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 (26.5%), video calling platforms (eg, Zoom) were the top three tools (eg, telephones, internet-based short messaging tools and video calling platforms) most frequently used digital health innovations for NCD management during the COVID-19 pandemic.

Conclusion While DHIs supported NCD management and their need (ie, health system challenges during the COVID-19 pandemic), they were the most frequently used digital health innovations for NCD management during the COVID-19 pandemic.

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.

Summary box
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. 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. Nearly every country experienced disruption in general healthcare services, with services in low-middle-income countries (LMICs) being affected the most. In particular, this abrupt disruption of health services has significantly affected individuals living with non-communicable diseases (NCDs). 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.

The WHO’s rapid assessment survey in May 2020 found disruptions in 50% of NCD rehabilitative services in 163 countries during the pandemic. 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. 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. Furthermore, these disruptions are likely to adversely impact the achievement of multiple NCD-related targets of the 2030 Sustainable Development Goals. 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. Reviews and WHO documents consistently highlight the need for innovations to respond to the (increasing) NCD burden during, and following, the COVID-19 era. This pandemic has spotlight digital technologies as a vital tool to innovatively support the response efforts to COVID-19. 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. Many reviews on digital health interventions (DHI) for NCD management have focused on a subset of NCDs (eg, use of telemedicine for mental health or neurological disorders), a specific time period within the pandemic (eg, technologies implemented in the first COVID-19 wave) or a subset of DHIs (eg, use of smartphones to ensure continuity of care during this pandemic). 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. 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. 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. 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. Rapid reviews have gained popularity and recognition to inform policy, and aid in health system strengthening within quick timeframes.

Eligibility criteria

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

Digital health

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.
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’. The WHO Classification of DHI v1.0 was subsequently used to map the functionalities of the DHIs included in our review.

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’.

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. Searches were managed on EndNote V.X9.

Study selection
Records were distributed among PK and NG for study selection. Screening was performed on Rayyan. 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 piloted 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.39 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
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. An overall summary of the characteristics of studies is followed by description of DHI according to the targeted NCD(s) domains. 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.

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.
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. 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

Figure 2  Digital health innovations implementation for the management of non-communicable diseases (NCDs) in various WHO regions.
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                                      |
|-------|------------|------------------|---------------------|-------------------------------------------------------------------------|
| Mental health (including neurological and neurodevelopmental disorders) |
| 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    | Kidori2021 | 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    | Motolesse2020 | 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            | Westen 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                                                           |
| Cardiovascular disease |
| 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
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.

**Table 1** Continued

| SL no | Study ID       | Type of evidence | WHO region       | Non-communicable disease targeted                                                                 |
|-------|----------------|------------------|------------------|---------------------------------------------------------------------------------------------------|
| Cancer|                |                  |                  |                                                                                                   |
| 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     | Knoeri2021     | 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    | Marcuse2021    | 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    | Steiner2021    | Quant            | Unclear          | Cancer                                              |
| 17    | Yerram2020     | Quant            | Region of the Americas | Cancer                                              |
| Diabetes (Type 1 and Type 2) | 
| 1     | Alromaihi2020 | Quant            | Middle East and North African Region | Diabetes mellitus                                   |
| 2     | Braune2021     | Quant            | European Region  | Paediatric diabetes                                 |
| 3     | Fraticelli2020 | 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                            |
| Chronic respiratory disease | 
| 1     | Jangalee2021   | Quant            | Region of the Americas | Chronic lung disease                                 |
| 2     | Philip2020      | Quant            | European Region  | Chronic obstructive pulmonary disease (COPD)         |
| Chronic liver disease | 
| 1     | Motz2021       | Quant            | Unclear          | Non-alcoholic fatty liver disease                   |
| Multiple NCD domains | 
| 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.

