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Preferences of people with chronic kidney disease regarding digital health interventions that promote healthy lifestyle: qualitative systematic review with meta-ethnography

Thái Bình Trần ,[1,2] Meghan Ambrens ,[3,4] Jennifer Nguyễn,[2,5] Eve Coleman,[3,5] Yannick Gilanyi,[5,6] Meg Letton,[1,3] Anurag Pandit,[5] Logan Lock,[5] Jeanette M Thom ,[7,8] Shaundeep Sen,[2,9] Kelly Lambert ,[1,10] Ria Arnold [1,2,5]

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For numbered affiliations see end of article.

Correspondence to
Associate Professor Ria Arnold; rarnold@uow.edu.au

ABSTRACT

Objectives Diet and physical activity are crucial for people with chronic kidney disease (CKD) to maintain good health. Digital health interventions can increase access to lifestyle services. However, consumers' perspectives are unclear, which may reduce the capacity to develop interventions that align with specific needs and preferences. Therefore, this review aims to synthesise the preferences of people with CKD regarding digital health interventions that promote healthy lifestyle.

Design Qualitative systematic review with meta-ethnography.

Data sources Databases Scopus, CENTRAL, MEDLINE, CINAHL and SPORTDiscus were searched between 2000 and 2023.

Eligibility criteria Primary research papers that used qualitative exploration methods to explore the preferences of adults with CKD (≥18 years) regarding digital health interventions that promoted diet, physical activity or a combination of these health behaviours.

Data extraction and synthesis Two independent reviewers screened title, abstract and full text. Discrepancies were resolved by a third reviewer. Consumers' quotes were extracted verbatim and synthesised into higher-order themes and subthemes.

Results Database search yielded 5761 records. One record was identified following communication with a primary author. 15 papers were included. These papers comprised 197 consumers (mean age 51.0±7.2), including 83 people with CKD 1–5; 61 kidney transplant recipients; 53 people on dialysis. Sex was reported in 182 people, including 53% male. Five themes were generated regarding consumers' preferences for digital lifestyle interventions. These included simple instruction and engaging design; individualised interventions; virtual communities of care; education and action plans; and timely reminders and automated behavioural monitoring.

Conclusion Digital health interventions were considered an important mechanism to access lifestyle services. Consumers' preferences are important to ensure future interventions are tailored to specific needs and goals. Future research may consider applying the conceptual framework of consumers' preferences in this review to develop and evaluate the effect of a digital lifestyle intervention on health outcomes.

PROSPERO registration number CRD42023411511.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The meta-ethnography approach allowed reviewers to generate novel, whole-of-phenomenon understandings that transcend the scope of any single study.
⇒ However, this approach is not without limitations. Since meta-ethnography seeks to synthesise qualitative studies with varying participants, settings and contexts; contextual nuances in each study may not be represented in the final synthesis.
⇒ Meta-ethnography is limited to qualitative evidence synthesis and may not be suitable for researchers looking to understand the scope of the literature on a topic.
⇒ The final synthesis does not provide immediate practical advice but rather a framework to inform further investigation.
⇒ Finally, meta-ethnography is a relatively new approach and there continues to be debates about the best meta-ethnography process, including eligibility criteria and appropriate number of constituent studies in a review.

INTRODUCTION

Chronic kidney disease (CKD) is a prevalent yet under-recognised condition characterised by irreversible kidney dysfunction.[1] Between 2017 and 2022, CKD affected 1 in 10 adults worldwide[2]; was the 12th-leading cause of global mortality[3] and accounted for 35 million disability-adjusted life-years.[4] People with CKD have a high risk of physical disability[5 6] and cardiovascular mortality[7 8] due to systemic complications such as cardiovascular and

neuromuscular disorders.[9–11] Furthermore, CKD incurs severe financial burden with the highest mean annual cost per person attributed to advanced stages requiring haemodialysis (INT$57 334) or transplantation (incident: INT$75 326; follow-up: INT$16 672).[12] Despite its burden, CKD is largely under-recognised with poor rates of documentation in primary care[13 14] and low recognition among people with biomarkers of kidney dysfunction.[15] Proactive strategies are needed to develop disease awareness, increase access to life-extending care and minimise disease burden.

Diet and physical activity are key strategies to prevent deterioration of health outcomes,[16 17] optimise health-related quality of life[18 19] and maintain physical independence[18 20 21] for people with CKD. However, consumers face numerous barriers to lifestyle management including low health literacy,[22 23] funding constraints for allied health physical activity services[24] and workforce limitations in rural settings.[25 26] Complex dietary requirements[27] and safety concerns relating to physical activity[28] also make behaviour change challenging. These factors highlight the need to develop innovative strategies to increase access to lifestyle interventions and support self-management.

Digital health interventions (DHIs) may provide a useful mechanism to promote healthy lifestyles for people with CKD.[29] DHI is defined as the use of health informatics to assist the delivery of healthcare (ie, provide education and instruction, record and display data, guide users' behaviours, provider reminders and facilitate provider–consumer communication).[30 31] In this review, DHI may include mobile health technology (eg, application software and short messaging services[30]), telehealth technology (eg, videoconferencing and audio call[32]), wearable technology (eg, step count monitor[30]), computerised systems (eg, websites[33]) or multicomponent interventions that use more than one type of technology. Digital lifestyle interventions in other cohorts such as diabetes,[34] cardiovascular disease[35] and mental illness[36] have demonstrated efficacy to improve health outcomes.

Despite widespread advocacy for healthcare digitalisation,[37–40] the preferences of people with CKD regarding digital interventions that promote a healthy lifestyle are unknown. 'Preferences' refer to attributes of digital lifestyle interventions that are desirable to achieve successful behaviour change.[41] This reflects a broad scope of subjective experiences including intervention content, function and strategy that contribute to behaviour change. Incorporating consumers' preferences can promote positive care experience,[42] improve perceptions of self-management[43] and enhance health outcomes.[44] Without consumers' preferences, health providers may develop interventions that do not align with consumers' needs and goals.[45] Therefore, this review aimed to synthesise the preferences of people with CKD regarding DHIs that promote healthy lifestyle.

METHODS

This is a qualitative systematic review with a meta-ethnography approach,[46] which involves synthesising data from primary studies to generate novel, whole-of-phenomenon understandings that transcend the scope of any one study. The review was registered with PROSPERO (number: CRD42023411511) and reported according to the meta-ethnography reporting guidelines[46] (online supplemental table S1), Enhancing Transparency in Reporting the Synthesis of Qualitative Research statement[47] (online supplemental table S2) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses[48] (online supplemental table S3).

Patient and public involvement

Patient and public were not involved in the design and conduct of this review. Findings of the review were informed by perspectives of people with CKD and will be disseminated at relevant consumers' advocacy events.

Selection criteria

The selection criteria were developed using the PICOS principle[49] and are as follows: Population: adults with CKD (≥18 years) including those receiving kidney replacement therapy, Intervention: DHIs that promoted diet, exercise, physical activity or a combination of these health behaviours, Comparator: any comparator, Outcome: participants' subjective experiences of digital lifestyle intervention attributes, Study design: primary studies that employed qualitative exploration methods.[41]

Data sources and searches

A pilot search was conducted to generate search terms in databases CENTRAL; SPORTDiscus; MEDLINE and CINAHL. Medical Subject Headings terms were used to identify diverse terms with similar meaning. A database search, including CENTRAL, Scopus, MEDLINE, CINAHL and SPORTDiscus, was conducted between January 2000 and April 2023 to identify papers that used contemporary technologies. The number of screened and eligible papers was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[48] Records were imported to the online platform Covidence.[50] After duplicates were removed, two independent reviewers completed title, abstract and full-text screening. Discrepancies were resolved by a third reviewer. Search terms are included in online supplemental table S4.

Quality appraisal

The Mixed Methods Appraisal Tool[51] (MMAT) and Critical Appraisal Skills Programme checklist[52] were used to appraise the quality of mixed-method and qualitative papers, respectively. Papers were assessed by two independent reviewers. This review did not exclude studies based on quality appraisal as lack of reporting did not indicate poorly conducted research.[53 54]

Data extraction

Two independent reviewers extracted descriptive data including study design; digital technology; data collection and analysis; sample size, age; CKD status and ethnicity. The Shapiro-Wilk test was conducted using SPSS V.26 to determine the normal distribution and calculate mean age.[55] One reviewer (TBT) used NVivo V.12 to extract quotes and themes from eligible papers and organised them into 'similar' or 'different' categories based on underlying meaning.[54] This was inspected by a second reviewer (MA) who confirmed the accuracy of data extraction. TBT created a synthesis document that noted similar, different or original meaning in each paper when compared with others.[56] The synthesis document was inspected by a second reviewer (MA) to determine the degree of similarity across papers.

