampling, 37.5%	57% female adolescents and 88% female caregivers, median age for adolescents 15 (IQR 11–18) years and for caregivers 49 (42–61) years	TPP (Teen Pocket PATH) app. Medication adherence and self-management for transplanted adolescents	PSSUQ, 8 questions, Likert scale 1 (strongly agree) to 7 (strongly disagree). Mixed method as interview for qualitative questions.3 domains for interview questions- general medical management, medication tracking and help features and appearance	No
Wilson et al. [49], (2016), Canada	$N=76$, convenient sampling, 28% ($n=21$) completed survey	$N=21$, 47.6% female, Median age 34.7 (IQR 13) years	CANVAS app. Adverse Event Following Immunization (AEFI) reporting of influenza vaccination	Usability Survey. 9 questions, Likert scale 1 (strongly disagree) to 5 (strongly agree)	No
Kenny et al. [50], (2015), Ireland	$N=43$, convenient sampling, 100%	88% female, mean age 16.0 ± 0.724 years	CopeSmart app. Foster positive mental health among adolescents	Self-report questionnaire, 16 questions, 3 domains- Usefulness ratings, App layout, Ease of use. Open-ended questions on the aspects of the app	No

Table 2 Types of questionnaires for interactive and standalone mHealth apps

Questionnaire	Interactive apps	Standalone apps
System Usability Scale (SUS) [53]	Lee et al. [15], Rezaee et al. [16], Rudolf et al. [19]	Akmal Muhammad et al. [27], Tonga et al. [32], Valente et al. [33], Ji et al. [35], Sung et al. [37], Everett et al. [41]
mHealth App Usability Questionnaire (MAUQ) [3]	Jaffar et al. [13]	Chumkasian et al. [30]
Post-Study System Usability Questionnaire (PSSUQ) [54]	-	Zhou et al. [39], Shellmer et al. [48]
Usefulness, Satisfaction and Ease of Use (USE) [55]	-	Tonga et al. [32], Stoll et al. [47]
Technology Acceptance Model (TAM) [56]	-	Chen et al. [24]
Questionnaire for User Interaction Satisfaction (QUIS) [57]	Chiang et al. [11]	-
Health Information Technology Usability Survey (Health-iTUES) [58]	Chen et al. [28]	-
Cai et al. [51] & Wood et al. [52]	Francis et al. [18]	-
Smartphone Usability Questionnaire (SURE) [59]	-	Marques et al. [36]
User Satisfaction Questionnaire [20]	Støme et al. [20]	-
Usability survey [60]	-	Wilson et al. [49]
Reactions to Program Scale (RPS) [61]	-	Stoll et al. [47]
Researcher developed questionnaire	Bosse et al. [12], Jiang et al. [14], Kooij et al. [17], Rudolf et al. [19], Bauer et al. [21], Casida et al. [22], Liu et al. [23], Al Ayubi et al. [25]	Alali et al. [26], Chulasai et al. [29], Hsia et al. [31], Adu et al. [34], Ji et al. [35], Battineni et al. [38], Ambrosini et al. [40], Wu et al. [42], Boisseau et al. [43], Boushey et al. [44], Prada et al. [46], Kenny et al. [50]