**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
### Digital health

| SL no | Study ID | Country of implementation | Digital health intervention summary | Comparison |
|-------|----------|---------------------------|-------------------------------------|------------|
| Mental health (including neurological and neurodevelopmental disorders) |
| 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 Lorio2021 | 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 (IDP) | 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    | Malika2021 | 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    | Pusipitasari2021 | 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 (CVI) | 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    | Vuk 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       |

#### Cardiovascular disease

| SL no | Study ID      | Country of implementation | Digital health intervention summary | Comparison |
|-------|---------------|----------------------------|-------------------------------------|------------|
| 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             | Telehabilitation and support        | None       |
| 4     | Lalande2021   | Unclear                    | Healing Hearts Together (HHT). Couple telepsychology | Yes        |
| 5     | Li2021        | China                      | Telemedicine consultation           | None       |
| 6     | McClachlan2021| New Zealand                | Telehealth consultations and support | None       |
| 7     | Rosman2021    | USA                        | Virtual AF self-management          | None       |
| 8     | Scherenberg2021| USA                        | Tele psychological consultations, counselling and support | None       |
| 9     | Wall2021      | Canada                     | Medly programme. Telemonitoring     | None       |
| 10    | Yiaslas2020   | USA                        | Heart Disease Reversal Programme. TeleManagement | None       |
| 11    | Zhao2021      | USA                        | Part of ReACT programme. Telemangement and support | Yes        |

#### Cancer

| SL no | Study ID      | Country of implementation | Digital health intervention summary | Comparison |
|-------|---------------|----------------------------|-------------------------------------|------------|
| 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     | Emanual2021   | 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         | Teleconsultations/ telemedicine based on clean and pandemic hospital | Yes        |
| 9     | Knoerli2021   | USA                        | Tele-yoga intervention             | Yes        |
| 10    | Lonnergan2021 | 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       |

#### Diabetes mellitus

| SL no | Study ID      | Country of implementation | Digital health intervention summary | Comparison |
|-------|---------------|----------------------------|-------------------------------------|------------|
| 1     | Akromaikh2020 | Bahrain                    | Telemedicine consultation and medication management | None       |
| 2     | Braune2021    | Germany                    | Digital diabetes clinic using service design methods | None       |
| 3     | Fraticelli2020| Italy                      | Web-based nutritional intervention  | Yes        |
| 4     | Hanson2021    | UK                         | Low carb programme health app. Remote digital health intervention | Yes        |
| 5     | Jiwan2021     | 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 Jr2021 | Unclear                    | Diabetes reporting. Telemedicine support | Yes        |

#### Chronic respiratory disease

| SL no | Study ID      | Country of implementation | Digital health intervention summary | Comparison |
|-------|---------------|----------------------------|-------------------------------------|------------|
| 1     | Jangalee2021  | Canada                     | Home-based virtual pulmonary rehabilitation programme with RPM | None       |
| 2     | Philip2020    | UK                         | Singing for lung health (SLH) intervention | Yes        |
Digital health

Table 2  Continued

| SL no | Study ID | Country of implementation | Digital health intervention summary | Comparison |
|-------|----------|---------------------------|------------------------------------|------------|
| Chronic liver disease | | | | |
| 1 | Motz2021 | Unclear | Telehealth exercise management | None |
| Multiple NCD domains | | | | |
| 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 | Songsiempong2021 | Thailand | Teleconsultations | None |
| 4 | Wu2020 | Taiwan | Telehealth for palliative care family conferences with shared decision making | None |

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.