Data synthesis

The reviewers noted similar meanings between papers and conducted an inductive thematic synthesis using the Framework approach.[57] Two reviewers used Microsoft Word and NVivo V.12 to form initial codes via line-by-line coding. These codes were refined collaboratively and organised into initial categories. These categories were further refined with other reviewers via iterative discussions to generate an analytical framework. Using this framework, the reviewers identified preliminary themes and subthemes that captured common meanings across multiple papers. This process optimised study rigour and ensured the analysis encapsulated the depth of qualitative data. Two independent reviewers developed a conceptual framework to represent the relationship between themes.[56] A final version was approved by all reviewers.

RESULT

Literature search

Database search yielded 5761 records. An additional record was included following communication with a primary author.[58] After 284 duplicates were removed, 5478 underwent title and abstract screening and 53 full texts were assessed. 15 papers were eligible[58–72] (figure 1).

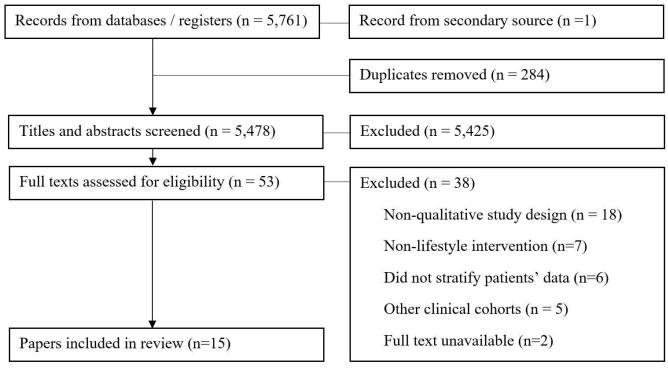

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of search process and study selection.

Study characteristics

There were nine qualitative[58 59 62 66–69 71 72] and six mixed-method papers[60 61 63–65 70] (table 1). 13 papers were from English-speaking countries, including USA (n=5),[64 67 69 70 72] Australia (n=4)[58 61 62 65]; Canada (n=2)[63 71] and the UK (n=2).[59 60] One study came from the United Arab Emirates[66] and one from China.[68] These papers reported consumers' preferences on a wide range of technologies, including websites (n=3)[59 60 63]; telehealth (n=3)[58 64 65]; mobile application (n=2)[66 67]; mobile phone text (n=2)[61 62]; unspecified mobile health (n=1)[69] and unspecified technology (n=1).[71] Furthermore, three papers explored consumers' preferences on more than one type of technology, including telephone call and mobile application[70]; information communication technologies and website[68]; and activity trackers and mobile applications.[72] A description of the function of each type of DHI was included in online supplemental table S5.

Consumers' characteristics

Two papers were supplementary publications that included the same cohort from another paper, including one on people with haemodialysis[61 62] and one on people with CKD 3–4.[58 65] Therefore, descriptive data was extracted from thirteen studies to avoid over-representation of any groups. This provided a sample of 197 consumers (mean age 51.0±7.2 (range 20–80)), including 83 with CKD 1–5 (42%); 61 kidney transplant recipients (31%); 31 on haemodialysis (16%) and 22 with an unspecified form of dialysis (11%). Two studies targeted consumers from regional[70] and rural settings[68] (n=28, 14% of the total sample). Sex distribution was reported in 11 studies (total=182 people), including 53% male and 47% female. 12 studies reported ethnicity (total=190 people), comprising white (45%); African (21%); Asian (19%); Pacific Islander (3%); Hispanic (2%); Indigenous (2%) and mixed heritage (2%). 16 consumers (8%) had unspecified ethnic backgrounds. Details can be found in online supplemental table S6.

Quality appraisal

All qualitative papers had clear aims, appropriate design and data collection methods.[58 59 62 66–69 71 72] Seven included coherent methodological frameworks.[58 59 62 67–69 71] Three reported how the relationship between researchers and consumers was considered[59 67 71] and four had clear statements of findings.[58 59 62 68] Detailed information is included in online supplemental table S7.

Four papers were appraised using MMAT tool for randomised quantitative, mixed-method design.[60 61 64 65] All four provided adequate rationale for mixed-method design.[60 61 64 65] Two demonstrated effective integration of quantitative and qualitative data.[64 65] One did not demonstrate effective integration[60] and another provided insufficient details on how integration occurred.[61] Detailed information is included in online supplemental table S8.

Two papers were appraised using the MMAT tool for non-randomised quantitative, mixed-method design.[63 70]

Table 1 Study characteristics

Paper	Design	Country	Intervention	Data collection method	Methodological approach
Website					
Castle *et al*, 2021[59]	Qualitative	UK	Diet, PA education	Think aloud and semistructured interview	Reflexive, thematic, inductive
Castle *et al*, 2022[60]	Mixed method	UK	Diet, PA education	Semistructured interview	Deductive, content
Donald *et al*, 2022[63]	Mixed method	Canada	Diet, PA education	Semistructured interview	Deductive, content
Mobile phone text					
Dawson *et al*, 2021[61]	Mixed method	Australia	Diet, PA education and reminder	Semistructured interview	Inductive, thematic
Dawson *et al*, 2021[62]	Qualitative	Australia	Diet, PA education and reminder	Semistructured interview	Inductive, content
Mobile health (unspecified)					
Sieverdes *et al*, 2015[69]	Qualitative	USA	Exercise programme	Key informant interview	Reflexive, thematic, inductive
Telehealth					
Gibson *et al*, 2020[64]	Mixed method	USA	Dietary education	Semistructured interview	Inductive content
Kelly *et al*, 2019[65]	Mixed method	Australia	Dietary education	Semi-structured interview	Reflexive, thematic, inductive
Warner *et al*, 2019[58]	Qualitative	Australia	Dietary education	Semistructured interview	Manifest content
Mobile application					
Fakih El Khoury *et al*, 2019[66]	Qualitative	UAE	Dietary education and monitoring	Semistructured interview	Reflexive, thematic, inductive
O'Brien and Rosenthal, 2020[67]	Qualitative	USA	Diet, PA education and reminder	Semistructured interview	NR
Unspecified technology					
Mathur *et al*, 2021[71]	Qualitative	Canada	PA education and programme	Semistructured interview	Deductive, thematic
Combined technology					
Chang *et al*, 2020[70]	Mixed method	USA	Diet education and reminder	Semistructured interview	Inductive, deductive, thematic
Shen *et al*, 2022[68]	Qualitative	PRC	Diet and PA education	Focus group and semistructured interview	Reflexive, thematic, inductive
Weber *et al*, 2021[72]	Qualitative	USA	PA education and programme	Formative, in-depth interview	Deductive, content

NR, not reported; PA, physical activity; PRC, People's Republic of China.

Only one provided adequate rationale for mixed-method design.[63] Both addressed inconsistencies between quantitative and qualitative data.[63 70] Detailed information is included in online supplemental table S9.

Qualitative data synthesis

There were 5 themes and 13 subthemes that typified consumers' preferences for digital lifestyle interventions. They included simple instruction and engaging design, individualised interventions, virtual communities of care, education and action plans, and timely reminders and automated behavioural monitoring. Illustrative quotes are included in online supplemental table S10.

Simple instruction and engaging design

Convey ideas using plain language and simple instruction

Plain language and simple instruction were considered optimal strategies to deliver education—'*[The intervention has] given me simple tasks, simple methods … to improve the situation … basic stuffs that we can understand.' (person with CKD 3–4, Australia*[65]). Consumers preferred everyday terms and cautioned against jargon which was only accessible to

a specialised audience—'*[the messages] made sense and were easy [to understand], that's why I liked it' (person undergoing haemodialysis, Australia*[62]).

Organised and engaging programme design elevates user-experience

Consumers noted the importance of an organised and engaging user-interface to ensure they can use the technology to its full potential—'*the best part about the website was how it is laid out, [you can] see the levels of potassium and phosphorus, the nutritional information.' (person with unspecified CKD, Canada*[63]). Consumers identified factors that may reduce user-experience, such as small font—'*On the Fitbit, [the font] is very small, and if I don't have my readers on, I can't read it' (transplant recipient, USA*[67]) and complicated navigability—'*To navigate around [the website] … I found it a bit difficult at first, I didn't really get it.' (kidney transplant recipient, UK).*[60] These quotes further emphasised the importance of suitable programme designs to optimise user-experience.

Individualised interventions

Personal and psychosocial factors influence motivation and capacity for change

Consumers identified personal and psychosocial health determinants as factors which may affect motivation and capacity for change. Personal factors included health complications—'*I can't get round the house with the sore foot' (person undergoing haemodialysis, Australia*[62]) while psychosocial factors included caring for loved ones or unstable living environment—'*I have a lifestyle that didn't fit with [the app] because I am not home much and have a lot of kids … so we eat out more than we probably should' (person with CKD 1–3a, USA*[70]).

