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# Digital health innovations for non-communicable disease management during the COVID-19 pandemic: a rapid scoping review

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## ABSTRACT

**Objective** To identify and summarise the digital health interventions (DHIs) implemented for non-communicable disease (NCD) management for COVID-19.

**Design** Rapid scoping review. Three reviewers jointly screened titles–abstracts and full texts. One reviewer screened all excluded records. Data were mapped to WHO DHI Classification and narratively summarised.

**Data sources** PubMed, CENTRAL, CINAHL, EMBASE.

**Eligibility criteria for selecting studies** Peer-reviewed primary research published between 1 November 2019 and 19 September 2021 on DHI for NCD management during the COVID-19 pandemic. Reviews, editorials, letters, commentaries, opinions, conference abstracts and grey literature were excluded.

**Results** Eighty-three studies drawn from 5275 records were included. A majority of the studies were quantitative in design. Forty per cent of the DHIs were implemented in the Americas. Nearly half of these DHIs targeted mental health conditions. A majority of the interventions were delivered remotely and via telephones. Zoom (26.5%), email (17%) and WhatsApp (7.5%) were the top three platforms for care delivery. Telemedicine, targeted client interventions, personal health tracking and on-demand information services for clients were the most frequently implemented interventions. Details regarding associated costs, sustainability, scalability and data governance of the DHI implementations were not described in the majority of the studies.

**Conclusion** While DHIs supported NCD management during the COVID-19 pandemic, their implementation has not been equitable across geographies or NCDs. While offering promise towards supporting the continuum of care during care delivery disruptions, DHIs need

## Summary box

### What is already known?

- The COVID-19 pandemic disrupted healthcare services, those with non-communicable diseases (NCDs) were disproportionately affected due to restrictive measures imposed to prevent SARS-CoV-2 transmission.
- Recent research has highlighted the role of digital health interventions (DHIs) for public health responses against COVID-19 and clinical care for COVID-19 and remote management in the context of pandemic.
- Reviews found that telemedicine was the most frequently employed intervention during COVID-19.

### What are the new findings?

- Nearly half of the DHIs were implemented for the management of mental health/neurological disorders.
- Commonly available telecommunications tools (eg, telephones, internet-based short messaging tools and video calling platforms) were the most frequently used digital health innovations for NCD management during the COVID-19 pandemic.
- This review mapped the DHIs for NCD management and their need (ie, health system challenges during the COVID-19 pandemic) using WHO DHI v1.0 classification.
- Targeted client communication and personal health tracking were most popular for NCD management towards addressing gaps in utilisation, access and availability posed by the disruptions to routine health services delivery.

to be embedded into healthcare delivery settings towards strengthening health systems rather than standalone parallel efforts to overcome system level challenges.

## Summary box

**How this study might affect research, practice or policy?**

- ▶ Need for focus on equitable distribution of DHIs for NCD management.
- ▶ Need for implementation research to explore sustainability of DHIs for NCD management.
- ▶ Need for transparent research reporting of financial, data governance and ethical aspects of DHI.

**INTRODUCTION**

COVID-19 has significantly impacted health systems globally. Containing the rapid spread of the SARS-CoV-2 has placed unprecedented demands on the health systems.<sup>1</sup> This sudden surge in demand coupled with pre-existing resource constraints and fragile healthcare delivery systems has disrupted routine healthcare services at all levels of the healthcare system.<sup>1,2</sup> Nearly every country experienced disruption in general healthcare services, with services in low/middle-income countries (LMICs) being affected the most.<sup>3</sup> In particular, this abrupt disruption of health services has significantly affected individuals living with non-communicable diseases (NCDs).<sup>4,5</sup> Health systems either ceased or scaled down services due to reasons such as: fear of contracting SARS-CoV-2 infections, repurposing of the health workforce for public health response and COVID-19 care, the conversion of NCD centres to isolation zones, closure(s) of health facilities for non-emergency conditions and enforcement of physical distancing norms such as lockdowns and travel restrictions.<sup>6,7</sup>

The WHO's rapid assessment survey in May 2020 found disruptions in 50% of NCD rehabilitative services in 163 countries during the pandemic.<sup>1</sup> Services for management of hypertension (53%), diabetes and its complications (49%), asthma (48%), cancer (42%) and cardiovascular diseases (CVDs) (31%) were affected. Additionally, people living with NCDs are at risk of worsening of their NCDs.<sup>8,9</sup> This was attributable to disruptions in essential NCD support and treatment services, a lack of access to appropriate management for conditions during the pandemic and a drastic decline in the utilisation of, for instance, chemotherapy services and urgent referrals.<sup>1,10-12</sup> Furthermore, these disruptions are likely to adversely impact the achievement of multiple NCD-related targets of the 2030 Sustainable Development Goals.<sup>9,13-15</sup> Thus, it is crucial to ensure the continuity of care for people living with NCDs amidst this pandemic, keeping in mind the interlinkages between NCDs and COVID-19.

This unprecedented situation has demanded novel solutions, adaptations or innovations in care delivery mechanisms to minimise in-person contact at the health facilities and promote remote care.<sup>9,16</sup> Reviews

and WHO documents consistently highlight the need for innovations to respond to the (increasing) NCD burden during, and following, the COVID-19 era.<sup>1,17</sup> This pandemic has spotlight digital technologies as a vital tool to innovatively support the response efforts to COVID-19.<sup>18,19</sup> Additionally, our previous work has highlighted the importance of, and opportunities for, digital technological solutions to ensure a continuum of care for people with NCDs.<sup>20,21</sup> Many reviews on digital health interventions (DHI) for NCD management have focused on a subset of NCDs (eg, the use of telemedicine for mental health or neurological disorders<sup>22,23</sup>), a specific time period within the pandemic (eg, technologies implemented in the first COVID-19 wave<sup>17</sup>) or a subset of DHIs (eg, use of smartphones to ensure continuity of care during this pandemic<sup>24</sup>). There is a need to build on these efforts and broaden the horizon of our understanding of technological innovations for NCD management during health emergencies such as COVID-19 pandemic.

