Charles Darwin University

Codesign of Digital Health Tools for Suicide Prevention

A Scoping Review

Wepa, Dianne; Neal, Martin; Abo-Gazala, Waseen; Cusworth, Sally; Hargan, Jae; Mistryh, Manoj; Vaughan, Jimmy; Giles, Stephen; Khan, Mehnaz

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Codesign of Digital Health Tools for Suicide Prevention: A Scoping Review

Dianne Wepa
ORCID: 0000-0003-0270-1778
Charles Darwin University, Darwin, Northern Territory, Australia,
University of Bradford, West Yorkshire, United Kingdom, Auckland
University of Technology, New Zealand, and University of South Australia, Australia

Martin Neal
Mental Health Nursing, School of Nursing & Healthcare Leadership, Faculty of Health Studies, University of Bradford, West Yorkshire, United Kingdom

Waseen Abo-Gazala
School of Nursing & Healthcare Leadership, Faculty of Health Studies, University of Bradford, West Yorkshire, United Kingdom

Sally Cusworth
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

Jae Hargan
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

Manoj Mistryh
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

Jimmy Vaughan
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

Stephen Giles
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

Mehnaz Khan
Patient and Public Involvement Group,
University of Bradford, West Yorkshire, United Kingdom

ABSTRACT

The importance of codesigning digital health tools for suicide prevention has gained popularity since 2012. Promoted as cost-effective and innovative, digital health tools are widely used but seldom described or evaluated from a codesign lens. This scoping review provides an overview of the research and gaps in the delivery of codesigned digital health tools for suicide prevention. This review is phase two within a three-phase study. Phase one involved a scoping review protocol which informed this scoping review and the results will contribute to a proof-of-concept project to develop a digital tool for suicide prevention (phase three). The search strategy followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-SCR) and Population, Concept, Context (PCC) framework to ensure reporting standards were maintained and supplemented by Arksey and O'Malley and Levac et al. The search for literature occurred from November 2022 to March 2023. Five data bases were searched: Medline, Scopus, CINAHL, PsycInfo and Cochrane Database of Systematic Reviews. Grey literature searches included government, non-government health websites, Google and Google Scholar. 3260 records were identified from the initial search and 61 were included in the final review. All members of the research team screened the included records. Data from published and grey literature were extracted and a narrative approach identified the results and five themes: acceptability by users, future inclusion of experts-by-experience, inconsistent use of Patient and Public Involvement (PPI), digital tools to supplement face-to-face therapy and digital divide. We found that none of the data from the included studies used codesign methodology and experts-by-experience roles were minimised as members of focus groups, advisory groups, pilot studies or at the final stage of usability testing. Future research is required where codesign involves co-authorship with experts-by experience, end-to-end partnership from design, implementation and evaluation of digital health tools for suicide prevention.

Keywords: Codesign, digital tools and suicide prevention

INTRODUCTION

Suicide affects more than 700,000 globally each year [1] and the ripple effect extends to the person's family, friends and community [2]. As a response to prevent suicide, over 10,000 digital health technologies (video conferencing, smartphone apps, texting and social media) emerged as the first port-of-call for people experiencing mental health distress especially during and immediately after the COVID-19 pandemic [3-7]. Given the exponential rise of digital solutions for suicide prevention, there appears however, to be a disconnect between bringing the technology to market and involving experts-by-experience or service users as co designers [8]. With a rapidly evolving technological environment, understanding the place and space of experts-by-experience in suicide prevention requires urgent attention.

For this scoping review codesign is defined. A definition of experts-by-experience is provided. Codesign is defined as 'a co-creation approach involving collaboration between researchers and end users from the onset' [9]. The authors of this project believe that codesign does not occur when experts-by-experience are consulted after the developers or researchers have decided on the outcome of their project. Experts-by-experience is a term that was selected by our research Patient and Public Involvement (PPI) group members, as it reflected the range of experiences as carers and mental health services users. Experts-by-experience is defined as 'people who

have recent personal experience of using and caring for someone who uses health, mental health and/or social care services '[10].

The aim of this scoping study is to present an overview of material reviewed and identify gaps within the literature. This scoping review is phase two within a three-phase study. During phase one, our scoping review protocol outlined the process for the study which informed this review [11]. Results from this scoping review will inform a funding application to codesign a proof-of-concept digital health tool for suicide prevention (phase three).

MATERIALS AND METHODS

We used the recommended six stages of scoping reviews [12,13] and the Preferred Reporting Items for Systemic Reviews and Meta-Analyses Extension for Scoping Reviews checklist (PRISMA-ScR) guidelines [14]. This review did not appraise the quality of evidence found as it sought to examine a topic which has not been systematically reviewed before. We used the Population-Concept-Context (PCC) framework to strengthen the importance of this methodology [15].

Stage One: Identifying the Research Question

Our research question was: *What is known from the existing literature about codesign of digital health tools for suicide prevention*. The PPC framework assisted with guiding us to identify the important aspects of the research question and determining the inclusion and exclusion criteria. We conducted our search from November 2022 to March 2023. The population of interest included patients, students, adults, internet users, experts by experience, service users and soldiers. Soldiers were included as we found in phase one of this study, they were a key group that feature in the literature and reviewers encouraged us to include them as a population of interest in phase two. Concept included codesign, suicide intervention, reduction and prevention. Context included countries such as New Zealand, UK, USA, Australia and the European Union that produced primary and secondary literature in the English language. The search timeframe was from 2012-2023 to ensure recency of the evolving nature of digital technology. The exclusion criteria were study protocols and opinion/editorial data. The search strings for published and grey literature are provided in Table 1.

Stage Two: Identifying Relevant Sources

Published Literature: Search Strategy:

The following licensed electronic databases (from 2012 to 2023) were systematically searched: Medline, Scopus, CINAHL, PsycInfo and Cochrane Database of Systematic Reviews. The initial sources were limited to English in the UK, Canada, USA, Australia and New Zealand. After receiving feedback during the review stage of our protocol, we extended the context to include European Union countries with publications in English. Furthermore, we identified articles such as systematic reviews where the researchers were located in these respective countries, however the data they sourced were from countries such as China, Japan and Sri Lanka.