Personalised interventions support engagement

Consumers emphasised the importance of individualised interventions to mitigate the effect of personal and psychosocial determinants of health—'*every person is going to be different… with [my coach] he can actually judge what your condition is and change the program to actually what's happening to you.' (person with CKD 3–4, Australia*[58]).

A virtual community of care

Promotes provider–consumer partnership

Digital interventions promoted provider–consumer partnership by allowing regular communication and support—'*[My coach] supported me over the weeks, the phone calls every now and again… to have someone there to pat you on the back … and explain different things you don't think of…' (person with CKD 3–4, Australia*[58]).

Connects people with common care experience

Consumers suggested digital intervention could facilitate connections between people with similar care experiences '*If they also have social media network built into [the app], that would be cool for kidney transplant patients where they could follow each other and talk.' (transplant recipient, USA*[69]) and advocated for future interventions to incorporate knowledge from people with lived experience—'*[the] doctor can only give what they've learned. They haven't necessarily experienced going through surgery … You need a bit of a balance [between clinician & patient-expert] (transplant recipient, UK*[60]).

Provide education and action plan

Increase coverage of lifestyle information

Consumers noted the potential of digital interventions to increase coverage of lifestyle information—'*[Patients] need something like this… there was lot of things when I had the transplant that I was thinking I didn't know… [The website] makes it a lot easier' (transplant recipient, UK*[59]).

Inform healthy decision-making

Consumers considered digital interventions to be an important tool to increase health literacy and inform healthy choices—'*I didn't know that one cup of soft drink contains 5 teaspoons of sugar and I don't eat biscuits anymore, not too much… I will just taste a small one but not the usual amount I had.' (person undergoing haemodialysis, Australia*[62]).

Provide encouragement for healthy behaviours

Consumers expressed that digital interventions enabled them to achieve small, gradual changes, which provided encouragement to attempt more comprehensive modification—*'That's what encouraged me to go on [with the intervention], because I could see the change, as I was making little [dietary] adjustments… all these little adjustments amount to great leaps and bounds' (person with CKD 3–4, Australia*[58]).

Consolidate knowledge and prevent misinformation

Consumers noted the lack of digital sources that were clinically tailored which may lead to misinformation—'*Online knowledge of food with high potassium is not detailed and sometimes conflicting.' (person with CKD 5, China*[68]). To support self-management, consumers indicated the importance of clinically tailored digital interventions to consolidate knowledge—'*… you know rather than going on the internet… other websites and stuff I found that [on] this particular website that there was a lot on there to help.' (transplant recipient, UK*[60]).

Timely reminders and automated behavioural monitoring

Timely and personalised reminders prompt action

Consumers affirmed the utility of reminders to prompt action and expressed the need for reminders to be timely and personalised according to their needs—'*Getting the [dietary text] messages while I was doing dialysis clicked off something in the back of my mind… If I have got them on a [non-dialysis day], I don't think I would have taken any notice.' (person undergoing haemodialysis, Australia*[62]).

Monitoring behaviour promotes accountability

Behavioural monitoring was perceived as an important strategy to promote personal accountability and adherence to the programme—'*… in terms of being accountable… you are being accountable to a system… you need to you know,*

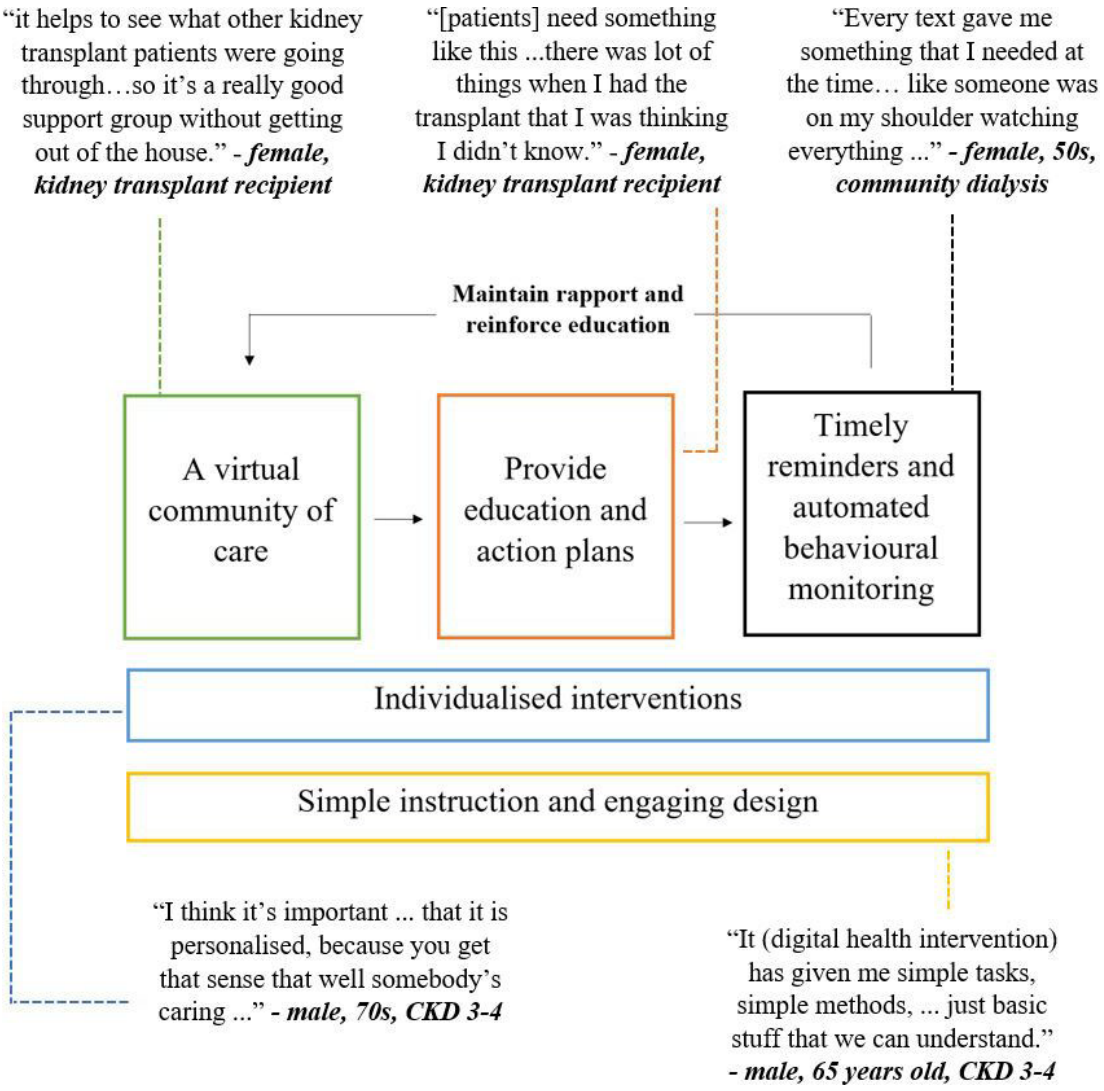

Figure 2 Conceptual framework of consumers' preferences regarding digital lifestyle interventions with illustrative quotes. The framework demonstrates a foundation of simple instruction, engaging design and individualised interventions that underpin an inter-related cycle of behavioural change strategies.

every week you need to be putting in the [weight and activity]' (transplant recipient, UK[60]*).*

Automated data capture enhances behavioural monitoring

Consumers suggested automated data capture could help overcome the difficulty with manual tracking and allow them to accurately monitor their progress—'*[Monitoring parameters in] the app is easier and much more convenient than recording them in a notebook.' (person undergoing peritoneal dialysis, China*[68]*).*

Conceptual framework

Consumers' preferences were represented as a conceptual framework to illustrate their relationships and inform the conduct of future digital lifestyle interventions (figure 2). At its base, the framework includes consumers' preferences for simple instruction, engaging design and individualised interventions. Simple instruction and engaging design are key characteristics of a user-friendly DHI. Consumers also outlined the need for providers to be aware of personal and psychosocial determinants of health and individualise their advice and interventions accordingly. Consumers then identified three requirements for change: virtual communities of care, education and action plans and provision of timely reminders and automated behavioural monitoring. Virtual communities of care involving relevant providers and consumers with similar care experiences were recommended to promote provider–consumer partnership and facilitate social support. Consumers recommended the provision of education and action plans to develop health literacy and inform healthy decision-making. Finally, timely reminders and automated behavioural monitoring were recommended to promote accountability. As behaviour change is a dynamic process, providers are recommended to address the requirements of change regularly by maintaining clinical rapport and reinforcing education.

Consumers' preferences for different types of DHIs

The papers in this review did not comprehensively evaluate consumers' preferences between different types of digital solutions that promoted healthy lifestyle. However, one paper suggested people with CKD 1–5 (including peritoneal dialysis) preferred application software over websites as applications were considered more accessible.[68] Across all eligible papers, qualitative data and lines of questioning suggested participants who used websites tended to express preferences for diverse modes of delivering lifestyle education (eg, interactive webinars[63] or combining clinicians and patient-experts' input[59]) while participants who used mobile health technology noted the importance of timely reminders[62] and tracking data related to lifestyle behaviours (eg, nutrition, fluid and levels of physical activity[67 69 70]). A summary of participants' preferences in each paper was included in online supplemental table S5.