In such a situation, we assessed that a scoping review was an appropriate and important first step to (1) comprehensively review, and map from, the breadth of available literature the DHI implemented during this pandemic for the management of various NCDs, (2) map the range and functionalities of the DHI and (3) to identify the gaps to inform future research efforts.<sup>25-28</sup> The rapid nature of the review will provide a timely and relevant response to the call for the 'Innovations in Non-communicable diseases' supplement by BMJ Innovations. This call highlighted the need and importance of understanding innovations for this pandemic.<sup>29</sup> We thus designed a rapid scoping review with an objective to identify, map and summarise, in a timely manner, the global DHI for people with NCDs during the COVID-19 pandemic.

**METHODOLOGY****Design**

A rapid scoping review was considered the most appropriate review design given the scope of the research question (ie, to identify and list all the DHIs for NCD management for COVID-19 pandemic), its relevance to the contemporary context globally and importance of summarising evidence within the limited timeframe.<sup>30-33</sup> The timeframe of the review was 2 months; this timeframe included review conceptualisation and design, execution and manuscript writing. The review was conducted in accordance with a protocol. A rapid review approach streamlines the steps of a traditional systematic review to produce timely and contextual evidence.<sup>33</sup> Rapid reviews have gained popularity and recognition to inform policy, and aid in health system strengthening within quick timeframes.<sup>30,34</sup>

**Eligibility criteria**

Primary peer-reviewed research on digital health innovations for the management of NCD designed or

adapted for the COVID-19 pandemic were eligible. All studies except reviews, editorials, letters, commentaries, perspectives, opinions, reports, conference abstracts and grey literature were eligible for inclusion. Only published English-language studies conducted on humans were included.

#### Population

Persons diagnosed with or living with an NCD, irrespective of the diagnostic criteria used.

#### Intervention

Any DHI related to NCD management. Keeping in mind the broad and dynamic nature of DHIs, we adopted the DHI definition used in the WHO Classification of DHI v1.0 as a 'discrete functionality of digital technology that is applied to achieve health objectives'.<sup>35 36</sup> The WHO Classification of DHI v1.0 was subsequently used to map the functionalities of the DHIs included in our review.<sup>36</sup>

#### Comparator

Any comparator including the standard-of-care, an alternate intervention or 'do nothing' scenario for NCD management. Studies without comparators were also eligible for inclusion.

#### Outcome

Our objective was to list the innovations meant for the management of NCD during the COVID-19 pandemic. Thus, we did not limit studies by type of outcomes or outcome measures. We operationally defined innovations as an umbrella term to include any novel intervention or solution implemented to overcome health service challenges during the COVID-19 era.

#### Settings

All settings including clinic/hospital, community or population, schools and so on were eligible for inclusion in the review.

#### Study context

DHIs should have been published between 1 November 2019 to the date of conducting searches, that is, 19 September 2021. Additionally, the DHIs should have been either designed for, or deployed during, the COVID-19 pandemic.

#### Management of NCD(s)

Studies should have included one or more of the following components to be eligible: 'treatment, referral, monitoring, support, follow-up, palliative care'.<sup>23</sup>

#### Exclusion

Grey literature, and studies related to vaccines, biologicals, pharmacological products, biomarkers, diagnostic studies, therapeutic trials, predictions, simulations,

infection control, management of COVID-19, protocols, preprints and burden of disease.

#### Searches

A broad search strategy was first developed for use on PubMed (PK and SM independently, modified after pilot-testing with the team) and subsequently adapted to the other databases (SM). Electronic searches were conducted on 19 September 2021 on PubMed, EMBASE (Ovid), CINAHL (EBSCO Host), Cochrane Central Register of Controlled Trials (CENTRAL). The final search strategy was a combination of free text, Medical Subject Headings and database specific subject headings for three domains of search—NCDs, management, innovations or interventions. The full electronic search strategies for all databases can be accessed on Open Science Framework.<sup>37</sup> Searches were managed on EndNote V.X9.<sup>38</sup>

#### Study selection

Records were distributed among PK and NG for study selection. Screening was performed on Rayyan.<sup>28</sup> Screening decisions were 'include', 'exclude' or 'maybe' (when in doubt). Study selection was performed on Rayyan in two sequential stages: title–abstract (Ti-Ab) followed by a full-text review. Excluded Ti-Ab and full texts were screened by SM. Ti-Ab that were marked as 'maybe' or where there were conflicting decisions between PK/NG and SM were taken forward to full-text review. Disagreements in the full-text review were resolved through discussions with MG and OJ. The rapid review timeframe precluded the process of contacting authors of studies for additional information. Thus, studies requiring additional information for the decision of inclusion were excluded. To ensure quality within the rapid review timeframe, independent screening for 30 records was performed by the screening team.

#### Data extraction

Data were extracted using a spreadsheet that was pilot-tested on five included full-text records by SM and PK on Google Sheets. Only the most essential study and innovation characteristics were extracted. Data items for charting included: study ID, study objective, study design (quantitative/qualitative/both), country of implementation, settings, NCD(s) targeted, type of innovation, brief details of intervention and comparator (summary/title of DHI, mode(s) of delivery, platforms and devices for delivery of DHI, security, financial aspects) and funding support (yes/no, partial/complete). The countries of implementation were categorised according to the WHO regions.<sup>39</sup> Study designs were further categorised as observational or interventional.

DHIs were mapped to the WHO's Classification of Digital Health Intervention v 1.0. categories 1.0 (Client), 2.0 (Healthcare providers), 4.0 (Data

Services) by MG.<sup>36</sup> The need of DHI was mapped to the Health Systems Challenges by MG, as recommended in the WHO DHI Classification document.<sup>36</sup> Data items were labelled as ‘unclear’ when there was inadequate information for that field. Due to the rapid nature of the review, no author contact was performed to acquire additional information.