The initial published data of 3210 records were identified and uploaded into EndNote X9.0, a citation and management software. Almost half were duplicates and removed (n=1570) and the remaining 1640 articles were exported into the reviewing software, Covidence, for title and abstract screening before full-text screening (Fig 1) [16].

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Grey Literature: Search Strategy:

A grey literature search (from 2012 to 2023) was conducted using institutional and government electronic databases and websites. Google and Google Scholar were searched with relevant results reviewed which included non-government organisations and social media. The sources selected were limited to English. 50 records were identified with 42 excluded once the inclusion/exclusion criteria were applied and 9 records were assessed for eligibility (Table 1). The included data were Samaritans, Facebook, Save.org, Lifeline, National Suicide Prevention, Forefront, Papyrus, Mental Health Commission and Beyond Blue (Fig 1).

Table 1: Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Time period	November 2022 – March 2023	Studies outside of these dates
Language	English	Non-English studies
Type of research	Primary research, secondary research, government and non-government websites, social media	Opinion and editorial articles, study protocols
Population & Concept	Patients, adults, internet users, experts-by experience, codesign, students, pupils, soldiers, service users who were included in literature related to suicide intervention, reduction, prevention	People that were not included in both population and concept
Context	New Zealand, United Kingdom, USA, Australia, European Union	Countries that did not produce literature in the English language

Stage Three: Source Selection

From the- 1640 articles uploaded into Covidence, the title and abstracts were screened by DW and WAB and MN resolved any conflicts. Full-text articles were discussed among the research team to ensure moderation of the process particularly with experts-by-experience. Once the inclusion and exclusion criteria were applied, we removed 1588 studies, leaving at total of 61 records (n=52 published articles, n=9 records from grey literature).

Stage Four: Charting the Data

All included data were first extracted from full-text articles and read and excerpts that were relevant to the research question were highlighted. Data from grey literature sources were also included in the data extraction table and included digital interventions predominantly from non-government websites. The data was charted according to the following categories: Author/Year, Aim/Objectives, Methods/Analysis, Population/Sample Size, Countries, Outcome/Limitations (Table 2).

Stage Five: Collating, Summarizing and Reporting the Results

This scoping study aimed to present an overview of material reviewed which is not synthesised as is the case with a systematic review. While this study followed an analytic framework, we did not attempt to present a view regarding the weight of evidence. The results therefore did not seek to assess the quality of evidence and cannot determine if the findings are generalizable. Having charted the data, however, we were able to present our findings in a narrative format after organising the data according to study characteristics (Table 3) and themes (Table 4).

DW reviewed the first iteration of themes according to the inclusion criteria and analysed iteratively the emerging categories from the published and grey literature. MN analysed the

emerging themes and referred to the full text where required. DW and MN worked together to simplify the descriptions and identified fuller commonalities according to the study characteristics and five themes. A final review was provided by the rest of the research team to confirm the results.

Table 2: Population, Concept, Context & Search String.

Population	**Search String**
Patients Adults Internet users Experts by experience Students Pupils Soldiers Service users	Patient* OR student* OR "internet user*" OR Adult* OR pupil* OR soldier* OR "experts by experience" OR "service user*"
Concept	
Suicide intervention Suicide reduction Digital intervention Suicide prevention Codesign	Codesign AND Softwar* OR app* OR tool* OR technolog* OR digital* AND suicide* OR "suicide prevent*" OR "suicide reduc*" OR "suicide intervent*" OR MH* OR "internet based" OR "web based" OR "mobile based"
Context	
United Kingdom Australia United States of America New Zealand European Union 2012-2023	>2012 AND PUBYEAR >2023 AND English lang* UK* AND United King* OR US* United State* AND Canad* AND NZ* OR New Zeal* AND European Un* OR EU*

Table 3: Data extraction table.

Published Literature					
Author/Year	Aim/objectives	Methods/Analysis	Population/sample size	Countries	Outcome/Limitations
Arshad et al 2020 5	Reviewed the acceptability feasibility and efficacy of mobile and web-based intervention for self-injurious thoughts and behaviours (STB)	Systematic Review of 22 trials 12 = Randomised Control Trials 9 = Single-arm studies 1 = crossover counterbalanced controlled design	Adults	USA, UK, China, Denmark, Australia, Sweden, Netherland, Japan, Belgium, France, Sri Lanka	Interventions limited within the literature; qualitative data excluded. Acceptability based upon participant reported experiences of using the intervention, specifically how helpful or useful the intervention was, or the perceived likelihood of using it again in the future. Feasibility based upon intervention engagement or usage rates (e.g., number of times accessing a mobile phone app during the study period). Suicidal ideation

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					was also included as a secondary outcome. Recommend involving those with lived experience of STB in the development to ensure interventions feel acceptable and useful to the individuals they have been designed to help.
Bailey et al 2020 30	Ethical issues and practical barriers to internet-based suicide prevention research	Mixed methods, 2 phases. Systematic search and online survey of researchers from phase one	15 x studies 15 x researchers	Australia, USA, Europe	Difficulties in managing risk in online environments. Half of respondents reported problems with obtaining ethics approval. Assessment and management of risk is more complex with internet-based intervention studies compared to face-to-face studies. Different countries had different ethics jurisdictions. Recommend inclusion of people with lived experience in the design of interventions and trials.
Baines et al 2022 25	Patient, public involvement in digital health innovation	Systematic review	433 x articles and grey literature	UK USA Canada Australia	Areas described: cancer n=50, mental health n=43, diabetes n=26, long-term conditions n=19. PPI most involved in the final passive stages e.g., usability testing. Ability to influence change was severely limited. Common barriers data privacy, security concerns, not involved early enough, lack of trust.
Balcombe & De Leo 2022a 36	Review of human-computer interaction in digital mental health	Modified integrative review	Population not specified	Australia	Focused on effectiveness, feasibility, accessibility, sociocultural inclusion, rigor and readiness for adoption and upkeep. Difficulty translating findings in clinical practice because of low engagement. Stepped model of care recommended with self-help or chatbots followed by therapist-guided digital therapy.