DISCUSSION

DHIs were considered important mechanisms to access lifestyle services for people with CKD. In addition to user-friendly technology, consumers' preferences illustrated the importance of appropriately qualified health providers to personalise behaviour change strategies, provide lifestyle education and action plans and facilitate timely reminders. The conceptual framework of consumers' preferences in this review may inform the design and conduct of future digital lifestyle interventions.

People with CKD expressed the importance of designing user-friendly technology by incorporating simple instruction and engaging design. Preferences for simple instruction reflected health promotion research where language characterised by concise sentences[73–76] and conversational styles[77 78] is preferred to deliver education. Preferences for organised and engaging user-interface encapsulate the concept 'system design characteristics' from the Technology Acceptance Model.[79] 'System design characteristics' are theorised to influence the degree which the system would be free of difficulty[80] and degree which the system may enhance users' capacity to perform a task.[81] Previous research recommends specific design characteristics such as arranging content by order of sequence[82] or perceived importance[83]; using meaningful, illustrative media[84 85] and applying specific typographic features[73] such as serif font type[86 87]; large font sizes[88] and specific colour schemes to maximise contrast between words and background.[86] Emerging research also recommends codesign of digital interventions to identify user-specific features,[89–91] reduce consumers' anxiety[92] and enhance confidence in digital systems.[93 94] In the context of DHIs, codesign may be enhanced by user-testing workshops with think-aloud interviews followed by periods of independent use with retrospective semistructured interviews and iterative changes.[95] Although think-aloud interviews have been shown to be effective at identifying factors that limit usability,[95] only one paper in this review implemented a user-testing workshop with concurrent, think-aloud feedback.[59] Future digital lifestyle interventions may benefit from more pre-emptive strategies to address factors affecting usability, increase intention to use and promote system usage.

Another important finding was that consumers recognised the influence of personal and psychosocial factors on capacity for change and advocated for individualised interventions to mitigate their effect. These preferences are similar to qualitative research in other clinical cohorts, including people with mental illness[96]; cancer[97] and chronic pain.[98] Collectively, they establish a common requisite for lifestyle interventions to be tailored to consumers' needs and preferences. A potential framework to inform lifestyle intervention design could be the Behaviour Change Wheel (BCW).[99] The BCW is a framework for behaviour interventions that centres around three requirements for change[100]: capability (physical and psychological), opportunity (social and physical) and motivation (automatic and reflective).[101] The BCW provides recommendations for intervention functions that are specific to each requirement for change,[99] such as training and education to develop physical and psychological capability[102] (eg, supporting healthy dietary patterns with recipes endorsed by governing bodies like Kidney Health Australia[103]), environmental restructuring to increase physical and social opportunity[104] (eg, increasing opportunities for clinician-led exercise with online platforms like the Kidney Beam programme[105]) and persuasion to promote reflective and automatic motivation[106] (eg, setting personalised goals to promote reflective motivation for increasing physical activity[107]). Previous research in people with CKD suggests the BCW may provide a useful framework to identify barriers associated with requirements for change[23 108] and determine appropriate intervention functions to address consumers' specific needs. Although research suggests theory-driven interventions may increase the prospect of successful behaviour change for people with chronic diseases,[109 110] evidence regarding the effect of theory-informed digital interventions for people with CKD is limited. Future research that employs digital technology may consider applying the BCW as a framework to inform intervention functions and evaluate the effect of digital interventions on consumers' self-efficacy and health outcomes.

Consumers in this review highlighted the role of digital interventions to foster provider–consumer partnerships and connect consumers to others with similar care experiences. This reflects the concepts of virtual care teams and virtual support groups. Virtual care teams refer to digitally connected multidisciplinary teams that provide coordinated interventions and communication across diverse geographic settings using specialised information and communication technologies.[111 112] Virtual support groups are peer-to-peer systems which allow consumers with similar care experiences to exchange knowledge and provide support.[113 114] Collectively, these functions help form a virtual community of care with relevant providers

and consumers. While these functions may help overcome sociogeographical barriers[115] and connect consumers to others with common care experiences,[116] the administration of virtual communities of care also presents challenges. Research suggests participation in virtual support groups does not guarantee active self-management as consumers vary in their involvement as either active collaborators or passive observers.[117] Increasing use of information and communication technologies is theorised to reduce opportunities for in-person interaction, leading to a process called 'progressive dehumanisation' of interpersonal relationships.[118–120] This is, however, in contrast with findings in this review which suggest digital solutions may enhance rapport by enabling regular communication and support. Research also suggests virtual support groups may facilitate misinformation if consumers' inputs are not monitored,[121] indicating the need for health providers' oversight. Furthermore, the effect of virtual communities of care on self-efficacy and health outcomes of people with CKD is unclear. This review identified several implementation strategies to support virtual communities of care including patients' forums,[63] social media networks[67] and group telehealth conferencing.[64] However, as yet, there is little consensus regarding the optimal strategy to promote consumers' engagement in virtual communities of care.[117 122] Future research may consider applying the implementation strategies identified in this review and evaluate the effect of a virtual community of care on health outcomes and self-efficacy for change.

In this review, consumers identified four avenues through which digital interventions enhance the delivery of lifestyle education and action plans: increasing coverage of information, informing healthy decision-making, providing encouragement and preventing misinformation. Qualitative research in other cohorts such as people with diabetes[123] and mental illness[124] also emphasises the role of digital interventions to increase access to lifestyle information. In this review, digital interventions were regarded as a valuable platform to develop health literacy, which, in turn, informs healthy decision-making. The association between health literacy and healthy living is well documented in people with CKD,[125–127] which suggests future digital lifestyle interventions may consider health literacy as an essential target for behaviour change. Consumers in this review highlighted that they were encouraged to attempt more comprehensive lifestyle modification following initial modest changes. This is consistent with previous research in behaviour change which counsels initial gradual changes to support ongoing engagement and accumulate health benefits.[128 129] Finally, consumers suggested digital interventions could empower behaviour change by preventing misinformation. The current literature recognises that consumers regularly engage in information-seeking behaviours[130] but cautions the use of digital sources outside the health sector as they may disseminate information that is inconsistent with evidence-based research.[131 132] Exposure to information outside the health sector can lead to confirmation bias,[133] where consumers select sources that validate prior, harmful beliefs despite their lack of scientific rigour.[132] Resources from healthcare providers are needed to guide information- seeking behaviours, prevent misinformation and inform healthy lifestyle choices.[134] These strategies may be considered by future digital interventions to enhance lifestyle education and promote successful behaviour change.

Finally, this review highlighted the importance timely reminders and automated behavioural monitoring to prompt action and promote accountability. This is not unique to people with CKD as previous research suggests reminders that are not tailored to users' lifestyle may have low receptivity and pose confidentiality risks.[135–137] Consumers in this review recommended that the timing, content and mode of delivering reminders should be tailored to optimise receptivity, maintain users' confidentiality and promote ongoing engagement. The challenges described by consumers regarding difficulties with manual data tracking suggest automated data capture may provide a useful strategy to accurately monitor progress. This is currently the case with technologies such as accelerometer[138 139] and peripheral devices.[140] However, caution is needed when using peripheral devices produced outside the health sector due to concerns with data governance and consumers' confidentiality.[141 142] Raw data from peripheral devices comes under the ownership of the manufacturers,[143] which raises concerns regarding consumers' control over potentially sensitive information.[144] Although manufacturers claim anonymity in data storage, research suggests consumers' activity and location may generate 'digital traces' that disclose sensitive information.[143] Future research may consider using sensors that are embedded within mobile devices and can facilitate direct data transfer to clinician-facing platforms. This places the responsibility of data governance with healthcare providers and consumers and minimises confidentiality risks associated with third party ownership. Future research may also consider generating individualised reminders that are receptive to health consumers and capable of securing their privacy.