### Data synthesis and reporting

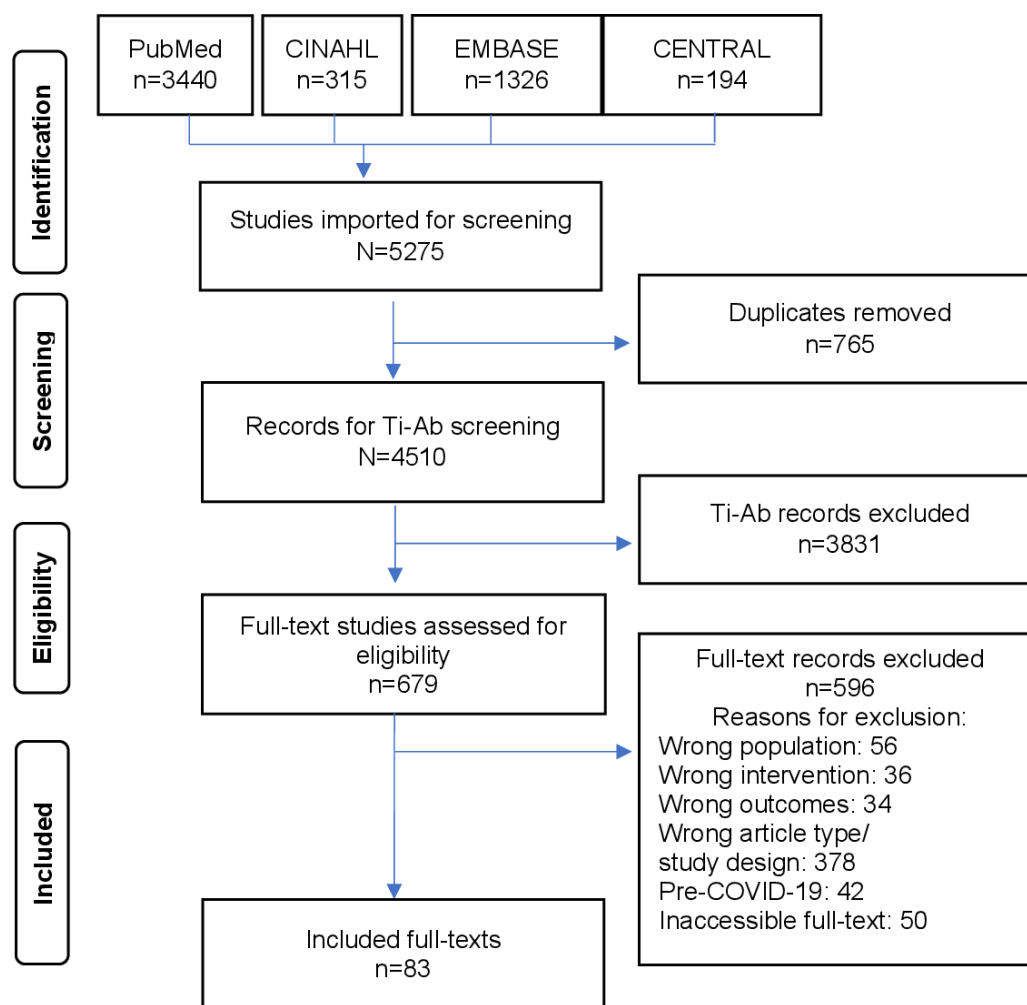
Results are summarised narratively using frequencies and percentages (MS Excel, Google Sheets), and supplemented with tables and figures (map, graphs). Tableau Desktop Public Edition V.2021.3.1 was used for summarising and mapping countries of DHI implementation.<sup>40</sup> An overall summary of the characteristics of studies is followed by description of DHI according to the targeted NCD(s) domains. We included neurological, neurodevelopmental and mental health conditions under the broad category of mental health. Results of WHO DHI classification mapping, and according to WHO region of implementation have been summarised under respective NCD domains. The reporting of this review has been informed by

the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines.<sup>41</sup>

## RESULTS

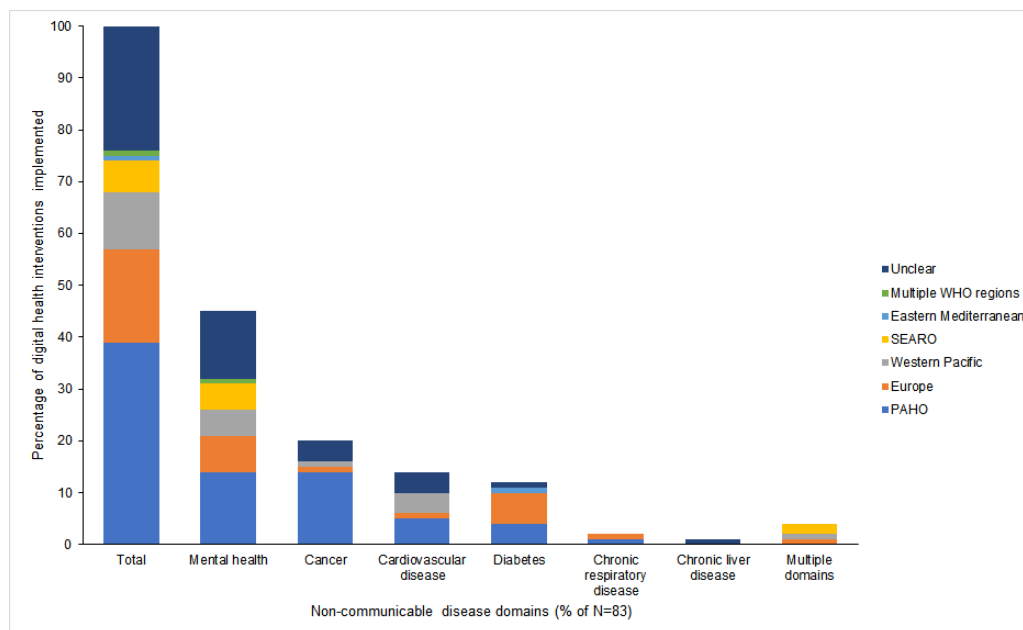
### Study selection results

We identified 5275 records through the search strategy. After removing 765 duplicates, 4510 titles and abstracts were screened. Of these, 679 records proceeded to full-text screening, of which 50 full texts were inaccessible. Of the 629 full-text records that were assessed for eligibility, 83 were included in the review as per the inclusion criteria (see online supplemental file for the list of included studies). The reasons for exclusion included: wrong article type/study design (63.3%), wrong population (9.4%), pre-COVID-19 implementation (7.03%), wrong interventions (6.03%) and wrong outcome/inadequate information on outcomes, for example, user experiences without providing details of innovation (5.7%). The results of study selection are outlined in figure 1.