Balcombe & De Leo 2022b 37	Review of digital tools for suicidal men	Integrative review	Adult men	Australia	Man, Up programme found active and empowering language useful. Digital phenotyping via tracking on a smartphone app can monitor patient status but not provide an intervention. Unclear what to prescribe for digital suicide prevention because of a lack of strategy integration. Need for co-design, development and evaluation when providing Virtual reality and video games.
Berrouiget et al 2014 38	Post-acute crisis text messaging for suicide prevention	Evaluate acceptability of text messaging 2 months after crisis	4 x men 14 x women Aged 24-61 years	France	First message sent within 48 hours which patients were satisfied. Service did not allow patients to reply but were prompted to keep follow up appointments and to ring health provider if required. Small study sample.
Biddle et al 2020 51	Explored distressed users' perceptions of formal online help during times of crisis	Grounded theory Reporting suicide-related internet use	53 x Adults	United Kingdom	Critical of websites that only offer signposting to offline services as their primary response. Many participants regularly used formal online help for ongoing mental health difficulties. Sites lacked a sense of community or opportunity for emotional connection. Want instant chat, if going online, want to stay online. Efforts have been made by Internet Service Providers to adjust search algorithms to prioritise help sites in suicide elated search output. However, research has focused on quantifying characteristics of help-seekers, trialling specific online interventions (e.g., apps), or examining online support groups, rather than seeking user evaluations of everyday online help pages. Recommend formal online help services be

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					reappraised to meet users' needs for immediacy and responsive help. Users should be co-producing new online materials and approaches. Incorporate interactive elements e.g., live chat, links to forums (moderated by health professionals), self-help tools and lived-experience content.
Brown et al 2020 39	Review mobile app to support suicide prevention gatekeepers in Australia	2 participatory design workshops	12 x Indigenous health workers and community workers	Australia	Change the term gatekeeper to responder which is a more culturally appropriate term. Combination of multiple support resources recommended e.g., mobile applications, social media and wallet cards, regular meetings. Recommend regular training for community members to include collaboration with community services.
Bush et al 2015 60	Proof-of-concept of virtual hope box (VHB) smartphone app	Phase 1 = VHB & development Phase 2 = clinical field testing	18 x high risk of self-harm veterans enrolled in Dialectical Behaviour Therapy (DBT) programme	USA	Usable therapeutic tool to supplement face-to-face therapy. Limited by sample size and entirely descriptive analyses.
Cohen et al 2021 58	Web-based support services for suicide prevention in young people and students	Sequential cross-sectional mixed methods, user-informed review	9 x young people 4 x general practitioners 232 sites	UK	11 suicide-specific online help services out of 232. 17 sites included lived experiences accounts of suicidal stories provided as hope and recovery. 5 sites provided offline telephone hotline or email service. 4 sites provided active peer support. Clarity, brevity and immediacy most important facets for young people. Preference for text-based rather than verbal forms of communication. Few services provided peer support.
Bruen et al 2020 40	Report the practicalities and acceptability of trialling digital technologies in	Interactions with a novel phone app: Strength Within Me and Fitbit for 7 days. Journaling and	79 x adult inpatients	United Kingdom	Natural language processing (NLP) using language from social media posts could identify people at risk of suicide. Facebook

	an inpatient mental health setting	rating mood and creating safety plans. Option to include Facebook.			accentuated participants' distress when comparing their lives with family and friends on Facebook posts. 4G connectivity was essential for reliable and continuous access to the app and can help reduce barriers to face-to-face help-seeking, such as stigma and discomfort about discussing one's own mental health. Findings restricted to an inpatient population. The practical components of trialling a novel phone app within health services may be valuable for future research and health care organizations. Recommend app to include uplifting quotes, self-help links, an SOS (abbreviation for distress) button for helpful contact numbers.
Buscher et al 2020 23	Does Cognitive Behaviour Therapy (CBT) target suicidal ideation	Systematic review and meta-analysis 6 x Randomised Control Trial (RCT)	2 x studies = youth 4 x studies = adults	Netherlands USA, Australia Belgium	Internet-based self-help interventions for suicide prevention considered a low-threshold treatment option to complement current services. Low number of included studies.
Buus et al 2020 41	Stakeholder perspectives on suicide prevention mobile phone app	Comparative thematic analysis of 4 focus groups using MYPLAN app for suicide prevention	4 x focus groups 5 x youth 8 x adults 3 x relatives 10 x clinicians	Denmark	Flexibility of app allowed for tailored safety planning compared to the more static paper version. Use of Hope Box reported as innovative and helpful. Collaborative process supported the analyses' credibility. Context of participants' experiences important to included. Intense feelings of despair could make it impossible to engage with planned strategies. Took special effort to engage with app if person felt better.
Castillo-Sanchez et al 2019 52	Review of mobile apps for suicide prevention	Descriptive analysis 16 parameters	16 x apps Population not specified	Canada Scotland Spain UK USA	Design and development of apps require support from health personnel to humanize them. Apps not updated regularly. Technical quality cannot

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					be determined. 82% of apps in English language only. Most outstanding apps had an average of 10,000 downloads. Only 3 apps had high value reviews: Stay Alive (201), Suicide Safety Plan (179), Virtual Hope Box (611). Non-inclusion of advertisements was useful and helped avoid detracting the person's concentration or overwhelming them. Virtual Hope Box met many of the parameters. Only app that offered 6 languages and highest number of downloads 10,000 and reviews 611. It is updated frequently. Omission of word suicide is notable and associated with negative emotions. Positive words such as hope is better option for suicide prevention. The Virtual Hope Box was developed at the National Centre for Tele-Health and Technology (US Department of Defence) and is based on the analogue version of the hope box concept, a therapeutic tool used by clinicians to help patients with depression or suicidal tendencies to redirect their negative thoughts toward reflecting on reasons for living instead. This app is particularly interesting because, based on the evaluated results, the technical elements of its use and design could be used in the development of similar apps. Low number of apps. User preference needs further investigation.
Chen & Chan 2022 21	Review of effectiveness of digital health interventions (DHI) on unintentional	Meta-analysis RCTs	34 x articles Population not specified	USA, Australia Belgium, Canada, Germany New Zealand	18 articles examined effectiveness for reducing suicide. Majority of studies conducted in developed countries which reflects