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

| SL no. | Platform | n (%)* |
|--------|----------|--------|
| I. Internet-based | | |
| 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) |
| II. Non-internet based† | | |
| 1 | Mail/Post | 3 (4) |
| 2 | Telephone hotlines/IVRS | 2 (2.4) |
| III. Unclear | | |
| 10 | 10 (12.3) |

Customisation of apps/tools

1. Customised/NCD-management specific | 34 (41) |
2. Unclear‡ | 9 (11) |

Compatible device(s)§

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.
Table 4: Summary of mapping of studies to WHO DHI classification V 1.0

| NCD domains                  | 1.0 clients, n (%) | 2.0 healthcare providers, n (%) | 4.0 data services, n (%) | Health system categories, n (%) |
|------------------------------|--------------------|---------------------------------|--------------------------|-------------------------------|
| Mental health conditions     | 1 (3)              | 2 (5)                           | 6 (16)                   | 0 10                           |
| Cancer                       | 2 (5)              | 4 (10)                          | 11 (29)                  | 35 (92) 1 (3) 5 (13) 4 (11) 5 (13) 0 0 5 (13) 1 (3) 0 0 0 25 (66) 7 (18) 8 (21) 29 (76) 4 (11) 1 (3) 10 (26) |
| Cardiovascular disease       | 2 (5)              | 4 (10)                          | 11 (29)                  | 35 (92) 1 (3) 5 (13) 4 (11) 5 (13) 0 0 5 (13) 1 (3) 0 0 0 25 (66) 7 (18) 8 (21) 29 (76) 4 (11) 1 (3) 10 (26) |
| Diabetes                     | 1 (3)              | 2 (5)                           | 6 (16)                   | 0 10                           |
| Respiratory                  | 1 (3)              | 2 (5)                           | 6 (16)                   | 0 10                           |
| Liver                        | 1 (3)              | 2 (5)                           | 6 (16)                   | 0 10                           |
| Multiple NCDs                | 4 (10)             | 4 (10)                          | 4 (10)                   | 1 2 3 4 5 6 7 7 8 9 10 11 12 |

NCD domains (n=83):
- Mental health conditions (n=38)*
- Cancer (n=17)*
- Cardiovascular disease (n=9)*
- Diabetes (n=13)*
- Respiratory (n=2)*
- Liver (n=1)*
- Multiple NCDs (n=4)*

NCDs used prescription and medication management for multiple NCDs. Half of the DHIs for cardiovascular conditions were commonly targeted conditions. A majority of the DHIs used targeted client communication (82%) and personal health tracking (64%). All of the CVD-related DHIs incorporated telemedicine. Thirty-six per cent of the DHIs incorporated prescription and medication management. Nine per cent of the DHIs provided services for data collection, management or use, and location mapping.

Cancers
Of the 17 DHIs (20.5%) for cancer/oncology management, the majority was implemented in the Americas (71%), followed by the European and Western Pacific regions (n=1 each, 6%). A majority of the DHIs were implemented for breast and lung cancers. All DHIs that were implemented for cancers used telemedicine. Half of the DHIs incorporated targeted client communications; 18% used personal health tracking and 12% incorporated client financial transactions. Six per cent of the DHIs provided services for data collection, management or use. Nearly 25% of the DHIs incorporated prescription and medication management.

Cardiovascular diseases
Thirteen per cent (n=11) of studies related to DHIs for CVD management, of which the locations of three studies (27%) were unclear. More than one-third of the DHIs were implemented in the Americas (n=8). Among the DHIs for cardiovascular conditions (n=11); coronary heart disease and heart failure were commonly targeted conditions. A majority of the DHIs used targeted client communication (82%) and personal health tracking (64%). All of the CVD-related DHIs incorporated telemedicine. Thirty-six per cent of the DHIs incorporated prescription and medication management. Nine per cent of the DHIs provided services for data collection, management or use, and location mapping.

Diabetes
Of the 10 DHIs (12%) implemented for type 1 and/or type 2 diabetes, half of the DHIs were implemented in Europe and one-third (n=3) in the Americas region. A relative majority of the studies used targeted client communication (70%) and personal health tracking (60%). One-third and one-fifth of the DHIs also used untargeted client communication and client-to-client communication, respectively. Telemedicine was used in 80% of the DHIs. Data collection, management and use, and data coding were incorporated in 40% and 10% of DHIs, respectively.