**Figure 1** PRISMA flow diagram depicting the selection of studies in our review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.





**Figure 2** Digital health innovations implementation for the management of non-communicable diseases (NCDs) in various WHO regions.

### Characteristics of digital health innovations for NCD management during COVID-19

Of the 83 included studies, 76% (n=63) were published during 2021. Fourteen studies were designed as interventional studies. The region of the Americas accounted for 40% (n=33) of the DHIs implemented (figure 2). Only one DHI was found to have been implemented across all WHO regions. The region of implementation was unclear in 20 studies (24%). The country of DHI implementation has been summarised in a Tableau Dashboard.<sup>32</sup> Most of the studies (n=71, 85.5%) were quantitative in design (table 1). Nearly one-third of the studies used a comparator to assess the impact or client experience of the DHI (table 2).

Telemedicine was the most frequently used DHI for NCD management during this pandemic (n=77, 93%), followed by targeted client communication (n=49, 59%) and personal health tracking (n=24, table 3). All the 83 DHIs addressed one or more challenges faced by health services delivery systems during the COVID-19 pandemic. Innovations in DHI occurred as a result of the following: DHIs designed and implemented for the COVID-19 pandemic; implementation of pre-COVID-19 DHIs that were underused or optional for NCD management; modifications in, or adaptations of, pre-COVID-19 non-DHIs; and scaling-up of existing DHIs during the COVID-19 pandemic. Some solutions were rapid and pragmatic adaptations that were never implemented prior to the onset of this pandemic. These DHIs thus responded to the urgent demand posed by the government-imposed mobility restrictions to contain the spread of SARS-CoV-2. Most DHIs were innovations aimed at improving utilisation or access (n=61, 73%), and/or availability

of health services for NCDs (n=51, 63%). A relative majority of the DHI (65.1%) were funded (partially or entirely) (see online supplemental file).

### Delivery modalities of DHIs

A relative majority of the DHIs for NCDs were delivered remotely (n=52, 63%). A minor proportion of DHIs was delivered in-person (n=3, 4%). More than one-third used a combination of both the online and in-person modes either for all of the participants or for a segment of the participants (n=28, 34%). Among the remotely delivered interventions, 13% offered an optional in-person face-to-face service delivery component. The predominant rationale for including face-to-face delivery included: study protocol-related procedures (eg, overseeing the installing of the app), physical assessments (eg, walking tests), specific components of the intervention (eg, outdoor group exercises), drug dispensing, clinical exceptions, patient preferences, technological barriers, or as deemed necessary by the providers. Results of the delivery modalities of DHIs are summarised in online supplemental file.

Studies typically described a combination of various software platforms and devices (table 3 and online supplemental file). The three most frequently used software platforms for health services delivery geared towards NCDs were conventional communication tools such as Zoom (n=22, 26.5%), email (n=14, 17%) and WhatsApp (n=6, 7.2%). Twelve DHIs (14.5%) integrated online platforms with their electronic health/medical records or hospital information system. Telephones (including smartphones) were the

**Table 1** Characteristics of studies included in the rapid scoping review (n=83)

Sl. no	Study ID	Type of evidence	WHO region	Non-communicable disease targeted
<b>Mental health (including neurological and neurodevelopmental disorders)</b>				
1	Banks2021	Both	European Region	Chronic epilepsy
2	Budhwani2021	Both	Region of the Americas	Mental health
3	Carroll unclear	Quant	Unclear	Mental health
4	Cooper2021	Both	Unclear	Dementia
5	D'Arma2021	Quant	European Region	Multiple sclerosis
6	Davenport2021	Quant	Western Pacific	Mental health
7	Di Lorito2021	Qual	European Region	Dementia
8	Gromatsky2021	Both	Region of the Americas	Mental health
9	Guan2020	Quant	Region of the Americas	Mental health
10	Hom2021	Quant	Region of the Americas	Mental health
11	Kidorf2021	Quant	Region of the Americas	Substance abuse disorder
12	Kim2021	Quant	Unclear	Parkinsonism
13	Levinson2021	Quant	Region of the Americas	Eating disorders
14	Lima2021	Both	South East Asian Region	Dementia
15	Locke2021	Quant	Region of the Americas	Mild cognitive impairment
16	Looi2020	Quant	Western Pacific	Mental health/psychiatry
17	Malka2021	Quant	European Region	Chronic post-traumatic stress disorder (PTSD)
18	Mesika2021	Quant	Unclear	Adult depression
19	Motolese2020	Quant	European Region	Parkinsonism
20	Nicholas2021	Both	Western Pacific	Mental health
21	Palma2021	Quant	Unclear	Mental health/life-limiting illness
22	Panda2021	Quant	South East Asian Region	Child epilepsy, other neurological disorders with epilepsy
23	Paul2020	Quant	Region of the Americas	Major depressive disorder
24	Peralta2020	Quant	Region of the Americas	Mental health
25	Ping2020	Quant	South East Asian Region	Mental health and psychosocial support
26	Pollard2021	Quant	Unclear	Autism spectrum disorders
27	Puspitasari2021	Quant	Unclear	Transdiagnostic psychiatric conditions
28	Ravindran2020	Quant	South East Asian Region	Mental health
29	Rojas2021	Quant	Unclear	Mental health
30	Sennott2020	Quant	Unclear	Parkinsonism
31	Shah2021	Quant	Unclear	Attention deficit hyperactivity disorder (ADHD)
32	Sharma2020	Quant	Region of the Americas	Child psychiatry
33.	Sun2021	Quant	Western Pacific	Mental health
34.	Tunuguntla2021	Quant	Multiple WHO regions	Insomnia
35.	Vukc evic Markovic2020	Quant	European Region	Mental health
36.	Weintraub2021	Quant	Region of the Americas	Opioid use disorder
37.	Wightman2021	Quant	Unclear	Opioid overdose
38.	Yellowlees2020	Quant	Region of the Americas	Mental health
<b>Cardiovascular disease</b>				
1.	Nogueira2021	Quant	Unclear	Chronic heart failure
2.	Bakogiannis2021	Quant	Unclear	Heart failure
3.	Batalik2021	Quant	European Region	Coronary heart disease
4.	Lalande2021	Quant	Region of the Americas	Cardiovascular disease
5.	Li2021	Quant	Western Pacific	Vascular disease
6.	McLachlan2021	Both	Western Pacific	Heart failure
7.	Rosman2021	Quant	Region of the Americas	Atrial fibrillation
8.	Scherrenberg2021	Quant	Unclear	Cardiac
9.	Wali2021	Qual	Region of the Americas	Health failure
10.	Yiaslas2020	Quant	Region of the Americas	Heart disease
11.	Zhao2021	Quant	Region of the Americas	Health failure