	injury, violence and suicide			Sweden Switzerland Netherlands UK, China, Sri Lanka	the digital divide among countries. DHI can be cost-effective and more accessible than traditional prevention programmes. Recommend policy makers should improve peoples' digital literacy.
De Jaegere et al 2019 17	Evaluating the effectiveness of online treatment of suicidal ideation	RCT of unguided web-based intervention 2 arm, parallel design RCT in general population in Flanders	18 years or older Experienced suicidal ideation Intervention group = 365 received access to unguided web-based intervention Control group = 359 placed on a waitlist	Belgium	Online self-help intervention more effective in reducing suicidal ideation and symptoms than waitlist control group.
Dickter et al 2019 42	Impact of online programme for depression and suicide intervention	Determine overall efficacy of CATCH-IT online programme for adolescent suicidal ideation and risk factors for suicide	83 x Adolescents 13 x primary care sites across four states Age 14 -21 years	USA	Higher self-esteem predicts lower suicidal ideation
Dimeff et al 2021 18	Feasibility, acceptability and effectiveness of Jaspr Health among suicidal adults in Emergency Departments (ED)	Pilot RCT Tablet-based app for direct use by patients which enables the delivery of 4 evidenced-based practices	31 x adults acutely suicidal in ED 14 x randomised 17 x care as usual control group	USA	Advisory group with lived experience assisted in developing the research procedures to ensure acceptability of the research method. Significant decrease in distress and agitation and learning to cope more effectively for participants. Small sample size
Dreier et al 2021 59	Sharing insights involving people with lived experience of suicide in the development of an online suicide prevention programme	Sequential explanatory mixed methods design with three measurement points, pre, post, follow-up of programme 8 Lives – Lived experience reports and facts on suicide	7 x Adults 18+ years old Affected by suicide or are close to those affected	Germany	Involving people with lived experience of suicide enriches research projects and can be empowering for the people involved and essential to create a credible programme. Evaluation of the programme development could have been more standardized.
Franco-Martin et al 2018 3	Review of existing technology for suicide prevention	Systematic review	30 x studies on adolescents	English speaking countries	51% = web technologies 22% = mobility solutions 12% = social networks 3% = machine learning 95 = others Collaboration required among technologists,

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					psychiatrists, patients and family members to advance the development of new technology-based solutions. Lack of studies on social networks. The use of technology mostly for training health professionals, families and patients. Those focused on adolescents have a greater acceptance of technologies.
Gibson et al 2019 53	Young peoples' talk about suicide	Focus groups, social constructionist approach	38 x young people aged 15-22 years, 9 x focus groups, not suicidal	New Zealand	Unhealthy silence on suicide in the public domain. Support of online community allows young people to escape adult surveillance and stigma. Limited sample and not targeting more marginalized youth populations.
Goldberg et al 2022 24	Mobile phone interventions for mental health	Systematic review	14 x meta-analyses of RCTs Adults, Adolescents	Not identified	1 x article focused on suicidal ideation. Text-messaging services outperformed non-specific controls. Results support the potential of mobile phone-based interventions.
Gould et al 2021 54	Effectiveness of Lifeline crisis interventions	Pre and post-chat survey	6 x core centres 70% under 24 years of age 40% minors	USA	39,911 chats. Chatters reported being less suicidal than when they started the chat. 2/3rds were female.
Hetrick et al 2018 43	Youth co-design of mobile phone app for major depression, suicidal ideation and self-harm	4 x co-design workshops with young people (design studio) 2 x focus groups with clinicians	11 x young adults 18-25 years old experienced depression, suicidal ideation, self-harm. 16 x clinicians	Australia	Focus on positive approach with naming 'well-being tracker'. Brief personalised interventions between face-to-face appointments. App not designed for young people not engaged in face-to-face treatment. Issue to balance needs of young people with potential clinical burden. Need to intervene with young people in real time with acute risk of suicide rather than using the app as a digital diary.
Hobson et al 2019	Mobile health for First Nations populations	Systematic review 13 studies	First Nations	Canada New Zealand Australia	Mental health and suicide prevention, particularly in the

26				USA	Australian context, were common themes (n=5). This is an important finding given the documented mental health challenges experienced by First Peoples of Australia, New Zealand, and the United States on account of intergenerational trauma. Scientific research is responding to the mental and emotional challenges faced by First Nations populations. Grey literature not included.
Josifovski et al 2022 44	Text message and online brief contact intervention following self-harm or suicide attempt	Non-randomised, single-arm intervention, mixed methods pilot study. Reconnecting After self-harm (RAFT)	13 x young adults and adults aged 16-65 years Presented to Australian ED in previous 7 days of self-harm or suicide attempt and have Australian mobile phone	Australia	Text messages well received indicating preferred method to be contacted. Significant reduction in number of self-reported self-harm episodes 12 months after presentation. High acceptability of 6 participants 12 months after. Small pilot, almost all female, no control group.
Kennard et al 2018 45	App support inpatient intervention to prevent post-discharge suicidal behaviour for adolescents	Pilot study As Safe as Possible (ASAP) to reduce suicide attempts following hospital discharge Randomised 3 x hour intervention inpatient unit	2 x sites 66 x adolescents aged 12-18 years old hospitalised for suicidal ideation n=26 Or recent suicide attempt n=40	USA	Participants reported high satisfaction, acceptability, feasibility with the intervention and app. Low rate of family engagement.
Kennedy et al 2020 46	Digital intervention to reduce suicide stigma among farming men	Adult learning model Ripple Effect digital intervention website.	169 x farming males aged 30-64 years. Personalise and tailored farming type, gender and experience of suicide. Post card messages, video stories, education and personal goal setting.	Australia	Majority of postcards and message's themes were growth, new realisations, hope and encouragement. Attitudinal and behaviour change with reduced stigma associated with mental health and suicide. Farmers have high level of suicide of suicide trajectory given their access to lethal means. Focus development on suicide safety planning targeting farmers. Maintaining engagement