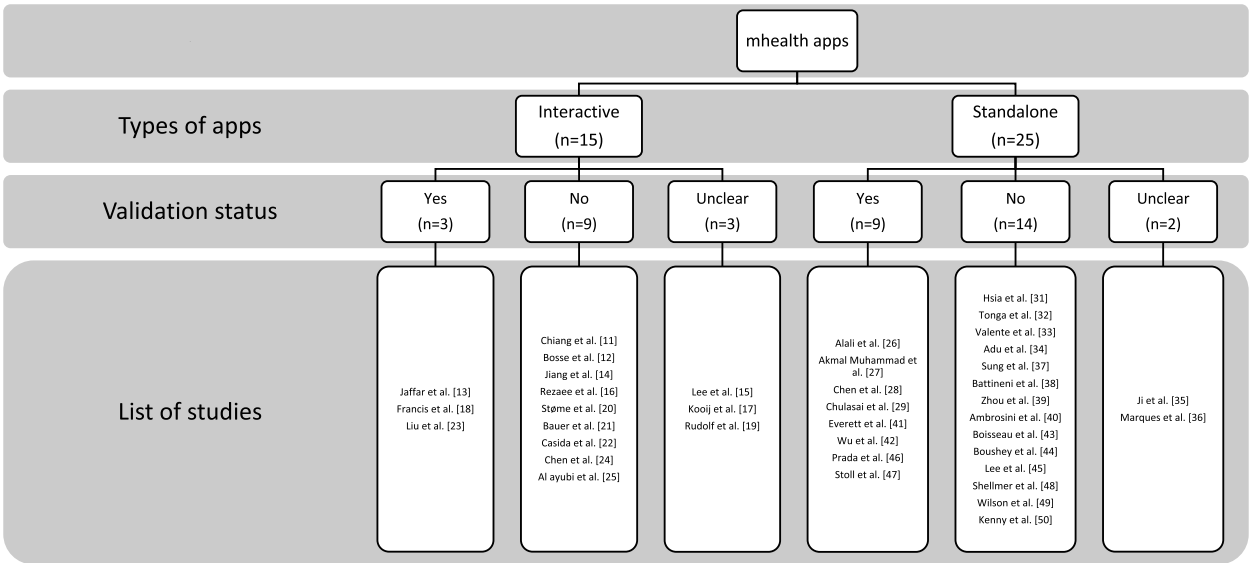

Fig. 2 Validation status of the questionnaire for interactive and standalone mHealth apps

studies used nonprobability sampling methods, with the majority using convenient sampling methods. The studies by Ji et al. [35] and Zhou et al. [39] reported random sampling. The majority of the studies did not validate the questionnaire.

Discussion

This review highlighted multiple questionnaires that were utilized to assess the usability of mHealth apps. It is vital to assess the usability of an mHealth app to ensure that it meets users' preferences and expectations as well

Table 3 Quality assessment via the Joanna Briggs Institute (JBI) critical appraisal checklist [10]

Authors	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Overall
Chiang et al. [11] 2023	Y	Y	Y	N	N	N	N	Y	Include (Poor)
Bosse et al. [12] 2022	Y	Y	N	N	UC	N	N	N	Include (Poor)
Jaffar et al. [13] 2022	Y	Y	Y	Y	Y	Y	Y	Y	Include
Jiang et al. [14] 2022	N	N	N	Y	Y	Y	N	Y	Include (Poor)
Lee et al. [15] 2022	Y	Y	Y	Y	Y	Y	UC	Y	Include
Rezaee et al. [16] 2022	Y	Y	Y	Y	Y	N	N	Y	Include
Kooij et al. [17] 2021	Y	Y	Y	Y	Y	N	UC	Y	Include
Francis et al. [18] 2020	Y	Y	N	Y	Y	Y	Y	Y	Inlcude
Rudolf et al. [19] 2019	Y	Y	Y	Y	Y	Y	UC	Y	Include
StØme et al. [20] 2019	Y	Y	Y	Y	Y	Y	N	Y	Include
Bauer et al. [21] 2018	Y	Y	UC	Y	Y	Y	N	Y	Include
Casida et al. [22] 2018	Y	Y	UC	Y	Y	N	N	Y	Include
Liu et al. [23] 2018	N	Y	Y	Y	N	N	Y	Y	Include
Chen et al. [24] 2017	Y	Y	N	Y	Y	N	N	N	Include (Poor)
Ayubi et al. [25] 2014	Y	Y	N	Y	N	N	N	N	Include (Poor)
Alali et al. [26] 2022	N	Y	Y	Y	Y	N	Y	Y	Include
Akmal Muhammad et al. [27] 2021	Y	Y	Y	Y	N	N	Y	Y	Include
Chen et al. [28] 2021	Y	Y	Y	Y	Y	Y	Y	Y	Include
Chulasai et al. [29] 2021	Y	Y	Y	Y	Y	N	Y	Y	Include
Chumkasian et al. [30] 2021	Y	Y	Y	Y	Y	N	Y	Y	Include
Hsia et al. [31] 2021	Y	Y	N	Y	Y	Y	N	Y	Include
Tonga et al. [32] 2021	N	Y	N	Y	Y	N	N	Y	Include (Poor)
Valente et al. [33] 2021	Y	Y	N	Y	Y	N	N	Y	Include (Poor)
Adu et al. [34] 2020	Y	Y	UC	Y	Y	Y	N	Y	Include
Ji et al. [35] 2020	Y	Y	Y	Y	Y	Y	UC	Y	Include
Marques et al. [36] 2020	Y	Y	Y	Y	Y	N	UC	Y	Include
Sung et al. [37] 2020	N	Y	Y	Y	N	N	N	Y	Include (Poor)
Battineni et al. [38] 2019	N	N	N	N	Y	N	N	N	Include (Poor)
Zhou et al. [39] 2019	N	Y	N	Y	Y	Y	N	Y	Include (Poor)
Ambrosini et al. [40] 2018	Y	Y	UC	Y	Y	Y	N	Y	Include
Everett et al. [41] 2018	Y	Y	Y	Y	Y	Y	Y	Y	Include
Wu et al. [42] 2018	Y	Y	UC	Y	N	N	Y	Y	Include
Boisseau et al. [43] 2017	Y	Y	Y	Y	Y	N	N	Y	Include
Boushey et al. [44] 2017	Y	Y	N	N	N	N	N	Y	Include (Poor)
Lee et al. [45] 2017	Y	Y	N	Y	Y	N	N	Y	Include
Prada et al.[46] 2016	Y	Y	Y	Y	Y	N	Y	Y	Include
Stoll et al. [47] 2017	N	Y	Y	Y	N	N	Y	N	Include (Poor)
Shellmer et al. [48] 2016	Y	Y	Y	Y	Y	Y	N	N	Include
Wilson et al. [49] 2016	N	Y	N	Y	N	N	N	N	Include (Poor)
Kenny et al. [50] 2015	Y	Y	N	Y	N	N	N	Y	Include (Poor)