Continued

Table 1 Continued

Sl. no	Study ID	Type of evidence	WHO region	Non-communicable disease targeted
<b>Cancer</b>				
1.	Aghedo2021	Quant	Unclear	Colon, rectal, anal, recurrent uroepithelial carcinoma cancers
2.	Berlin2021	Quant	Region of the Americas	Cancer
3.	Brown2021	Quant	Unclear	Breast, lung and haematologic cancers
4.	Chen2021	Quant	Western Pacific	Cancer
5.	Emard2021	Qual	Region of the Americas	Cancer
6.	Gardner2021	Quant	Region of the Americas	Cancer
7.	Gothe2021	Quant	Region of the Americas	Adult cancer survivors
8.	Karacin2021	Quant	European Region	Cancer
9.	Knoerl2021	Quant	Region of the Americas	Breast, gastrointestinal, gynaecological cancer survivors with chronic chemotherapy-induced peripheral neuropathy pain
10.	Lonergan2021	Quant	Region of the Americas	Cancer
11.	Marchese2021	Quant	Region of the Americas	Cancer
12.	Myers Virtue2021	Quant	Region of the Americas	Cancer
13.	Patt2021	Quant	Region of the Americas	Cancer
14.	Pritchett2021	Quant	Region of the Americas	Cancer
15.	Specht2020	Quant	Region of the Americas	Breast cancer
16.	Steimer2021	Quant	Unclear	Cancer
17.	Yerram2020	Quant	Region of the Americas	Cancer
<b>Diabetes (Type 1 and Type 2)</b>				
1.	Alromaihi2020	Quant	Middle East and North African Region	Diabetes mellitus
2.	Braune2021	Quant	European Region	Paediatric diabetes
3.	Fratice2020	Quant	European Region	Type 2 diabetes/impaired glucose regulation in overweight/obesity
4.	Hanson2021	Quant	European Region	Diabetes mellitus
5.	Jiwani2021	Qual	Region of the Americas	Type 2 diabetes mellitus
6.	Jones2020	Quant	Region of the Americas	Diabetes
7.	Leon-Vargas2021	Both	Region of the Americas	Type 1 and type 2 diabetes mellitus
8.	Luzi2021	Quant	European Region	Type 1 and type 2 diabetes mellitus
9.	Mackenzie2020	Quant	European Region	Type 2 diabetes mellitus
10.	Zeller Jr.2021	Quant	Unclear	Type 1 diabetes mellitus
<b>Chronic respiratory disease</b>				
1.	Jangalee2021	Quant	Region of the Americas	Chronic lung disease
2.	Philip2020	Quant	European Region	Chronic obstructive pulmonary disease (COPD)
<b>Chronic liver disease</b>				
1.	Motz2021	Quant	Unclear	Non-alcoholic fatty liver disease
<b>Multiple NCD domains</b>				
1.	Kesavadev2021	Quant	South East Asian Region	Multiple NCDs/comorbidities
2.	Pareyson2021	Quant	European Region	Chronic neurological disorders
3.	Songsermpong2021	Quant	South East Asian Region	Hypertension and diabetes
4.	Wu2020	Quant	Western Pacific	Cancer and stroke

NCD, non-communicable disease; Qual, qualitative; Quant, quantitative.

most frequently used device (n=65, 78.3%) to deliver the DHI. Customised/NCD-management specific apps/platforms were the DHIs implemented across 34 studies (41%). Use of DHI components such as the platform, type of software, compatible devices were inadequately described in 10%, 9% and 7% of DHIs, respectively.

#### Financial sustainability and data governance

Specific information around the costs of the innovation and its implementation such as operational, maintenance and associated personnel costs were not described clearly across 64% (n=53) of the studies. A small proportion of these DHIs (10%) was offered as free to the patients, including those that were funded