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					recommended for future development.
Kimberly et al 2017 47	Usability, feasibility and acceptability of Crisis Care	Web-based prototype of Crisis Care pilot-tested	20 x parents 20 x adolescents, 16 x females, 4 x males Outpatient paediatric hospital	USA	App has the capacity to reduce feelings of isolation and loneliness. High acceptability and usability by adolescents and parents. Helped connect adolescents to parents. Potential to enhance family-focused safety family procedures, intervention and treatment. Small sample size, predominately female.
Kiosses et al 2021 48	Emotion regulation tablet app for middle-aged and older adults at high suicide risk	Feasibility and acceptability of two case studies Use of WellPATH app. 12-week psychotherapy intervention	12 x middle aged and older adults 50 years and older Suicidal ideation at discharge from hospital	USA	WellPATH app feasible and accepted among middle-aged and older adults at high suicide risk. Reduced negative emotions and reinforced emotion regulation strategies.
Kreuze et al 2017 27	Technology-enhanced suicide prevention interventions	Systematic review CDC Risk and Protective Factors Ecological Model	16 x studies. Standalone or adjunct interventions delivered by mobile phone apps, text message, telephone, computer, web CD-ROM and video. Population not specified	USA	Technology-enhanced approaches performed favourably for depressed mood, anxiety, hopelessness and negative automatic thoughts. Telephone management reduced suicidal thoughts, suicide re-attempts and suicide mortality. Technology-enhanced interventions was more affordable than face-to-face interventions alone and reduced stigma.
Lai et al, 2014 31	Review of web-based suicide prevention	Literature review	15 x articles All populations	Not specified	Three key factors assist with web-based suicide prevention strategies: ease of accessibility, degree of anonymity and text-based communication. Web-based approaches advantages due to stigma, physical/psychological limitations or geographical location and cost-effective. Issues of confidentiality, safety in an acute crisis.
Martinengo et al 2019	Adherence to clinical guidelines for	Systematic review	69 x apps General population Students	Australia Spain, UK USA	Only 5 of the depression and suicide prevention apps offered the 6 suicide

28	suicide prevention and depression apps		Veterans	New Zealand Canada Bangladesh	prevention strategy domains. Failure of Apple and Google app stores and health app industry in self-governance, quality and safety assurance. Risks and benefits to users' needs to be identified. 34 apps belonged to Health and Fitness category and 14 14 categorised as medical.
Martinez-Miranda et al 2019 49	Acceptability of mobile-based conversational agent for prevention and detection of suicidal behaviour	Exploratory pilot for virtual agent, HelPath	12 x participants aged 20-53 years old, Past suicidal behaviour/ideation/planning or attempt	Mexico	60% of participants reported emotional competence and adherence. Appearance and voice of avatars required improvement to reflect users.
Meier et al 2022 61	SERO – Mobile app for suicide prevention	Proof-of-concept SERO app to	Focus groups Health professionals, people with illness experience and relatives to test 6 strategies for suicide prevention: 1 Tracking mood or suicidal thoughts 2 Safety plan development 3 offer activities to deter suicidal thoughts 4 Information an education 5 Access to support networks 6 Access to emergency counselling	Switzerland	Potential for self-management, self-assessment and self-reflection. Limitations with app considered a medical device and requires further funding to meet legal regulations.
Milne-Ives et al 2022 32	Artificial intelligence and machine learning in mobile apps for mental health	Scoping review	4 x articles Population not specified	UK USA	Importance of maintaining user engagement. Sample size small
Morgieve et al 2020 50	Use of EMMA app	Case report study Ecological Mental Momentary Assessment (EMMA) Longitudinal Clinical assessment 1,3,5 months	14 x participants Presence of mental disorders and suicidal thoughts and behaviours.	France	Recommend integrating EMMA into existing emergency procedures. Interpret co-design as being consulted early and through focus groups, not in publication.
O'Grady et al 2020 55	Develop SafePlan app for suicide prevention	Focus groups Survey	15 x mental health care professionals 18 x secondary school students aged 14-16 years	Ireland	Ready for trailing. Core function to provide interactive safety plan for people with suicidal thoughts/ behaviours as an adjunct to face-to-face therapy. High acceptability and usability. No automated

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					warning to inform people when they should consider seeking professional help.
O'Toole et al 2019 19	App-assisted treatment for suicide prevention	Compare treatment	129 x adults aged 18-65 years Outpatient suicide prevention clinic Treatment as usual with app = 69 and without = 69	Denmark	Group receiving treatment as usual in combination with access to mobile app experienced a smaller decrease in self-reported suicide risk immediately following treatment.
Pospos et al 2017 29	Web-based tools and apps to mitigate burnout, depression and suicidality among healthcare students and professionals	Systematic review	36 x articles 14 x web-based tools 22 x mobile applications Healthcare students only	Not specified	No inclusion of health professionals. 2 focused on suicide prevention: Virtual Hope box (improves users' ability to cope with unpleasant thoughts and emotions) & Stay Alive (customized safety plan, breathing & grounding exercise tutorials. Online discussion forum, links to other resources). Recommend applying user-centred design for future tools.
Primack et al 2021 56	Feasibility and acceptability of mobile app for the prevention of suicide	Mobile Application for the Prevention of Suicide (MAPS) Semi-structured interviews	8 x veterans 2 weeks post-treatment from psychiatric facility	USA	Ability to address suicide risk in real time. Intended to adjunct to therapy rather than stand-alone treatment. High rating of acceptability. Participants would use it again and recommend to a friend. Ability to help users to understand themselves and their emotions.
Rassy et al 2021 33	Information and communication technology use in suicide prevention	Scoping review	115 studies Population not specified	Not identified	ICT play a major role in suicide prevention however large-scale evaluation studies are needed to further examine their effectiveness. 10 studies referred to universal suicide prevention strategies using health promotion through educational websites and awareness campaigns. ICT may provide a sense of being connected to people who are otherwise isolated and reluctant to use offline services. Algorithms