Strengths and limitations

To our knowledge, this is the first review to synthesise the preferences of people with CKD regarding DHIs that promote a healthy lifestyle. The meta-ethnography approach generated novel, whole-of-phenomenon understandings that transcend the scope of any single study. However, there are limitations. 10 papers that form the synthesis excluded people with low English proficiency,[58 60–65 67 70 72] meaning the synthesis may not apply to people with English as a second language who face distinctive barriers to care such as language discordant interventions.[145–149] Consumers had a large age range (20–80, mean 51.0±7.2), which suggests their preferences may have limited generalisability to older people[150] with specific barriers to behaviour change such

as cognitive impairment.[151 152] Furthermore, 8/13 of the eligible studies explored the preferences of people with kidney replacement therapy (online supplemental table S6). People with CKD 3–5 without kidney replacement therapy comprised a small proportion of consumers in this review (n=40, 20%) despite having the largest representation in tertiary kidney care settings.[153] Therefore, the results of this review may have limited generalisability to CKD cohorts not receiving kidney replacement therapy. People from rural settings (n=28, 14%)[68 70] and people with Pacific Islander; Indigenous and Hispanic heritage were under-represented (online supplemental table S6). Under-representation of these groups is common in clinical research[154–156] despite the disproportionate prevalence of CKD[157–160] and numerous sociogeographical barriers to care such as shortage of health providers and distance from health facilities.[161–163] These factors reflect an urgent need to generate community-specific knowledge and develop accessible healthcare platforms to serve the needs of these disadvantaged groups.

Future research

Future research may consider comparing consumers' experiences with different modes of technology to determine their preferences for specific forms of DHIs or combinations of complementary technologies such as interactive webinars to instruct exercise, apps to record and display data and telehealth to facilitate provider–consumer communication. Future research may also consider exploring the preferences of cohorts that were under-represented in this review such as people not receiving kidney replacement therapy, people with low English proficiency; older people; people from rural communities and people with ethnic minority membership. Finally, the conceptual framework of consumers' preferences in this review may be used to develop and evaluate the effect of a digital lifestyle intervention on self-efficacy and health outcomes.

Conclusion

People with CKD consider DHIs to be an important platform to promote a healthy lifestyle. Consumers' preferences for digital lifestyle interventions included simple instructions and engaging design; individualised interventions; virtual communities of care; education and action plans; and timely reminders and automated behavioural monitoring. Future research may consider applying the conceptual framework of consumers' preferences in this review to design and evaluate the effect of a digital lifestyle intervention. Future research may also generate acceptability data for people with CKD 3–5 without kidney replacement therapy whose preferences appear limited in current research. These findings would support the integration of digital solutions in clinical practice and increase opportunities for healthy living in a population with numerous challenges for behaviour change.

Author affiliations
[1]School of Medical, Indigenous and Health Sciences, University of Wollongong Faculty of Science Medicine and Health, Wollongong, New South Wales, Australia
[2]Department of Renal Medicine, Concord Repatriation General Hospital, Concord, New South Wales, Australia
[3]Falls, Balance and Injury Research Centre, Neuroscience Research Australia, Randwick, New South Wales, Australia
[4]School of Population Health, University of New South Wales Faculty of Medicine, Sydney, New South Wales, Australia
[5]School of Health Sciences, University of New South Wales Faculty of Medicine, Sydney, New South Wales, Australia
[6]Centre for Pain IMPACT, Neuroscience Research Australia, Randwick, New South Wales, Australia
[7]School of Health Sciences, The University of Sydney Faculty of Medicine and Health, Sydney, New South Wales, Australia
[8]Sydney Musculoskeletal Health, The University of Sydney, Sydney, New South Wales, Australia
[9]Concord Clinical School, The University of Sydney Faculty of Medicine and Health, Sydney, New South Wales, Australia
[10]Illawarra Shoalhaven Local Health District, Wollongong, New South Wales, Australia

X Thái Bình Trần @ThaiBinhTran4 and Meghan Ambrens @meghan_ambrens

Contributors Research idea and design: TBT, KL, JMT, SS and RA; data extraction: TBT, JN, MA, EC, YG, ML, AP and LL; data synthesis/analysis: TBT, MA, KL, JMT, SS and RA; supervision: RA, KL, SS and JMT. Each author provides significant intellectual contribution during manuscript production and revision. RA is the guarantor for this research. All authors acknowledge accountability by ensuring all questions pertaining to the accuracy or integrity of this work were appropriately examined and resolved.

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ORCID iDs
Thái Bình Trần http://orcid.org/0000-0002-0437-7118
Meghan Ambrens http://orcid.org/0000-0001-9117-7722
Jeanette M Thom http://orcid.org/0000-0002-6575-3711
Kelly Lambert http://orcid.org/0000-0001-5935-7328
Ria Arnold http://orcid.org/0000-0002-7469-6587