**Review**

**Table 2** List of digital health innovations implemented in various countries

SL no	Study ID	Country of implementation	Digital health intervention summary	Comparison
<b>Mental health (including neurological and neurodevelopmental disorders)</b>				
1	Banks2021	Ireland	Telemedicine Low-cost high Value E-care (LoVE)-virtual clinics	Yes
2	Budhwani2021	Canada	Virtual care management Part of Women's Virtual	Yes
3	Carroll Unclear	Unclear	Tele-health outpatient consultation and rehabilitation services	None
4	Cooper2021	Unclear	Telemedicine Cognitive well-being intervention	None
5	D'Arma2021	Italy	'Virtual Instrument fOr healthy Lifestyle Adherence' Healthy lifestyle promotion	None
6	Davenport2021	Australia	Pre-clinic triage	None
7	Di Lorito2021	UK	Tele-rehabilitation	None
8	Gromatsky2021	USA	VA Caring for Our Nation's Needs Electronically behavioural therapy, psychoeducation and support. Telehealth	None
9	Guan2020	Canada	FOCUS programme Virtual continuity of care including rehabilitation and support	None
10	Hom2021	USA	Virtual/remote partial hospital programme (PHP) stepping down from in-patient care management	None
11	Kidorf2021	USA	Medminder 'Jon' version electronic pillbox Take home medicine management	None
12	Kim2021	Unclear	Remotely supervised technology-based intervention Reinforcing, and multimodal exercise management strategy	None
13	Levinson2021	USA	Telehealth exposure-based intensive outpatient programme (IOP)	Yes
14	Lima2021	India	Clinical telemedicine using hybrid face robot Cognitive engagement and mental health support delivery	Yes
15	Locke2021	USA	Telemedicine programme Virtual mental health and behavioural change intervention	Yes
16	Looi2020	Australia	Telepsychiatry consultations and psychotherapy	Yes
17	Mesika2021	Israel	Telehealth psychotherapy	Yes
18	Malka2021	Unclear	Telepsychiatry therapy and support	None
19	Motolese2020	Italy	Remote patient monitoring	None
20	Nicholas2021	Australia	BRACE project. Telehealth therapy	Yes
21	Palma2021	Unclear	Palliative Hospital-Centred Spiritual and Psychological Telehealth System	None
22	Panda2021	India	Teleconsultation, therapy and support	None
23	Paul2020	USA	Telepsychotherapy	None
24	Peralta2020	Dominican Republic	Teleconsultation	None
25	Ping2020	Malaysia	Ultra-brief psychological interventions (UBPI). Tele Mental Health and Psychosocial Support Service. Hotlines.	None
26	Pollard2021	Unclear	Telehealth therapy	Yes
27	Puspitasari2021	Unclear	Adult Transitions Programme Tele behavioural therapy and support	None
28	Ravindran2020	India	24/7 National Helpline for Psychosocial Support and Mental Health Services	None
29	Rojas2021	Unclear	Cognitive-behavioural therapy for suicide prevention (BCBT-SP). Clinical video telehealth (CVT)	None
30	Sennott2020	Unclear	Telehealth outreach well-being support	None
31	Shah2021	Unclear	Teleconsultations and management	None
32	Sharma2020	USA	Telemental health learning services	None
33	Sun2021	China	Mindfulness for Growth and Resilience. Mindfulness-based learning mHealth	Yes
34	Tunuguntla2021	Multiple countries	Yoga of Immortals (YOI) therapy	None
35	Vukc evic Markovic2020	Serbia	Online expressive writing intervention	Yes
36	Weintraub2021	USA	Caroline County TeleMedicine mobile treatment unit (TM-MTU) initiative	None

Continued



Table 2 Continued

SL no	Study ID	Country of implementation	Digital health intervention summary	Comparison
37	Wightman2021	Unclear	Emergency department (ED) Call back. Harm reduction services and addiction treatment	None
38	Yellowlees2020	USA	Virtual Telepsychiatry Clinic consultations	None
<b>Cardiovascular disease</b>				
1	Nogueira2021	Unclear	Telemedicine consultations and management	Yes
2	Bakogiannis2021	Unclear	The Hellenic Educational Self-care and Support Heart Failure app (ThessHF app)	None
3	Batalik2021	Czech republic	Telerehabilitation and support	None
4	Lalande2021	Unclear	Healing Hearts Together (HHT). Couple telepsychology	Yes
5	Li2021	China	Telemedicine consultation	None
6	McLachlan2021	New Zealand	Telehealth consultations and support	None
7	Rosman2021	USA	Virtual AF self-management	None
8	Scherrenberg021	Unclear	Tele psychological consultations, counselling and support	None
9	Wali2021	Canada	Medly programme. Telemonitoring	None
10	Yiaslas2020	USA	Heart Disease Reversal Programme. TeleManagement	None
11	Zhao2021	USA	Part of ReACT programme. Telemanagement and support	Yes
<b>Cancer</b>				
1	Aghedo2021	Unclear	Tele-multidisciplinary clinic (MDC)	None
2	Berlin2021	Canada	Virtual Care Management System (VCMS) using Agile service design process	None
3	Brown2021	Unclear	'Virtual-Hybrid Approach to clinic'. Telemedicine services	None
4	Chen2021	China	Teleconsultation and medication management	None
5	Emard2021	USA	Virtual mind–body programme	None
6	Gardner2021	USA	Tele-neuropsychology continuity of care	Yes
7	Gothe2021	USA	STAYFit exercise management intervention	Yes
8	Karacin2021	Republic of Turkey	Teleconsultation/ telemedicine based on clean and pandemic hospital	Yes
9	Knoerl2021	USA	Tele-yoga intervention	Yes
10	Lonergan2021	USA	Teleclinic visits	Yes
11	Marchese2021	Canada	Virtual pharmacy care model	None
12	Myers Virtue2021	USA	Telepsychology	Yes
13	Patt2021	USA	Remote patient symptom management	None
14	Pritchett2021	USA	Mayo Clinic COVID-19 Remote patient monitoring (RPM) programme	Yes
15	Specht2020	USA	Telehealth preoperative and postoperative services	None
16	Steimer2021	Unclear	RPM programme	None
17	Yerram2020	USA	Telemedicine visits and Clinical patient service (CPS) intervention	None
<b>Diabetes mellitus</b>				
1	Alromaihi2020	Bahrain	Telemedicine consultation and medication management	None
2	Braune2021	Germany	Digital diabetes clinic using service design methods	None
3	Fratlicelli2020	Italy	Web-based nutritional intervention	Yes
4	Hanson2021	UK	Low carb programme health app. Remote digital health intervention	Yes
5	Jiwani2021	USA	Behavioural lifestyle intervention	None
6	Jones2020	USA	Virtual co-management service. Teleconsultations	Yes
7	Leon-Vargas2021	Columbia	Remote diabetes management	None
8	Luzi2021	Italy	Tele-monitoring for remote care continuity. Remote glucose control system	Yes
9	Mackenzie2020	UK	Massive open online course for self-management	None
10	Zeller Jr.2021	Unclear	Diabetes reporting. Telemedicine support	Yes
<b>Chronic respiratory disease</b>				
1	Jangalee2021	Canada	Home-based virtual pulmonary rehabilitation programme with RPM	None
2	Philip2020	UK	Singing for lung health (SLH) intervention	Yes

Continued

**Table 2** Continued

SL no	Study ID	Country of implementation	Digital health intervention summary	Comparison
<b>Chronic liver disease</b>				
1	Motz2021	Unclear	Telehealth exercise management	None
<b>Multiple NCD domains</b>				
1	Kesavadev2021	India	Telemedicine for patient management/in-patient level care	None
2	Pareyson2021	Italy	Neuro-telemedicine services, including tele-visits and tele-neurorehabilitation	None
3	Songsermpong2021	Thailand	Teleconsultations	None
4	Wu2020	Taiwan	Telehealth for palliative care family conferences with shared decision making	None

NCD, non-communicable disease.