					helped identify individuals at risk of suicide, but a clinical application of these algorithms is yet to be developed.
Reen et al 2022 34	Mobile apps for suicide prevention and privacy policies	Ascertain the efficacy of mobile intervention in preventing suicide & investigating privacy strategies	35 x apps 41 x articles Population not specified	Not specified	Lack of research on how users' privacy is managed. Recommend more interactive apps and apply user-centre design approach.
Rice et al 2016 35	Implementation and moderation of online suicide intervention	Review of online and social media suicide intervention studies	3 x online and social media intervention studies of adolescents 14–25-year-olds	Australia	Moderation of interventions are required to monitor adolescents' behaviours online.
Rozek et al 2020 20	Machine learning to predict suicide attempts in the military	Secondary data analysis of RCT testing the efficacy of CBT treatment compared to treatment as usual.	152 x Veterans 76 = CBT 76 = Treatment as usual	USA	Small sample size. Inconclusive findings.
Varzgani et al 2021 63	Review of suicide prevention through smartphone applications	Systematic review	30 x articles All populations	Not specified	Categorised features are user engagement, safety planning, helplines and support, coping strategies, self-assessment. Most apps are not sustained over time because of the lack of engagement features. 3 apps used Imaginator, LifeApp engagement such as notifications, alerts, reminders Imaginator added gamification and a reward badge system, points, avatars. 2 apps, SafePlan and BeyondNow allowed sharing of safety plans with family or support network. BeyondNow app provided video outlining practice of safety planning. All apps included emergency helplines. MyPlan included locating nearest emergency department. 10 apps had distraction feature provided music, games, mindfulness exercises, stories and

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					videos. 6 apps provided suicidal thought tracking with self-reported scales, questionnaires, therapy sessions with experts. Limited with some apps including therapy and some were stand alone.
Povey et al 2016 57	Explore Aboriginal and Torres Strait Islander experiences of two apps	Qualitative study 2 culturally responsive e-mental health apps, 3 x focus groups, ibobly and AIMHi apps	9 x Aboriginal community members	Australia	Acceptability of apps for people with less severe mental illnesses. Motivation, technological competence and literacy likely to influence acceptability. Clinician support to use apps recommended. Apps complement rather than replace face-to-face services. Culturally relevant language and graphics. Balance between security and usability. Small sample size from one location.
Robinson et al 2015 6	Social media and suicide prevention	Systematic review	30 x studies Population not specified	Australia	Social media platforms can reach large numbers of otherwise hard-to-reach people. Acceptability of providing an anonymous, accessible and non-judgmental forum. Sites generally governed by an ethical code of conduct and successfully moderated by trained volunteers who received professional supervision. Users used platforms to seek peer support as opposed to professional support. Very few people used the sites to seek information about suicide methods or suicide partners. Challenges with controlling user behaviour, accurately assessing risk, privacy and confidentiality. Platforms as opposed to offline help and support could further marginalize people from mainstream society. Possibility of normalising of suicide-related behaviour as a

					response to one's problems.
Tighe et al 2017 64	Evaluate the effectiveness of a self-help mobile app (ibobbly) for suicide prevention	Pilot randomised control trial Randomised to receive acceptance-based therapy over 6 weeks (through app) or waitlisted for 6 weeks	61 x Aboriginal adults aged 18-35 years	Remote and very remote North-western Australia	Apps for suicide prevention reduce distress and depression but do not show significant reductions on suicide ideation or impulsivity. 16 participants did not have suicide ideation as a baseline making it difficult to demonstrate a significant effect in a small sample.
Torous et al 2018 50	Assess whether technology-based solutions reduce suicide	Clinical review of smartphones, sensors and machine learning	Mental Health clinicians	Not applicable	Apple App Store and Google Play store targeting suicide prevention are not evidence based and few have been clinically validated. Apps need to augment care and never to fragment care. Majority of apps are never opened more than once. Little data on use of smartphone apps for child and adolescent populations as concerns about privacy, legal and efficacy. Dearth of research on digital tools for suicide prevention in older adults. Considering that older adults are at the highest risk for death by suicide, there is an even greater need to offer new effective tools for this population.
Torok et al 2020 7	Does direct and indirect digital interventions effective in reducing suicidal ideation and behaviours.	Systematic review and meta-analysis	16 x studies 10 x direct interventions 6 x indirect interventions All populations	Belgium, USA, Australia, Netherlands, Germany	Self-guided digital interventions directly targeting suicidal ideation are effective immediately post-intervention. Indirect interventions were not significant. Digital interventions should be promoted and disseminated widely, especially where there is a lack of, or minimal access to health services. Overall effect size of interventions is small, the population impact could be significant.

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Witt et al 2017 52	Online and mobile apps for self-management of suicidal ideation and self-harm	Systematic review and meta-analysis	7 x databases 14 x non-overlapping studies 3,356 x participants	Australia, USA Germany Netherlands Sweden Switzerland	Digital interventions associated with reductions for suicidal ideation scores at post-intervention. No evidence of a treatment effect for self-harm or attempted suicide. Only 5 developed specifically for self-management of suicidal ideation. Only 1 developed for the self-management of self-harm.

Grey Literature			
Author/Year	Methods/Analysis	Countries	Outcome/Limitations
Payrus 62	N/A	UK	Self-harm prevention and suicide prevention focus. Trustees experience suicide with family members. Not clear if youth are actively involved in co-design of services or website.
Samaritans 2018 - 2019 65	Service Review	International	Reviewed their services and launched a text service (SHOUT) in 2019 and a suicide prevention website (StayingSafe) in 2018. Consulted people with lived experience, video footage and safety plans.
Facebook 2017 66	Service Review	International	Artificial Intelligence (AI) commenced to detect suicidal posts before they are reported. Only liaised with mental health experts and not service users.
Save.org 67	N/A	USA, UK, India, Canada	Focused on raising public awareness and education. Not clear if co-design of services or website occurred.
National Suicide Prevention 68	N/A	UK	Work with a network of organisations and individuals in suicide prevention. Focused on raising public awareness and education. Not clear if co-design of services or website occurred.
Lifeline 69	N/A	International	Crisis response helpline. Provided in different languages with option to phone a trained counsellor. Not clear if co-design of services or website occurred.
Forefront 70	N/A	USA	Focused on raising public awareness and education in schools, higher education, workplaces and communities. Not clear if co-design of services or website occurred.
Mental Health & Wellbeing Commission 2021 71	N/A	New Zealand	Focused on raising public awareness and education. Created by the government after an enquiry into mental health and addiction. Some involvement with people with lived experience at governance level.
Beyond Blue	N/A	Australia	Focused on raising public awareness and education on anxiety, depression and suicide. Safety planning

72			app available to download from website. Phone and chat options with trained counsellor. Not clear if co-design of services or website occurred.