REFERENCES

1 Rath T. Chronic Kidney Disease - from Pathophysiology to Clinical Improvements.2018. Available: http://www.intechopen.com/books/chronic-kidney-disease-from-pathophysiology-to-clinical-improvements
2 Sundström J, Bodegard J, Bollmann A, *et al*. Prevalence, outcomes, and cost of chronic kidney disease in a contemporary population of 2· 4 million patients from 11 countries: the Careme CKD study. *Lancet Reg Health Eur* 2022;20:100438.
3 Carney EF. The impact of chronic kidney disease on global health. *Nat Rev Nephrol* 2020;16:251–2.
4 Bikbov B, Purcell CA, Levey AS, *et al*. Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the global burden of disease study 2017. *The Lancet* 2020;395:709–33.
5 Plantinga LC, Johansen K, Crews DC, *et al*. Association of CKD with disability in the United States. *Am J Kidney Dis* 2011;57:212–27.
6 Salam SN, Eastell R, Khwaja A. Fragility fractures and osteoporosis in CKD: pathophysiology and diagnostic methods. *Am J Kidney Dis* 2014;63:1049–59.
7 Kirkman DL, Bohmke N, Carbone S, *et al*. Exercise intolerance in kidney diseases: physiological contributors and therapeutic strategies. *Am J Physiol Renal Physiol* 2021;320:F161–73.
8 Ronco C, Haapio M, House AA, *et al*. Cardiorenal syndrome. *J Am Coll Cardiol* 2008;52:1527–39.
9 Löfman I, Szummer K, Hagerman I, *et al*. Prevalence and Prognostic impact of kidney disease on heart failure patients. *Open Heart* 2016;3:e000324.
10 Arnold R, Pianta TJ, Issar T, *et al*. Peripheral neuropathy: an important contributor to physical limitation and morbidity in stages 3 and 4 chronic kidney disease. *Nephrol Dial Transplant* 2022;37:713–9.
11 Arici M. Management of Chronic Kidney Disease: A Clinician's Guide. Berlin Heidelberg: Springer, 2014.
12 Jha V, Al-Ghamdi SMG, Li G, *et al*. Global economic burden associated with chronic kidney disease: A pragmatic review of medical costs for the inside CKD research programme. *Adv Ther* 2023;40:4405–20.
13 Khanam MA, Kitsos A, Stankovich J, *et al*. Chronic kidney disease monitoring in Australian general practice. *Aust J Gen Pract* 2019;48:132–7.
14 Tangri N, Moriyama T, Schneider MP, *et al*. Prevalence of Undiagnosed stage 3 chronic kidney disease in France, Germany, Italy, Japan and the USA: results from the multinational observational REVEAL-CKD study. *BMJ Open* 2023;13:e067386.
15 Tuot DS, Plantinga LC, Hsu C, *et al*. Chronic kidney disease awareness among individuals with clinical markers of kidney dysfunction. *Clin J Am Soc Nephrol* 2011;6:1838–44.
16 Rhee CM, Ahmadi SF, Kovesdy CP, *et al*. Low-protein diet for conservative management of chronic kidney disease: a systematic review and meta-analysis of controlled trials. *J Cachexia Sarcopenia Muscle* 2018;9:235–45.
17 Yan B, Su X, Xu B, *et al*. Effect of diet protein restriction on progression of chronic kidney disease: A systematic review and meta-analysis. *PLoS ONE* 2018;13:e0206134.
18 Barcellos FC, Santos IS, Umpierre D, *et al*. Effects of exercise in the whole spectrum of chronic kidney disease: a systematic review. *Clin Kidney J* 2015;8:753–65.
19 Villanego F, Naranjo J, Vigara LA, *et al*. Impact of physical exercise in patients with chronic kidney disease: systematic review and meta-analysis. *Nefrología (English Edition)* 2020;40:237–52.
20 Greco A, Paroni G, Seripa D, *et al*. Frailty, disability and physical exercise in the aging process and in chronic kidney disease. *Kidney Blood Press Res* 2014;39:164–8.
21 Neale EP, Rosario VD, Probst Y, *et al*. Lifestyle interventions, kidney disease progression, and quality of life: A systematic review and meta-analysis. *Kidney Med* 2023;5:100643.
22 Lambert K, Mullan J, Mansfield K, *et al*. A cross-sectional comparison of health literacy deficits among patients with chronic kidney disease. *J Health Commun* 2015;20 Suppl 2:16–23.
23 Clarke AL, Jhamb M, Bennett PN. Barriers and Facilitators for engagement and implementation of exercise in end-stage kidney disease: future theory-based interventions using the behavior change wheel. *Semin Dial* 2019;32:308–19.
24 Bennett PN, Kohzuki M, Bohm C, *et al*. Global policy barriers and Enablers to exercise and physical activity in kidney care. *J Ren Nutr* 2022;32:441–9.
25 Bellamy J. 2021/22 ESSA national workforce profile report. *Exercise & Sport Science Australia* 2023.
26 Campbell KL, Murray EM. Allied health services to Nephrology: an audit of current workforce and meeting future challenges. *J Ren Care* 2013;39:52–61.
27 Palmer SC, Hanson CS, Craig JC, *et al*. Dietary and fluid restrictions in CKD: a thematic synthesis of patient views from qualitative studies. *Am J Kidney Dis* 2015;65:559–73.
28 Zhang J, Bennett PN. The perception of people with chronic kidney disease towards exercise and physical activity: a literature review. *RSAJ* 2019;15:97–104.
29 Graham-Brown MPM, Smith AC, Greenwood SA. Digital health interventions in chronic kidney disease: levelling the playing field *Clin Kidney J* 2023;16:763–7.
30 Shachak A, Borycki E, Reis SP. Health Professionals' Education in the Age of Clinical Information Systems, Mobile Computing and Social Networks. Academic Press, 2017.
31 Aitken M, Gauntlett C. Patient Apps for Improved Healthcare: From Novelty to Mainstream. Parsippany, NJ: IMS Institute for Healthcare Informatics, 2013.
32 Totten AM, Womack DM, Eden KB, *et al*. Telehealth: mapping the evidence for patient outcomes from systematic reviews. 2016.
33 Jeddi FR, Nabovati E, Amirazodi S. Features and effects of information technology-based interventions to improve self-management in chronic kidney disease patients: a systematic review of the literature. *J Med Syst* 2017;41:1–13.
34 Kebede MM, Zeeb H, Peters M, *et al*. Effectiveness of Digital interventions for improving Glycemic control in persons with poorly controlled type 2 diabetes: a systematic review, meta-analysis, and meta-regression analysis. *Diabetes Technology & Therapeutics* 2018;20:767–82.
35 Ramachandran HJ, Jiang Y, Tam WWS, *et al*. Effectiveness of home-based cardiac Telerehabilitation as an alternative to phase 2 cardiac rehabilitation of coronary heart disease: a systematic review and meta-analysis. *Eur J Prev Cardiol* 2022;29:zwab106:1017–43:.
36 Young CL, Trapani K, Dawson S, *et al*. Efficacy of online Lifestyle interventions targeting Lifestyle behaviour change in depressed populations: A systematic review. *Aust N Z J Psychiatry* 2018;52:834–46.
37 World Health Organization. Global diffusion of eHealth: making universal health coverage achievable: report of the: world health organization. 2017.
38 World Health Organization. Global action plan on physical activity 2018-2030: more active people for a healthier world. 2019.
39 World Health Organization. Global strategy on Digital health 2020-2025. 2021.
40 Australian Medical Research Advisory Board. Australian Medical Research and Innovation Priorities 2022-2024. Australian Government,
41 Soekhai V, Whichello C, Levitan B, *et al*. Methods for exploring and eliciting patient preferences in the medical product Lifecycle: a literature review. *Drug Discov Today* 2019;24:1324–31.
42 Kuipers SJ, Cramm JM, Nieboer AP. The importance of patient-centered care and Co-creation of care for satisfaction with care and physical and social well-being of patients with multi-morbidity in the primary care setting. *BMC Health Serv Res* 2019;19:13.
43 Nkhoma KB, Cook A, Giusti A, *et al*. A systematic review of impact of person-centred interventions for serious physical illness in terms of outcomes and costs. *BMJ Open* 2022;12:e054386.
44 Mirzaei M, Aspin C, Essue B, *et al*. A patient-centred approach to health service delivery: improving health outcomes for people with chronic illness. *BMC Health Serv Res* 2013;13:1–11.
45 Kennedy BM, Rehman M, Johnson WD, *et al*. Healthcare providers versus patients' understanding of health beliefs and values. *Patient Exp J* 2017;4:29–37.
46 France EF, Cunningham M, Ring N, *et al*. Improving reporting of meta-Ethnography: the eMERGe reporting guidance. *BMC Med Res Methodol* 2019;19:25.
47 Tong A, Flemming K, McInnes E, *et al*. Enhancing transparency in reporting the synthesis of qualitative research: ENTREQ. *BMC Med Res Methodol* 2012;12:181.
48 Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med* 2009;151:264–9.
49 Amir-Behghadami M, Janati A. Population, intervention, comparison, outcomes and study (PICOS) design as a framework to formulate eligibility criteria in systematic reviews. *Emerg Med J* 2020;37:387.
50 Babineau J. Product review: Covidence (systematic review software). *J Can Health Libr Assoc* 2014;35:68.
51 Pace R, Pluye P, Bartlett G, *et al*. Testing the Reliability and efficiency of the pilot mixed methods appraisal tool (MMAT) for systematic mixed studies review. *Int J Nurs Stud* 2012;49:47–53.