(eg, by the Ministries or implementing institutions). Information on data governance, in specific data security-related aspects of the DHI were not clearly described in more than half the studies (59%, n=49). The remaining studies described basic measure around

health information and data security such as use of encryption, software solutions for security, compliance with guidelines (eg, Health Insurance Portability and Accountability Act, General Data Protection Regulation). However, specific details around data governance of these DHIs could not be ascertained across most of the studies, even for those that mentioned using a secure or privacy-compliant platform.

**Table 3** Platforms used by DHI implemented (n=83)

Sl. no.	Platform	n (%)*
<b>I. Internet-based</b>		
1	Zoom	22 (26.5)
2	Email	14 (17)
3	Upgraded/ integrated with electronic health or medical records or hospital systems	12 (14.5)
4	WhatsApp	6 (7.2)
5	Cisco Webex	4 (5)
6	Microsoft Teams	3 (4)
7	Facebook	3 (4)
8	WeChat based mini-programs	2 (2.4)
9	Hybrid face robot	1 (1.2)
10	Doximity	1 (1.2)
11	Jitsi	1 (1.2)
12	LINE	1 (1.2)
13	LinkedIn	1 (1.2)
14	OTN system	1 (1.2)
15	Twitter	1 (1.2)
<b>II. Non-internet based†</b>		
1	Mail/Post	3 (4)
2	Telephone hotlines/ IVRS	2 (2.4)
<b>III. Unclear</b>		
10 (12.3)		
<b>Customisation of apps/tools</b>		
1.	Customised/NCD-management specific	34 (41)
2.	Unclear‡	9 (11)
<b>Compatible device(s)§</b>		
1	Telephone¶	65 (78.3)
2	Computer/laptop	20 (24.1)
3	Tablet	10 (12)
4	Unclear	7 (8.4)

\*DHIs typically used multiple platforms, thus percentages do not add to 100.

†Typically used in combination with one or more internet-based platforms.

‡Includes web-based, mobile or audio and/or video platforms.

§Excludes monitoring devices/personal health tracking devices.

¶Includes smartphones and landline among others.

DHIs, digital health interventions; IVRS, Integrated Voice Response System;

NCD, non-communicable disease.

#### Digital health innovations for specific NCDs

Details of DHI implementation and classification according to the WHO DHI classification v1.0 are summarised in table 4 and the online supplemental file. In terms of the specific NCDs targeted, the following were the priority implementations.

#### Mental health conditions

Forty-six per cent (n=38) of the DHI related to the management of mental health conditions, neurological or neurodevelopmental diseases. More than one-third of the studies aimed at mental health conditions were implemented in the Americas (n=12). The location of implementation was unclear in 30% (n=11) of the studies (table 1). These innovations covered a broad range of conditions such as neurological or neurodevelopmental disorders, depression, dementia, Parkinson's disease/Parkinsonism, chronic post-traumatic stress disorder, eating disorders, chronic epilepsy (including childhood epilepsy). The specific mental health condition was unclear in as many as 40% of the studies. Telemedicine was the most frequently used intervention (n=35, 92%). Fifty-five per cent of these DHIs incorporated targeted client communication; 16% had client-to-client communication and personal health tracking provision; 26% had on-demand information services to clients and 3% reported on client financial transactions. Regarding data services, 13% provided services for data collection, management or use and 3% had data coding services.

#### Cancers

Of the 17 DHIs (20.5%) for cancer/oncology management, the majority was implemented in the Americas



for the management of NCDs during the COVID-19 pandemic. The most frequently targeted NCDs related to mental health, neurological or neurodevelopmental conditions. Telemedicine was the most frequently implemented intervention. Telemedicine or telehealth has been widely used during this present COVID-19 pandemic for its long-lasting ‘remote’ care continuity solutions for NCDs such as cancer,<sup>42</sup> mental health<sup>43</sup> and spiritual support for critical or end-of-life situations.<sup>44</sup> A scoping review on technologies for any health condition in the first COVID-19 wave similarly found telemedicine as the most frequently implemented technology (85%).<sup>17</sup> The demand for innovations was amplified multifold during this pandemic, especially because of the mobility restrictions imposed by the governments to contain the spread of SARS-CoV-2. This in turn adversely affected the continuity of care for people living with NCDs.

Using the WHO DHI classification helped us identify the key elements that are likely to impact the large-scale DHI implementation including financial aspects, sustainability and broader data governance requirements for overcoming regulatory restrictions across geographies. The WHO DHI classification v 1.0 is vital to categorise technologies implemented to support needs of the health system and is especially useful for evidence synthesis approaches among others.<sup>36</sup> Despite some challenges in broader application and/or adoption by particular stakeholders involved in clinical care,<sup>45</sup> mapping the DHIs to their corresponding health system challenges promotes an understanding of the deployments and their needs.<sup>36</sup> This endeavour can provide a shared language to inform planners, decision makers and researchers about the ‘functionalities of digital health implementations’ for NCD management,<sup>25</sup> especially for rapid implementation in health emergencies such as the COVID-19 pandemic. We found that targeted client communications, personal health tracking and on-demand health information services for clients were the three most frequently used client interventions. This is expected since our review focused on management of special groups of people, in particular, those diagnosed with NCDs. The latter two interventions reflect the need for continuation of monitoring and supportive services—a critical component of continuum of NCD care during the COVID-19 pandemic. The pandemic has also resulted in significant lifestyle changes for people living with NCDs, especially among those with diabetes and with risk factors of cardiovascular diseases.<sup>12</sup> Interventions for self-management will be important to mitigate the worsening of existing conditions due to, for instance, limited opportunities for outdoor physical activities due to the closure of parks and gymnasiums.<sup>12</sup>