Other NCDs
Two (2.4%) and one DHI (1.2%) were implemented for chronic respiratory and liver diseases, respectively. Four DHIs (5%) were implemented for more than one NCD domain, half (n=2) of which were implemented in the South East Asian Region (SEAR). All multiple NCD-related DHIs used targeted client communication, while 50% of DHIs for respiratory conditions used client-to-client communications. Telemedicine was used by all respiratory-related and liver-related DHIs compared with 75% of the implemented DHIs for multiple NCDs. Half of the DHIs for multiple NCDs used prescription and medication management. Data collection, management and use services

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were used by half of the DHIs for both respiratory and multiple NCDs.

**DISCUSSION**

This rapid scoping review identifies and summarises the attributes of digital health innovations implemented for the management of NCDs during the COVID-19 pandemic. The most frequently targeted NCDs related to mental health, neurological or neuro-developmental 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, mental health and spiritual support for critical or end-of-life situations. 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%). 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. Despite some challenges in broader application and/or adoption by particular stakeholders involved in clinical care, mapping the DHIs to their corresponding health system challenges promotes an understanding of the deployments and their needs. This endeavour can provide a shared language to inform planners, decision makers and researchers about the ‘functionality of digital health implementations’ for NCD management, 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. 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.

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. 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.

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. 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. 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. 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. Needless to say, a complete shift to telemedicine without addressing the above challenges will only worsen existing inequities in access and disease outcomes. Digital technologies are increasingly being recognised as critical innovations to strengthen health services delivery systems. 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. 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. 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. 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.

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. In the long term, embedding DHIs within healthcare delivery systems is a promising approach for their sustainability, and DHIs can effectively support integrated care models for NCDs. 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. 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.

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’. 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’. 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.

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, 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). 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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NG jointly wrote the first draft. SM, MAG, AJ and OJ critically revised subsequent drafts for intellectual content. All authors read and approved the final manuscript.