Y Yes, *N* No, *UC* Unclear, *NA* Not applicable

Q1: Were the criteria for inclusion in the sample clearly defined?

Q2: Were the study subjects and the setting described in detail?

Q3: Was the exposure measured in a valid and reliable way?

Q4: Were objective, standard criteria used for measurement of the condition?

Q5: Were confounding factors identified?

Q6: Were strategies to deal with confounding factors stated?

Q7: Were the outcomes measured in a valid and reliable way?

Q8: Was appropriate statistical analysis used?

as the optimal use of the app. SUS [53], which was originally developed to assess the usability of the system, was the most commonly used questionnaire for both interactive and standalone mHealth apps. In addition, the SUS was translated into multiple languages, such as Malay [27], German [19] and Chinese [14]. Moreover, the SUS is an easy and quick tool for assessing usability with scoring. This enabled the SUS to be the most preferred option because it could be used across a wider variety of subjects.

Other questionnaires, such as the PSSUQ [54] and TAM [56], were originally designed to assess the usability of computer systems and to measure the acceptance and use of technology, respectively. The SURE questionnaire reported by Marques et al. [36] was not designed for the assessment of mHealth but rather for the usability assessment of smartphones. However, there was no statement on the validation, adaptation, or adoption of the questionnaire, and a comparison with the original article could not be made, as the latter was not in English [59]. This review highlights the point that these questionnaires were not specific to mHealth apps. However, these questionnaires have been adopted and adapted in many studies and have often not been validated. A common reason for this could be that the validation process is often very time-consuming and can pose a challenge for those inexperienced in questionnaire development and validation. As a consequence, certain usability aspects of mHealth apps may not be reliably measured. Furthermore, these questionnaires may not gauge the benefit of mHealth apps for end users, as they are unable to provide unique information related to mHealth apps.

A few researchers have developed questionnaires consisting of Likert scale questions and open-ended questions [19, 22, 40, 50] or mixed methods with interview questions [12, 18, 32, 48]. The interviews and open-ended questions were intended to evaluate the recommendations to improve the apps and the satisfaction of the respondents with the app as well as the medical care service.

On the other hand, Health-ITUES was designed to assess the perceptions of nurses toward a web-based communication system [58]. To cater to a different target population, a previous study modified and validated the Health-ITUES to assess the usability of mHealth apps among HIV patients [62]. Additionally, Chen et al. modified and validated the Health-ITUES to assess the perceptions of chronic heart disease patients towards self-management and risk factors [28].

Interactive mHealth apps are possibly more favourable, as they involve communication between patients or users and either healthcare providers or the community that has the same disease. This function improved access to healthcare and served as a sharing platform for the users [63]. Considering that only 53% of the studies involving interactive mHealth apps assessed the communication between the users and healthcare providers or the community, a more in-depth questionnaire would be more beneficial in assessing these vital functions of interactive apps.