We found that commonly used communication tools were the most frequently used interventions for health services delivery during the pandemic for the management of NCDs. As found in our review, repurposing

of the available communication channels (eg, Zoom, WhatsApp, telephones) to ensure continuum of care during the COVID-19 pandemic.<sup>17</sup> We additionally found emails to be a popular medium for health services delivery and continuum of care. Innovative practices need not be always inventive in nature; advances that are initiated and evaluated rigorously in other jurisdictions add to the evidence base of effective public health programmes in order to be scaled-up and implemented more widely. Rapid deployment of novel health innovations during public health crises has been described previously.<sup>46 47</sup>

Our review noted that telemedicine was the most commonly used digital health innovation for NCD management during the pandemic. This is no surprise as telemedicine offers multiple advantages, particularly relevant in this COVID-19 pandemic, that Dorsey *et al* refer to as its 5 Cs: ‘accessible care, increased convenience, enhanced comfort, greater confidentiality, reduced risk of contagion’.<sup>48</sup> However, some of the challenges they and the telemedicine literature highlight hold relevance to our findings broadly. These have to do with technological barriers, digital literacy, financial and security aspects.<sup>17 42 48–52</sup> We found an inequitable regional distribution in DHI implementation with most implementations in the Americas, especially the USA. This is similarly reported in other studies and possibly reflects the technological advancement of the countries and the regional SARS-CoV-2 burden.<sup>1 17</sup> Furthermore, studies in our review either required segments of the population facing technological barriers to continue with in-person visits, or provided technological support (ie, donated or funded). Additionally, financial and security challenges exist particularly when DHIs collect, manage, store or transmit client health information; a majority of the DHIs in our review incorporated one or more of these functions. However, the majority of the DHIs in our review did not adequately address or report these design aspects.

The absence or presence of (access to) reliable technology, finances, digital literacy and motivation, thus determine inclusion and uptake for many DHIs.<sup>53</sup> Needless to say, a complete shift to telemedicine without addressing the above challenges will only worsen existing inequities in access and disease outcomes.<sup>17 42 50 51 53</sup> Digital technologies are increasingly being recognised as critical innovations to strengthen health services delivery systems.<sup>54–56</sup> Thus, it becomes imperative to address the above aspects for scalability and continued uptake, considering the widespread use and integration of telemedicine in routine NCD care.<sup>49</sup> COVID-19 restrictions made digital solutions necessary in many social sectors, and this society-wide transition is poised to significantly change the ways in which whole societies engage in, and enact health.<sup>57</sup> Despite years of consistent efforts for the mainstreaming of DHIs,



the health service delivery disruptions during this pandemic forced the health systems to pivot towards digital innovations for NCD-focused care delivery.<sup>58</sup> This review highlights the considerable capacity for health systems to undertake this shift. However, sustaining these interventions beyond mere pilot projects has been a long-standing challenge for digital health implementors.<sup>59</sup>

Regular monitoring and evaluation of digital health innovations is the first step towards ensuring effective and safe DHI implementation, and several toolkits are available for this purpose.<sup>60</sup> In the long term, embedding DHIs within healthcare delivery systems is a promising approach for their sustainability,<sup>61</sup> and DHIs can effectively support integrated care models for NCDs.<sup>62</sup> The WHO's framework on Integrated People-Centred Health Services outlines an approach to institutionalising DHIs within digitally augmented, comprehensive care through supportive policies, sustainable financing, a suitably trained workforce and reliable infrastructure.<sup>63</sup> It is also important that the DHI interoperates seamlessly with other DHIs within the broader digital health ecosystem, highlighting the importance of coding languages and interoperability standards.<sup>64</sup>

Finally, we bring attention to the use of the term 'health innovations', defined by the WHO as one that 'aims to develop and deliver new or enhanced health policies, systems, products, technologies, services and delivery methods to improve people's health'.<sup>65</sup> Innovations are multifaceted in nature and are continuously being prototyped, piloted and deployed at scale or adapted to cater across services for a long time in tune with the healthcare sector challenges. A consensus across the literature is that to be an innovation would mean for it to be 'patient-centric' and to bring in 'something new or significantly different from other solutions in the field'.<sup>65-72</sup> Many studies in our review loosely referred to the need and/or use of innovations, and were limited by an inadequate description of 'innovation'. On the other end, elaborate accounts brought clarity regarding the need, design (eg, using service design methods) and implementation of novel solutions. We thus support the call to researchers to explicitly define the need and design of their innovations in order to prevent a dilution of its meaning.<sup>70</sup>

This is the first rapid scoping review identifying global digital health literature for NCD management during the COVID-19 pandemic, and mapping it to WHO DHI Classification, to the best of our knowledge. While expediting the review, we incorporated measures for quality assurance for the review. Search strategies, screening protocol and data abstraction template were developed based on standard scoping and rapid review guidelines and literature review,<sup>17 30-33 73 74</sup> pilot-testing, multiple discussions within a team experienced in content and methods.

To minimise selection bias, we standardised procedures, trained and calibrated the team, and had one reviewer screen all excluded records. Mapping of studies to WHO DHI classification was performed by review members experienced in digital health and the WHO DHI classification tool (MG and NG).<sup>51</sup> We used a comprehensive search strategy to minimise the risk of missing potential inclusions. However, we acknowledge that potentially relevant studies may have been missed because of the rapid nature of the review (eg, author contact for additional information, screen reference lists of included studies, seek grey literature/non-English language studies/ conference abstracts).

## CONCLUSION

This review outlines the considerable progress made in digital health service delivery for NCDs during the COVID-19 pandemic, while noting the potential challenges to scale-up and wide spread adoption of DHI for NCD management. Health systems, despite their constraints, have made considerable efforts to continue service provision despite systemic disruptions. We have highlighted the important role of commonly available telecommunication tools for NCD management during the COVID-19 pandemic. Broadly, DHIs offer a promising and sustainable approach to NCD management. However, the distribution of DHI implementation for NCD management has not been equitable geographically or across NCDs, with certain regions (such as the Americas) and NCDs (eg, mental health conditions) documenting far more innovations than others. As the pandemic wears on, it is important that the diffusion of such innovations for NCD management reach those in LMICs where the need for them is greatest. This presents a noble and worthwhile agenda for more research and implementation of DHIs for NCDs as the health systems gear towards building back better beyond the COVID-19 pandemic.

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