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REFERENCES
1 World Health Organization. The impact of the COVID-19 pandemic on noncommunicable disease resources and services: results of a rapid assessment. Geneva: World Health organization, 2020. Available: https://www.who.int/teams/noncommunicable-diseases-covid-19&publication=9789240010291 [Accessed 20 Oct 2021].
2 World Health Organization. Noncommunicable diseases. Available: https://www.who.int/news-room/facts-sheets/detail/noncommunicable-diseases [Accessed 21 Oct 2021].
3 World Health Organization. Pulse survey on continuity of essential health services during the COVID-19 pandemic. interim report. who reference number: WHO/2019-nCoVEHS_continuity/surveys). 1. Geneva: World Health Organization, 2020.
4 Chudasama YV, Gillies CL, Zaccardi F, et al. Impact of COVID-19 on routine care for chronic diseases: a global survey of views from healthcare professionals. Diabetes Metab Syndr 2020;14:965–7.
5 Minghui R, Simao M, Mikkelsen B, et al. Gaps in access to essential medicines and health products for noncommunicable diseases and mental health conditions. Bull World Health Organ 2020;98:582–582A.
6 Shahzad H, Mubarak F, Satarr AK. The novel coronavirus (COVID-19) pandemic and the response in low-to-middle income countries. Curr Breast Cancer Rep 2021;63–8.
7 Kuehn BM. Despite improvements, COVID-19’s health care disruptions persist. JAMA 2021;325:2335.
8 Bello B, Uche U. COVID-19: are non-communicable diseases risk factors for its severity? Am J Health Promot 2021;35:720–9.
9 Thankappan K. Coronavirus disease 2019 and noncommunicable diseases: lessons learned so far and implications for the future. Int J Noncommun Dis 2020;5:155–7.
10 Di Gessa G, Maddock J, Green MJ. Mental health inequalities in healthcare, economic, and housing disruption during COVID-19: an investigation in 12 longitudinal studies. medRxiv 2021.
11 Lai AG, Pasea L, Banerjee A, et al. Estimated impact of the COVID-19 pandemic on cancer services and excess 1-year mortality in people with cancer and multimorbidity: near real-time data on cancer care, cancer deaths and a population-based cohort study. BMJ Open 2020;10:e043382.
12 Palmer K, Monaco A, Kivipelto M, et al. The potential longer-term impact of the COVID-19 outbreak on patients with noncommunicable diseases in Europe: consequences for healthy ageing. Aging Clin Exp Res 2020;32:1189–94.
13 Abdulkadri A, Floyd S, Mkrtchyan I. Addressing the adverse impacts of non-communicable diseases on the sustainable development of Caribbean countries. studies and perspectives series-ECLAC subregional headquarters for the Caribbean, no. 100 (LC/TS.2021.4/LC/CAR/TS.2021/2), Santiago, economic Commission for Latin America and the Caribbean (ECLAC) 2021.
14 Singh Thakur J, Nangia R, Singh S. Progress and challenges in achieving noncommunicable diseases targets for the sustainable development goals. FASEB Bioadv 2021;3:563–8.
15 Min Y, Perucci F. Impact of COVID-19 on SDG progress: a statistical perspective: policy brief. United nations, 2020. Available: https://digitallibrary.un.org纪录/record/3881166/files/PB_81.pdf [Accessed 20 Oct 2021].
16 Liu S, Yang L, Zhang C, et al. Online mental health services in China during the COVID-19 outbreak. Lancet Psychiatry 2020;7:e17–18.
17 Abd-Alrazaq A, Hassan A, Abuelezz I, et al. Overview of technologies implemented during the first wave of the COVID-19 pandemic: Scoping review. J Med Internet Res 2021;23:e29136.
18 Budd J, Miller BS, Manning EM, et al. Digital technologies in the public-health response to COVID-19. Nat Med 2020;26:1183–92.
19 Abd-Alrazaq AA, Alajlan M, Alhuwail D, et al. Blockchain technologies to mitigate COVID-19 challenges: a scoping review. Comput Methods Programs Biomed Update 2021;1:100001.
20 Gudi N, Konapur R, John O, et al. Telemedicine supported strengthening of primary care in who South East Asia region: lessons from the COVID-19 pandemic experiences. BMJ Innov 2021;7:580–5.
21 Gudi N, Yadav UN, John O. Challenges and opportunities in employing digital health to address self-management needs of people with NCDS in India. BMJ Innov 2023;9:19–22.

16 Murthy S, et al. BMJ Innov 2023;9:3–18. doi:10.1136/bmjinnov-2021-000903
22. Hartasanchez SA, Heen AF, Kunneman M, et al. Remote shared decision making through telemedicine: a systematic review of the literature. Patient Educ Couns 2022;105:336-365.

23. Houston E, Kennedy AG, O’Malley D, et al. Telemedicine in neurology: a scoping review of key outcomes in movement disorders. Telemed J E Health 2021. doi:10.1089/tmj.2021.0117. [Epub ahead of print: 08 Jun 2021].

24. Iyengar K, Upadhyay GA, Vaiyha R, et al. COVID-19 and applications of smartphone technology in the current pandemic. Diabetes Metab Syndr 2020;14:733-7.

25. Arakse H, O’Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005;8:19-32.

26. Mays N, Pope C, Popay J. Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. J Health Serv Res Policy 2005;10 Suppl 1:6-20.

27. Levac D, Colquhoun H, O’Brien KK. Scoping studies: advancing the methodology. Implement Sci 2010;5:69.

28. Peters MDJ, Marmie C, Tricco AC, et al. Updated methodological guidance for the conduct of scoping reviews. J Evid Synth 2020;18:2119-26.

29. McKimm A. Call to action for the BMJ Innovations community after COVID-19. BMJ Innov 2021;7:1-2.

30. Garside C, Gartlehner G, Nussbaumer-Streit B, et al. Cochrane rapid reviews methods group offers evidence-informed guidance to conduct rapid reviews. J Clin Epidemiol 2021;130:13-22.