In 2019, Zhou et al. developed a 21-item mHealth App Usability Questionnaire (MAUQ) with three domains, namely, ease of use and satisfaction (8 items), system information arrangement (6 items) and usefulness (7 items), for interactive mobile applications for health from the patient's perspective. In addition, an 18-item questionnaire for standalone mHealth for patients was developed with questions on ease of use (5 items), interface and satisfaction (7 items) and usefulness (6 items) [3]. Jaffar et al. utilized the translated and validated Malay version of the MAUQ as an interactive app [13]. The MAUQ is more specific for assessing the usability of end users towards mHealth apps, as it consists of health-related questions such as those concerning access to health, interactions with healthcare providers and improvements in self-management.

While the MAUQ questionnaires were more specific for assessing the usability of end users for mHealth apps, the majority of the studies utilized researcher-developed questionnaires. This is possibly because each mHealth app has its own unique features and functions such that only app-specific questionnaires can be used to assess the usability and satisfaction of its end users comprehensively. However, the main issue was that these questionnaires, although they were designed most specifically for the app, were almost always not validated. Tsang et al. concluded that to ensure that a questionnaire is psychometrically adequate, it is necessary that it undergoes a validation process [64].

This review synthesized evidence from questionnaires used to assess the usability and satisfaction of end users with mHealth apps, which included vigorous searches via multiple databases. Every phase involved two reviewers, hence reducing bias. Nevertheless, the findings of this review should be interpreted in light of its limitations. Although extensive search strategies were employed to identify relevant articles, some studies may have been missed because of the terminology used. In addition, non-English language articles were excluded, which may have reduced the representativeness of our findings. This review involved a usability assessment of multiple mHealth apps for various health and disease types. In addition, the wide variety of questionnaires used with limited scoring caused the reporting of the results to be inconsistent across the studies. Several studies were of poor quality but were included

because the intention was to review the current evidence from questionnaires.

The overall implication of these results highlights the existence of a significant gap in the available tools for assessing the usability and satisfaction of mHealth apps. The lack of validated, intentionally designed questionnaires specific to mHealth apps compromises the reliability of research outcomes, whereas the adaptation of existing tools may fail to fully achieve an optimal user experience. Researchers and practitioners in the field should direct their aim towards developing, validating and implementing more targeted questionnaires that are intended to assess not only usability but also user satisfaction and the impact of interactive features, which are key to the successful use of these technologies in healthcare settings. Addressing these issues would be an effective pathway towards sustaining mHealth apps, thus ensuring better healthcare services and improved patient outcomes.

Conclusion

Various questionnaires have been used to assess the usability and satisfaction of mobile health applications, with the majority being researcher-developed questionnaires followed by the System Usability Scale (SUS) for both interactive and standalone mobile health applications. The majority of the questionnaires were not validated prior to use. In addition, most existing questionnaires that are readily available were not designed to assess the usability of mHealth apps specifically; however, they were adapted or modified to customize to the mHealth app without validation. More than half of the studies involving interactive apps comprehensively assess features exclusive to interactive apps. It is vital to assess the benefit of this function, as it allows healthcare providers to extend the reach to patients. Researchers have developed questionnaires, although the optimal design flexibility is still a drawback if it is not validated. The usability and satisfaction of mHealth apps are important measures for ensuring their continuous use. Ideally, all questionnaires should be customized and validated for a specific mHealth app prior to assessment of its usability and satisfaction.

Abbreviations

App	Application
AEFI	Adverse event following immunization
CEO	Chief executive officer
COVID-19	Coronavirus Disease
Health-ITUES	Health Information Technology Usability Survey
HIV	Human immunodeficiency virus
JBI	Joanna Briggs Institute
KEPT	Kegel exercise pregnancy training
MAUQ	MHealth App Usability Questionnaire
mHealth	Mobile health
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSSUQ	Post-Study System Usability Questionnaire
QUIS	Questionnaire for User Interaction Satisfaction
RPS	Reactions to Program Scale
SKAMA	*'Skala Kebolehgunaan Aplikasi Mudah Alih'*
SURE	Smartphone Usability Questionnaire
SUS	System Usability Scale
TAM	Technology Acceptance Model
USE	Usefulness, Satisfaction and Ease of Use

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P.C.L., Y.L.L., R.R. and H.Z. contributed to the study conception, design, material preparation and analysis. All authors contributed equally to this work including data collection, writing and review of manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This research is registered in the National Medical Research Register, Malaysia (No. NMRR-22–02846-I21) and approved by the Medical Research Ethics Committee, Malaysia. There was no consent form involved in the literature search, and no patient identifiers were used.

Consent for publication

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Competing interests

The authors declare no competing interests.

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