RESULTS

Study Characteristics of the Included Studies

Table 3 provides an overview of the study characteristics. There were several study types from the 52 published articles including four randomized control trials [17-20], one meta-analysis of randomised control trials [21], one clinical review [22], four systematic review and meta-analysis [4, 7, 23, 24], nine systematic reviews [3, 5, 6, 25-29, 63], one mixed methods [30], five literature or scoping reviews [31-35], two integrative reviews [36- 37], thirteen pilots or trials [38- 50], seven qualitative studies [51-57), two sequential cross-sectional mixed methods (58-59) and two proof-of-concept [60-61].

The following demographics were noted from the published and grey literature. 7 x articles identified young people specifically ranging from 14- 22 years old [35, 42- 43, 47, 53, 58- 59). 1 x website targeted youth [62] and 1 x article focused on young females [54]. 6 x articles focused on young people alongside adults, carers, parents and/or healthcare professionals [12, 23, 28, 45, 49, 55]. Adults were identified within 6 articles with an age range from 24-61 years [5, 38, 40, 51, 59]. Two articles specifically discussed adult males [37, 46].

Older adults aged over 50 years were discussed in one article [48]. Veterans were discussed in four articles [20, 28, 56, 60]. Ethnicity was focused on the experiences of Indigenous cultures within 5 articles from Australia, New Zealand, Canada and USA [26, 39, 57, 59, 64]. 16 published articles and 8 items of grey literature did not specify which populations the authors were targeting, or it was implied that all populations were included [21, 25, 27, 29-34, 36, 38, 50-52, 65-72].

Theme One: Acceptability by Users

Table 4 provides an overview of the five themes that emerged from the 52 peer reviewed articles and 9 items from grey literature. We found the first theme of *acceptability by users* was prominent from the published literature (n=19). The articles either examined acceptability of digital tools for suicide prevention explicitly or it emerged as a key finding [5-6, 18, 23-24, 35-40, 45, 47-49, 54-57]. Interestingly, almost half of the 19 items (n=9) specifically reviewed suicide prevention and self-injury apps to establish if users found them acceptable [5, 18, 40, 45, 47-48, 55- 57]. The remaining published literature focused on text messaging services [6, 35] or involved systematic reviews of social media platforms and mobile phone-based interventions [6, 24, 36]. Only one article reviewed the chat function on the Samaritan's website, a major non-government organisation that has a long history of providing suicide prevention services [54].

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Table 4: Study characteristics of included data.

Author	**Study type**
[17–20]	Randomised control trials (RCT)
[21]	Meta-analysis of randomised control trials
[22]	Clinical review
[4], [7], [23-24]	Systematic review and meta-analysis
[3], [5-6], [25-29], [63]	Systematic review
[30]	Mixed methods
[31-34]	Literature review / scoping review
[36-37]	Integrative review
[38-50]	Pilots / trials
Author	**Demographics**
[35], [42-43], [47], [53], [58], [59]	Young people aged 14-22 years old
[62]	Youth
[54]	Young females
[12], [23], [28], [45], [49], [55]	Young people, adults, carers, parents and/or healthcare professionals
[5], [38], [40], [51], [59]	Adults aged 24-61 years old
[37], [46]	Adult males
[48]	Older adults aged over 50 years old
[20], [28]. [56], [60]	Veterans
[26], [39], [57], [59], [64]	Ethnicity focus on Indigenous cultures
[21], [25], [27], [29], {30-34], [36], [38], [50-52], [65-72]	Not specified or implied all populations were included

Table 5: Narrative grouping of data into themes.

Author	**Theme**
Theme 1: Acceptability by users	
[5], [18], [40], [45], [47-48], [55- 57]	Suicide prevention and self-injury apps
[6], [35]	Text messaging services
[6], [24], [36]	Social media platforms and mobile phones
[54]	Chat function
Theme 2: Future inclusion of experts-by-experience	
[3]	Adolescents and greater acceptance of technologies
[5], [26], [30], [65]	Lived experience in design of interventions and trials
[32], [46], [50]	Importance of user engagement or focus groups
[29], [34], [37], [39], [51]	Codesign, coproduction, collaboration, user centred
Theme 3: Inconsistent use of Public, Patient Involvement (PPI)	
[66]	Consulted mental health experts and not service users
[25]	Final stages of usability testing
[58]	Middle stage of research as user-informed
[41]	Collaborate to support the analysis
[18], [43], [53], [55], [57], [59], [61]	Members of focus groups or advisory groups
[19], [44-47], [49], [56], [64]	Pilot studies or prototypes
[48]	Case studies
Theme 4: Digital tools to supplement face-to-face therapy	

[17], [19], [38], [50]	Self-guided digital tools most effective immediately post-intervention
[20], [23], [57], [64]	Low threshold treatment complements face-to-face therapy
[28], [33]	Clinical applications of algorithms to identify suicide risk required
[35], [42-43]	Moderation of interventions required for adolescents
[17], [36], [52], [55-56], [60], [63]	Engagement still required with clinical practice
Theme 5: Digital Divide	
[40]	4G connectivity essential
[21]	Majority of research in developed countries
[32]	More affordable and reduced stigma