31. Munn Z, Peters MDJ, Stern C, et al. Systematic review or scoping review? guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 2018;18:1-7.

32. Peters MDJ, Godfrey CM, Khalil H, et al. Guidance for conducting systematic scoping reviews. Int J Evid Based Healthc 2015;13:141-6.

33. Tricco AC, Langlois E, Straus SE. Rapid reviews to strengthen health policy and systems: a practical guide. Geneva: World Health Organization, 2017: Licence: CC BY-NC-SA 3.0 IGO.

34. Tricco AC, Antony J, Zarin W, et al. A scoping review of rapid review methods. BMC Med 2015;13:1-15.

35. World Health Organization. Who guideline: recommendations on digital interventions for health system strengthening. Geneva: World Health Organization, 2019: Licence: CC BY-NC-SA 3.0 IGO.

36. World Health Organization. Classification of digital health interventions V1.0: a shared language to describe the uses of digital technology for health: World Health organization, 2018. Available: https://apps.who.int/iris/bitstream/handle/10665/260480/WHO-RRH-18.06-eng.pdf;jsessionid=EF5C78012765D3D18F62E3B3C71E67DC?sequence=1 [Accessed 21 Oct 2021].

37. Murthy S, Kamath P, Godinho M. Digital health innovations for non-communicable disease management during the COVID-19 pandemic: a rapid scoping review. OsF 2022.

38. EndNote X9 [program]. Available: https://endnote.com/ [Accessed 7 Feb 2022].

39. World Health Organization. Who regional offices. Available: https://www.who.int/about/who-we-are/regional-offices [Accessed 22 Oct 2021].

40. Murthy S. Tableau public: free data visualization software: Shruti Murthy, 2021. Available: https://public.tableau.com/app/profile/shruti.murthy

41. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018;169:467-73.

42. Paterson C, Bacon R, Dwyer R, et al. The role of telehealth during the COVID-19 pandemic across the interdisciplinary cancer team: implications for practice. Semin Oncol Nurs 2020;36:1515090.

43. Raphael J, Winter R, Berry K. Adapting practice in mental healthcare settings during the COVID-19 pandemic and other contingencies: systematic review. BJPsych Open 2021;7:e62.

44. Papadopoulos I, Lazzarino R, Wright S, et al. Spiritual support during COVID-19 in England: a scoping study of online sources. J Relig Health 2021;60:2209-30.

45. Merollir M, Hinman RS, Lawford BJ, et al. Digital health interventions in physical therapy: development of client and health care provider survey instruments. JMRIResProtoc 2021;10:e25177.

46. Centers for Disease Control and Prevention. Guide to community preventive services, 2020. Available: http://www.thecommunityguide.org [Accessed 10 Nov 2021].

47. Hinton CF, Kraus LE, Richards TA, et al. The guide to community preventive services and disability inclusion. Am J Prev Med 2017;53:898-903.

48. Dorsey ER, Okan MS, Bloom BR. Care, convenience, comfort, confidentiality, and contagion: the 5 Cs that will shape the future of telemedicine. J Parkinsons Dis 2020;10:893-7.

49. Hoffer-Hawluk M, Moran A, Zerihun L, et al. Telemedicine interventions for hypertension management in low- and middle-income countries: a scoping review. PLoS One 2021;16:e0254222.

50. Spiess PE, Greene J, Keenan RJ, et al. Meeting the challenge of the 2019 novel coronavirus disease in patients with cancer. Cancer 2020;126:3174-5.

51. Katzow MW, Steinway C, Jan S. Telemedicine and health disparities during COVID-19. Pediatrics 2020;146.

52. Seixas AA, Olaye IM, Wall SP, et al. Optimizing healthcare through digital health and wellness solutions to meet the needs of patients with chronic disease during the COVID-19 era. Front Public Health 2021;9:667654-4.