52 Long HA, French DP, Brooks JM. Optimising the value of the critical appraisal skills programme (CASP) tool for quality appraisal in qualitative evidence synthesis. *Res Method Med Health Sci* 2020;1:31–42.
53 Bourgeault I, Dingwall R, De Vries R. Recognizing quality in qualitative research. In: *SAGE Handbook of Qualitative Health Research*. 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: Sage, 2010: 559–74. Available: https://methods.sagepub.com/book/sage-hdbk-qualitative-methods-in-health-research
54 Atkins S, Lewin S, Smith H, *et al*. Conducting a meta-Ethnography of qualitative literature: lessons learnt. *BMC Med Res Methodol* 2008;8:21:1–10:.
55 Ghasemi A, Zahediasl S. Normality tests for statistical analysis: a guide for non-statisticians. *Int J Endocrinol Metab* 2012;10:486–9.
56 Cahill M, Robinson K, Pettigrew J, *et al*. Qualitative synthesis: a guide to conducting a meta-Ethnography. *Br J Occupat Ther* 2018;81:129–37.
57 France EF, Uny I, Ring N, *et al*. A methodological systematic review of meta-Ethnography conduct to articulate the complex Analytical phases. *BMC Med Res Methodol* 2019;19:35.
58 Warner MM, Tong A, Campbell KL, *et al*. Patients' experiences and perspectives of Telehealth coaching with a dietitian to improve diet quality in chronic kidney disease: a qualitative interview study. *J Acad Nutr Diet* 2019;119:1362–74.
59 Castle EM, Greenwood J, Chilcot J, *et al*. Usability and experience testing to refine an online intervention to prevent weight gain in New kidney transplant recipients. *Br J Health Psychol* 2021;26:232–55.
60 Castle EM, Dijk G, Asgari E, *et al*. The feasibility and user-experience of a Digital health intervention designed to prevent weight gain in New kidney transplant recipients—the Exertion2 trial. *Front Nutr* 2022;9:887580.
61 Dawson J, Campbell KL, Craig JC, *et al*. A text Messaging intervention for dietary behaviors for people receiving maintenance Hemodialysis: a feasibility study of KIDNEYTEXT. *Am J Kidney Dis* 2021;78:85–95.
62 Dawson J, Tong A, Matus Gonzalez A, *et al*. Patients' experiences and perspectives of a mobile phone text Messaging intervention to improve dietary Behaviours in Haemodialysis. *Nutrit Dietet* 2021;78:516–23.
63 Donald M, Beanlands H, Straus S, *et al*. An eHealth self-management intervention for adults with chronic kidney disease, my kidneys my health: A mixed-methods study. *Cmajo* 2022;10:E746–54.
64 Gibson CA, Gupta A, Greene JL, *et al*. Feasibility and acceptability of a Televideo physical activity and nutrition program for recent kidney transplant recipients. *Pilot Feasibility Stud* 2020;6:126.
65 Kelly JT, Warner MM, Conley M, *et al*. Feasibility and acceptability of Telehealth coaching to promote healthy eating in chronic kidney disease: a mixed-methods process evaluation. *BMJ Open* 2019;9:e024551.
66 Fakih El Khoury C, Karavetian M, Halfens RJG, *et al*. Dietary application for the management of patients with Hemodialysis: a formative development study. *Healthc Inform Res* 2019;25:262.
67 O'Brien T, Rosenthal A. Preferred features in mobile health applications for kidney transplant recipients: A qualitative approach. *Nephrol Nurs J* 2020;47:529–36.
68 Shen H, van der Kleij R, van der Boog PJM, *et al*. Digital tools/eHealth to support CKD self-management: A qualitative study of perceptions, attitudes and needs of patients and health care professionals in China. *Int J Med Inform* 2022;165:S1386-5056(22)00125-3.
69 Sieverdes JC, Raynor PA, Armstrong T, *et al*. Attitudes and perceptions of patients on the kidney transplant waiting list toward mobile health—delivered physical activity programs. *Prog Transplant* 2015;25:26–34.
70 Chang AR, Bailey-Davis L, Hetherington V, *et al*. Remote dietary counseling using Smartphone applications in patients with stages 1-3A chronic kidney disease: a mixed methods feasibility study. *J Ren Nutr* 2020;30:53–60.
71 Mathur S, Janaudis-Ferreira T, Hemphill J, *et al*. User-Centered design features for Digital health applications to support physical activity behaviors in solid organ transplant recipients: A qualitative study. *Clin Transplant* 2021;35:e14472.
72 Weber MB, Ziolkowski S, Bootwala A, *et al*. Perceptions of physical activity and technology enabled exercise interventions among people with advanced chronic kidney disease: a qualitative study. *BMC Nephrol* 2021;22:373.
73 Sharma M. Theoretical Foundations of Health Education and Health Promotion. Jones & Bartlett Learning, 2021.
74 Warde F, Papadakos J, Papadakos T, *et al*. Plain language communication as a priority competency for medical professionals in a Globalized world. *Can Med Educ J* 2018;9:e52–9.
75 Thominet L, Hamel LM, Baidoun F, *et al*. Physicians' use of plain language during discussions of prostate cancer clinical trials with patients. *Patient Educ Couns* 2022;105:3453–8.
76 Simmons RA, Cosgrove SC, Romney MC, *et al*. Health literacy: cancer prevention strategies for early adults. *Am J Prev Med* 2017;53:S73–7.
77 Gruman J, Rovner MH, French ME, *et al*. From patient education to patient engagement: implications for the field of patient education. *Patient Educ Couns* 2010;78:350–6.
78 Young A, Tordoff J, Smith A. What do patients want?' Tailoring medicines information to meet patients' needs. *Res Social Adm Pharm* 2017;13:1186–90.
79 Marangunić N, Granić A. Technology acceptance model: a literature review from 1986 to 2013. *Univ Access Inf Soc* 2015;14:81–95.
80 Sharp JH. Development, extension, and application: a review of the technology acceptance model. *Director* 2006;7:3–11.
81 Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: A comparison of two theoretical models. *Manag Sci* 1989;35:982–1003.
82 Huang S-L, Shiu J-H. A user-centric adaptive learning system for E-learning 2.0. *J Educat Technol Soc* 2012;15:214–25.
83 Ricci F, Rokach L, Shapira B. Recommender systems: techniques, applications, and challenges. In: *Recommender Systems Handbook*. 2021: 1–35.
84 Houts PS, Doak CC, Doak LG, *et al*. The role of pictures in improving health communication: a review of research on attention, comprehension, recall, and adherence. *Patient Education and Counseling* 2006;61:173–90.
85 Schubbe D, Scalia P, Yen RW, *et al*. Using pictures to convey health information: A systematic review and meta-analysis of the effects on patient and consumer health behaviors and outcomes. *Patient Education and Counseling* 2020;103:1935–60.
86 Doak LG, Doak CC, Meade CD. Strategies to Improve Cancer Education Materials. 1996.
87 Kitching JB. Patient information leaflets-the state of the art. *J R Soc Med* 1990;83:298–300.
88 Estey A, Jeremy P, Jones M. Developing printed materials for patients with visual deficiencies. *J Ophthalmic Nurs Technol* 1990;9:247–9.
89 Nusir M, Rekik M. Systematic review of Co-design in Digital health for COVID-19 research. *Univers Access Inf Soc* 2022;1–15.
90 Laver K, Davis A, Gwilt I, *et al*. Self-assessment of the home environment to plan for successful ageing: report from a Digital health Co-design workshop. *PLOS Digit Health* 2022;1:e0000069.
91 Gan DZQ, McGillivray L, Larsen ME, *et al*. Technology-supported strategies for promoting user engagement with Digital mental health interventions: A systematic review. *Digit Health* 2022;8:20552076221098268.
92 Foong HF, Kyaw BM, Upton Z, *et al*. Facilitators and barriers of using Digital technology for the management of diabetic foot ulcers: A qualitative systematic review. *Int Wound J* 2020;17:1266–81.
93 Wu K, Zhao Y, Zhu Q, *et al*. A meta-analysis of the impact of trust on technology acceptance model: investigation of moderating influence of subject and context type. *Int J Inform Manag* 2011;31:572–81.
94 Taylor ML, Thomas EE, Vitangcol K, *et al*. Digital health experiences reported in chronic disease management: an umbrella review of qualitative studies. *J Telemed Telecare* 2022;28:705–17.
95 Bradbury K, Watts S, Arden-Close E, *et al*. Developing Digital interventions: a methodological guide. *Evidence-Based Complementary and Alternative Medicine* 2014;2014:1–7.
96 Browne J, Naslund JA, Salwen-Deremer JK, *et al*. Factors influencing engagement in In-Person and remotely delivered Lifestyle interventions for young adults with serious mental illness: A qualitative study. *Early Intervention Psych* 2024;18:42–8.
97 Ivankova NV, Rogers LQ, Herbey II, *et al*. Features that middle-aged and older cancer survivors want in web-based healthy Lifestyle interventions: qualitative descriptive study. *JMIR Cancer* 2021;7:e26226.
98 Fernandes LG, Devan H, Fioratti I, *et al*. At my own pace, space, and place: a systematic review of qualitative studies of Enablers and barriers to Telehealth interventions for people with chronic pain. *Pain* 2022;163:e165–81.
99 Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for Characterising and designing behaviour change interventions. *Implementation Sci* 2011;6:42.