Theme Two: Future Inclusion of Experts-By-Experience

The second theme identified from 12 articles located in the published literature recommended the *future inclusion of experts-by-experience* [3, 5, 26, 29, 30, 32, 34, 37, 39, 46, 50, 51]. One item from grey literature also emerged within this theme [65]. The terminology and ways to involve experts-by-experience varied among the literature. For example, involving people with *lived experience* in the design of interventions and trials was specifically highlighted in four studies [5, 26, 30, 65]. *Codesign, coproduction, user-centred design and collaboration* were terms used in five studies where the emphasis was on end-to-end input, albeit in a generalised format [29, 34, 37, 39, 51]. To a lesser extent, the importance of *user engagement* or *focus groups* was recommended in three studies [32, 46, 50] and one study specifically recommended targeting *adolescents* whom the authors argued have a greater acceptance of technologies [3]. Interestingly, given that the recommendations from these articles were to include experts-by-experience within health research, we found it surprising that such recommendations were identified and not followed through by the authors themselves. We found one exception where the Samaritans' website was reviewed from 2017-2019 [65]. The review involved repackaging the Samaritans' web-based services and text service, SHOUT. Following consultation with people with lived-experience a new website (StayingSafe) included strategies for developing a safety plan and lived-experience video footage. The review found that it was important to continue evaluating developments and identify models of effective help provision. In addition, it was noted that users should be involved not only in such evaluation, but also as co-producers of new online materials and approaches.

Theme Three: Inconsistent use of Patient and Public Involvement (PPI)

Patient and Public Involvement (PPI) in research is defined as 'Research being carried out *with* or *by* members of the public rather than *to, about* or *for* them' [73]. Notwithstanding, *the Inconsistent use of PPI theme* emerged from 19 published articles where the authors where unclear about the purpose and role of PPI [18-19, 25, 41, 43-49, 53, 55-58, 61, 64]. Furthermore, Facebook, a major online networking site, stated that their company liaised with mental health experts (not service users) and considered this type of consultation met the requirements of PPI research [66]. None of the data from the published and grey literature identified PPI as co-authors and used a variation of terms to imply codesign methodology. For example, PPI were involved passively during the final stages of usability testing for digital tools [25], the middle of the research as user-informed participants [58], part of a collaborative process to support the analysis [41], as members of focus groups or advisory groups [18, 43, 53, 55, 57, 59, 61], pilot studies or prototypes [19, 44-47, 49, 56, 64] and case studies [48].

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Theme Four: Digital Technology Tools to Supplement Face-To-Face Therapy

The theme of *digital technology tools as a supplement to face-to-face therapy*, emerged from 20 articles within the published literature [7, 17, 19, 20, 23, 28, 33, 35-36, 38, 42-43, 50, 52, 55-57, 60, 63-64]. From within this theme, four articles found that self-guided digital tools were most effective immediately post-intervention [17, 19, 38, 50]. It was not clear however if the effectiveness continued once the studies were complete and the digital tools such as tablets and mobile phones were returned to the researchers. Four articles noted that low threshold treatments were successful as a complement face-to-face therapy [20, 23, 57, 64]. People that were considered actively at high risk of suicide were not included in the studies. Websites and platforms such as Facebook were reviewed where clinical applications of algorithms were recommended as a future requirement to identify suicide risk [28, 33]. As a high-risk group for suicide, moderation of digital interventions was recommended in three studies particularly for adolescents [35, 42-43] and engagement with clinical practice is still required [17, 36, 52, 55-56, 60, 63]. Although the articles recommend digital intervention as part of model of care, 9 articles involved limited sample sizes and were not generalizable [38, 60, 23, 52, 56, 20, 57, 64, 7].

Theme Five: Digital Divide

The digital divide is the gap that exists between individuals who have access to modern information and communication technology and those who lack access [74]. Although only three articles were included within the theme of *digital divide*, we felt its impact required attention as disparities associated with access, geography and income were identified [21, 32, 40].

One article noted that 4G connectivity was essential for reliable and continuous access to the applications [40]. Those on low incomes tended to use 2G and 3G technology that did not require smartphones and relied on text messaging services. Similarly, a second article found that technology-enhanced interventions such as telephone management were more affordable than face-to-face interventions and reduced stigma [32]. Furthermore, the majority of research on digital technology and suicide prevent was conducted in First-world countries, which excluded less developed countries [21]. Recommendations include policy makers improving peoples' digital literacy and inclusion of research with more countries on a global scale [21].

STAGE SIX: STAKEHOLDER CONSULTATION

The experts-by-experience members of this project are part of the university's PPI group and regularly provide input into programmes or research. The group were approached by the primary researcher to be part of the project and were paid as per the National Institute of Health and Care Research guidelines [73]. The members met monthly to review the articles and the chairperson meet with the primary researcher in between meetings. All members have been identified on funding applications, publications and conference presentations.

DISCUSSION

This scoping review was the first to explore what is known about codesign, digital tools and suicide prevention. Our findings highlighted the disconnect between developers, researchers and experts-by-experience understanding and acceptability of the digital health tools. For example, none of the published articles were clear about codesign as a methodology and end users were only included passively through focus groups, advisory groups, or during the testing

stage of pilot studies or prototypes, as opposed to being involved in the end-to-end production of the tools. Despite the initial engagement of experts-by-experience with digital tools for suicide prevention immediately after an intervention, the removal of regular monitoring by health professionals once trials were completed, contributed to lack of data to confirm if engagement with the tools continued.

Supplementation of digital solutions in partnership with face-to-face therapy will increase especially for digital natives such as adolescents. The ethical concerns over how younger populations will have their privacy safeguarded is an area that is yet to be developed more fully within the literature. The digital divide is noteworthy as a future concern as countries such as the United Kingdom are phasing out 2G and 3G networks in 2023 to make room for faster 5G networks [75]. The implications for those on low incomes and experiencing mental distress may not be visible to the public as access to digital platforms in the future will require uninterrupted connectivity through smartphones and internet access.

LIMITATION

A limitation of this scoping review is the exclusion of literature that was not written in the English language. Based on feedback on our scoping protocol, we extended our search to include countries from the European Union and countries such as China, Japan and Sri Lanka. The search criteria would be extended to non-English articles for future reviews.

CONCLUSION

When we conducted this scoping review from a codesign perspective, we were surprised by the lack of literature published and unpublished, that also followed the same methodology. We believe our findings will support future researchers and developers to implement codesign that maintains the integrity of their project. Authentic involvement requires experts-by-experience as co-authors and end-to-end partners from design, implementation and evaluation of digital health tools for suicide prevention.

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