53. Watts G. COVID-19 and the digital divide in the UK. Lancet Digit Health 2020;2:e395-6.

54. Kickbusch I, Piselli D, Agrawal A, et al. The Lancet and financial times Commission on governing health futures 2050: growing up in a digital world. Lancet 2021;398:1727-76.

55. The Lancet Digital Health. Digital technologies: a new determinant of health. Lancet Digital Health 2021;3:e684.

56. Sieck CJ, Sheon A, Ancker JS, et al. Digital inclusion as a social determinant of health. NPI Digit Med 2021;4:52-4.

57. Godinho MA, Borda A, Kariotis T, et al. Knowledge co-creation in participatory policy and practice: building community through data-driven direct democracy. Big Data & Society 2021;8:2053515721210194.

58. The Medical Futurist. COVID-19 and the rise of telededicine, 2020. Available: https://medicalfuturist.com/covid-19-was-needed-for-telemedicine-to-finally-go-mainstream/ [Accessed 20 Oct 2021].

59. Wilson K, Gertz B, Arenth B. The journey to scale: moving together past digital health pilots. Seattle: path, 2014. Available: path.azureedge.net/media/documents/PATH_Journey_to_Scale_R2.pdf [Accessed 21 Oct 2021].

60. Godinho MA, Ansari S, Guo GN, et al. Toolkits for implementing and evaluating digital health: a systematic review.
of rigor and reporting. *J Am Med Inform Assoc* 2021;28:1298–307.

61 Jonnagaddala J, Godinho MA, Liaw S-T. From telehealth to virtual primary care in Australia? a rapid scoping review. *Int J Med Inform* 2021;151:104470.

62 Godinho MA, Jonnagaddala J, Gudi N, et al. mHealth for integrated People-Centred health services in the Western Pacific: a systematic review. *Int J Med Inform* 2020;142:104259.

63 Godinho MA, Ashraf MM, Narasimhan P. Digital health, social enterprise & citizen engagement in Integrated People-Centred Health Services: a hermeneutic systematic review and preliminary framework synthesis. 2nd Asia Pacific Conference on Integrated Care, 2021:196.

64 Liaw S-T, Guo JGN, Ansari S, et al. Quality assessment of real-world data repositories across the data life cycle: a literature review. *J Am Med Inform Assoc* 2021;28:1591–9.

65 World Health Organization. WHO compendium of innovative health technologies for low-resource settings. COVID-19 and other health priorities. Geneva: World Health Organization, 2021: License: CC BY-NC-SA 3.0 IGO.

66 Berlin A, Lovas M, Tuong T, et al. Implementation and outcomes of virtual care across a tertiary cancer center during COVID-19. *JAMA Oncol* 2021;7:597–602.

67 WHO health innovation group (WHIG) Geneva: World Health organization. Available: https://www.who.int/phi/2016_05health_innovation-brochure.pdf [Accessed 22 Oct 2021].

68 Adams R, Tranfield D, Denyer D. A taxonomy of innovation: configurations of attributes in healthcare innovations. *Int J Innov Mgt* 2011;15:359–92.

69 Greenhalgh T, Robert G, Macfarlane F, et al. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q* 2004;82:581–629.

70 Kimble L, Massoud MR. What do we mean by innovation in healthcare. *Eur Med J* 2017;1:89–91.

71 Cheng Y-T, Van de Ven AH. Learning the innovation journey: order out of chaos? *Organization Science* 1996;7:593–614.

72 Garcia R, Calantone R. A critical look at technological innovation typology and innovativeness terminology: a literature review. *J Prod Innov Manage* 2002;19:110–32.

73 Nikoloski Z, Alqunaibet AM, Alfawaz RA, et al. Covid-19 and non-communicable diseases: evidence from a systematic literature review. *BMC Public Health* 2021;21:1–9.

74 Jonnagaddala J, Godinho MA, Liaw S-T. From telehealth to virtual primary care in Australia? a rapid scoping review. *Int J Med Inform* 2021;151:104470.