100 Ellis K, Pears S, Sutton S. Behavioural analysis of postnatal physical activity in the UK according to the COM-B model: a multi-methods study. *BMJ Open* 2019;9:e028682.
101 Marks DF. The COM-B system of behaviour change: properties, problems and prospects. *Qeios* 2020.
102 Chen D, Zhang H, Cui N, *et al*. Development of a behavior change intervention to improve physical activity adherence in individuals with metabolic syndrome using the behavior change wheel. *BMC Public Health* 2022;22:1740.
103 Kidney Health Australia. Diet and nutrition. 2020. Available: https://kidney.org.au/your-kidneys/living-with-kidney-disease/health-and-wellbeing/diet-nutrition
104 Ojo SO, Bailey DP, Brierley ML, *et al*. Breaking barriers: using the behavior change wheel to develop a tailored intervention to overcome workplace inhibitors to breaking up sitting time. *BMC Public Health* 2019;19:1126.
105 Greenwood SA, Young HML, Briggs J, *et al*. Evaluating the effect of a Digital health intervention to enhance physical activity in people with chronic kidney disease (kidney BEAM): a Multicentre, randomised controlled trial in the UK. *Lancet Digit Health* 2024;6:e23–32.
106 Michie S, West R. Behaviour change theory and evidence: a presentation to government. *Health Psychology Review* 2013;7:1–22.
107 Billany RE, Smith AC, Stevinson C, *et al*. Perceived barriers and Facilitators to exercise in kidney transplant recipients: A qualitative study. *Health Expect* 2022;25:764–74.
108 Evangelidis N, Craig J, Bauman A, *et al*. Lifestyle behaviour change for preventing the progression of chronic kidney disease: a systematic review. *BMJ Open* 2019;9:e031625.
109 Prestwich A, Webb TL, Conner M. Using theory to develop and test interventions to promote changes in health behaviour: evidence, issues, and recommendations. *Curr Opin Psychol* 2015;5:1–5.
110 Bluethmann SM, Bartholomew LK, Murphy CC, *et al*. Use of theory in behavior change interventions: an analysis of programs to increase physical activity in posttreatment breast cancer survivors. *Health Educat Behav* 2017;44:245–53.
111 Tsiknakis M. Virtual communities in health and social care. virtual communities: concepts, Methodologies, tools and applications: IGI global. 2011;367–86.
112 Samal L, Fu HN, Camara DS, *et al*. Health information technology to improve care for people with multiple chronic conditions. *Health Serv Res* 2021;56:1006–36.
113 Kingod N, Cleal B, Wahlberg A, *et al*. Online peer-to-peer communities in the daily lives of people with chronic illness: a qualitative systematic review. *Qual Health Res* 2017;27:89–99.
114 Chen J, Wang Y. Social media use for health purposes: systematic review. *J Med Internet Res* 2021;23:e17917.
115 Haleem A, Javaid M, Singh RP, *et al*. Telemedicine for Healthcare: capabilities, features, barriers, and applications. *Sens Int* 2021;2:100117.
116 Kamalpour M, Rezaei Aghdam A, Watson J, *et al*. Online health communities, contributions to Caregivers and resilience of older adults. *Health Soc Care Community* 2021;29:328–43.
117 Barello S, Triberti S, Graffigna G, *et al*. eHealth for Patient Engagement: A Systematic Review. *Front Psychol* 2015;6:2013.
118 Li C, Ning G, Xia Y, *et al*. Does the Internet bring people closer together or further apart? the impact of Internet usage on interpersonal communication. *Behav Sci (Basel)* 2022;12:425.
119 Chen H, Qin J, Li J, *et al*. The influence of Internet use on interpersonal interaction among Chinese urban residents: the mediating effect of social identification. *Asian J Public Opinion Res* 2016;3:84–105.
120 Demiris G. The diffusion of virtual communities in health care: concepts and challenges. *Patient Educ Couns* 2006;62:178–88.
121 Resende G, Melo P, Sousa H, *et al*. (Mis)Information dissemination in Whatsapp: gathering, analyzing and countermeasures. In: Almeida J, ed. WWW '19; San Francisco CA USA, May 13, 2019 10.1145/3308558.3313688 Available: https://dl.acm.org/doi/proceedings/10.1145/3308558
122 Iqbal MP, Newman B, Ellis LA, *et al*. Characterising consumer engagement in virtual models of care: A systematic review and narrative synthesis. *Patient Educ Couns* 2023;115:S0738-3991(23)00302-6.
123 Pal K, Dack C, Ross J, *et al*. Digital health interventions for adults with type 2 diabetes: qualitative study of patient perspectives on diabetes self-management education and support. *J Med Internet Res* 2018;20:e40.
124 Patel S, Akhtar A, Malins S, *et al*. The acceptability and usability of Digital health interventions for adults with depression, anxiety, and Somatoform disorders: qualitative systematic review and meta-synthesis. *J Med Internet Res* 2020;22:e16228.
125 Warsame F, Haugen CE, Ying H, *et al*. Limited health literacy and adverse outcomes among kidney transplant candidates. *Am J Transplant* 2019;19:457–65.
126 Schrauben SJ, Hsu JY, Wright Nunes J, *et al*. Health behaviors in younger and older adults with CKD: results from the CRIC study. *Kidney International Reports* 2019;4:80–93.
127 Billany RE, Thopte A, Adenwalla SF, *et al*. Associations of health literacy with self-management Behaviours and health outcomes in chronic kidney disease: a systematic review. *J Nephrol* 2023;36:1267–81.
128 Jamison DT, Breman JG, Measham AR. Disease control priorities in developing countries (2ND edition). 2006. Available: http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-6179-5
129 Kris-Etherton PM, Petersen KS, Després J-P, *et al*. Strategies for promotion of a healthy Lifestyle in clinical settings: pillars of ideal cardiovascular health: a science advisory from the American heart Association. *Circulation* 2021;144:e495–514.
130 Cline RJW, Haynes KM. Consumer health information seeking on the Internet: the state of the art. *Health Educ Res* 2001;16:671–92.
131 Jacobs W, Amuta AO, Jeon KC. Health information seeking in the Digital age: an analysis of health information seeking behavior among US adults. *Cogent Social Sci* 2017;3:1302785.
132 Swire-Thompson B, Lazer D. Public health and online misinformation: challenges and recommendations. *Annu Rev Public Health* 2020;41:433–51.
133 Keselman A, Browne AC, Kaufman DR. Consumer health information seeking as hypothesis testing. *J Am Med Inform Assoc* 2008;15:484–95.
134 Lee K, Hoti K, Hughes JD, *et al*. Dr Google and the consumer: a qualitative study exploring the Navigational needs and online health information-seeking behaviors of consumers with chronic health conditions. *J Med Internet Res* 2014;16:e262.
135 Szinay D, Jones A, Chadborn T, *et al*. Influences on the uptake of and engagement with health and well-being Smartphone Apps: systematic review. *J Med Internet Res* 2020;22:e17572.
136 Morrison LG, Hargood C, Pejovic V, *et al*. The effect of timing and frequency of push Notifications on usage of a Smartphone-based stress management intervention: an exploratory trial. *PLoS ONE* 2017;12:e0169162.
137 Bidargaddi N, Almirall D, Murphy S, *et al*. To prompt or not to prompt? A Microrandomized trial of time-varying push Notifications to increase proximal engagement with a mobile health App. *JMIR Mhealth Uhealth* 2018;6:e10123.
138 Padhye NSJingWPattern of active and inactive sequences of diabetes self-monitoring in mobile phone and paper diary users. In: Padhye NS, Wang J, eds. 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); users2015: IEEE, Milan.
139 Ong SW, Jassal SV, Miller JA, *et al*. Integrating a Smartphone–based self–management system into usual care of advanced CKD. *Clin J Am Soc Nephrol* 2016;11:1054–62.
140 Phillips SM, Cadmus-Bertram L, Rosenberg D, *et al*. Wearable technology and physical activity in chronic disease: opportunities and challenges. *Am J Prev Med* 2018;54:144–50.
141 Cilliers L. Wearable devices in Healthcare: privacy and information security issues. *Health Inf Manag* 2020;49:150–6.
142 Kong T, Scott MM, Li Y, *et al*. Physician attitudes towards—and adoption of—mobile health. *Digit Health* 2020;6:2055207620907187.
143 de Montjoye Y-A, Hidalgo CA, Verleysen M, *et al*. Unique in the crowd: the privacy bounds of human mobility. *Sci Rep* 2013;3:1376.
144 Piwek L, Ellis DA, Andrews S, *et al*. The rise of consumer health Wearables: promises and barriers. *PLoS Med* 2016;13:e1001953.
145 Piller I, Zhang J, Li J. Peripheral Multilingual scholars confronting Epistemic exclusion in global academic knowledge production: A positive case study. *Multilingua* 2022;41:639–62.
146 Ngo-Metzger Q, Sorkin DH, Phillips RS, *et al*. Providing high-quality care for limited English proficient patients: the importance of language Concordance and interpreter use. *J Gen Intern Med* 2007;22:324–30.
147 Khatri RB, Assefa Y. Access to health services among culturally and linguistically diverse populations in the Australian universal health care system: issues and challenges. *BMC Public Health* 2022;22:880.
148 White J, Plompen T, Tao L, *et al*. What is needed in culturally competent Healthcare systems? A qualitative exploration of culturally diverse patients and professional interpreters in an Australian Healthcare setting. *BMC Public Health* 2019;19:1096.

149 de Moissac D, Bowen S. Impact of language barriers on quality of care and patient safety for official language minority Francophones in Canada. *J Patient Exp* 2019;6:24–32.
150 Wagner N, Hassanein K, Head M. Computer use by older adults: A multi-disciplinary review. *Comput Human Behav* 2010;26:870–82.
151 Zammit AR, Katz MJ, Bitzer M, *et al*. Cognitive impairment and dementia in older adults with chronic kidney disease: A review. *Alzheimer Dis Assoc Disord* 2016;30:357–66.
152 Arning K, Ziefle M. Understanding age differences in PDA acceptance and performance. *Comput Human Behav* 2007;23:2904–27.
153 Kampmann JD, Heaf JG, Mogensen CB, *et al*. Prevalence and incidence of chronic kidney disease stage 3–5 – results from Kiddico. *BMC Nephrol* 2023;24:17.
154 Umaefulam V, Kleissen T, Barnabe C. The representation of indigenous peoples in chronic disease clinical trials in Australia, Canada, New Zealand, and the United States. *Clin Trials* 2022;19:22–32.
155 Ramirez AG, Chalela P. Equitable representation of Latinos in clinical research is needed to achieve health equity in cancer care. *JCO Oncol Pract* 2022;18:e797–804.
156 Fernandez-Bou AS, Ortiz-Partida JP, Dobbin KB, *et al*. Underrepresented, Understudied, Underserved: gaps and opportunities for advancing justice in disadvantaged communities. *Environ Sci Policy* 2021;122:92–100.
157 Domislović M, Domislović V, Stevanović R, *et al*. Chronic kidney disease in rural population. *Acta Clin Croat* 2022;61:228–38.
158 Garcia-Garcia G, Jha V, World Kidney Day Steering Committee*. Chronic kidney disease in disadvantaged populations. *Braz J Med Biol Res* 2015;48:377–81.
159 Xiang J, Morgenstern H, Li Y, *et al*. Incidence of ESKD among native Hawaiians and Pacific Islanders living in the 50 US States and Pacific Island territories. *Am J Kidney Dis* 2020;76:340–9.
160 Ricardo AC, Flessner MF, Eckfeldt JH, *et al*. Prevalence and correlates of CKD in Hispanics/Latinos in the United States. *Clin J Am Soc Nephrol* 2015;10:1757–66.
161 Scholes-Robertson NJ, Howell M, Gutman T, *et al*. Patients' and Caregivers' perspectives on access to kidney replacement therapy in rural communities: systematic review of qualitative studies. *BMJ Open* 2020;10:e037529.
162 Scholes-Robertson N, Gutman T, Howell M, *et al*. Perspectives on access to dialysis and kidney transplantation in rural communities in Australia. *Kidney Int Rep* 2022;7:591–600.
163 Bharati J, Jha V. Global kidney health Atlas: a spotlight on the Asia-Pacific sector. *Kidney Res Clin Pract* 2022;41:22–30.