Digital health for quality healthcare: A systematic mapping of review studies

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Abstract

Objective: To systematically catalogue review studies on digital health to establish extent of evidence on quality healthcare and illuminate gaps for new understanding, perspectives and insights for evidence-informed policies and practices.

Methods: We systematically searched PubMed database using sensitive search strings. Two reviewers independently conducted two-phase selection via title and abstract, followed by full-text appraisal. Consensuses were derived for any discrepancies. A standardized data extraction tool was used for reliable data mining.

Results: A total of 54 reviews from year 2014 to 2021 were included with notable increase in trend of publications. Systematic reviews constituted the majority (61.1%, (37.0% with meta-analyses)) followed by scoping reviews (38.9%). Domains of quality being reviewed include effectiveness (75.9%), accessibility (33.3%), patient safety (31.5%), efficiency (25.9%), patient-centred care (20.4%) and equity (16.7%). Mobile apps and computer-based were the commonest (79.6%) modalities. Strategies for effective intervention via digital health included engineering improved health behaviour (50.0%), better clinical assessment (35.1%), treatment compliance (33.3%) and enhanced coordination of care (24.1%). Psychiatry was the discipline with the most topics being reviewed for digital health (20.3%).

Conclusion: Digital health reviews reported findings that were skewed towards improving the effectiveness of intervention via mHealth applications, and predominantly related to mental health and behavioural therapies. There were considerable gaps on review of evidence on digital health for cost efficiency, equitable healthcare and patient-centred care. Future empirical and review studies may investigate the association between fields of practice and tendency to adopt and research the use of digital health to improve care.

Keywords
Digital health, systematic mapping, quality healthcare, mHealth, technology-enhanced

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Introduction

Digital health has shifted the paradigm of quality medical care. In the literature, digital health is diversely defined. From a review of 1527 papers, the seminal study by Fatehi et al. finds 95 unique definitions of digital health, yet common to these definitions is digital intervention that examines the provision of healthcare rather than the use of the technology itself. Empowered by the industrial revolution 4.0, digital health invigorates applications of digital technology that changes the landscape of conventional medical practice. As a result, there is an increasing interest to capitalize digital health to improve the quality of healthcare.

To understand how digital health may improve healthcare quality, this study adopts six domains of quality as

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being defined by the consensus of experts; patient safety, access to healthcare, effective treatment, efficient use of resources, equity of care across subgroups of populations and patient-centred care. The judgement among these experts were in coherence with the following descriptions of quality care from the World Health Organization (WHO).

Patient safety relates to the delivery of care which minimizes risks and harms. Effective treatment denotes improved health outcomes to patients and community. Efficiency indicates optimum use of resources that avoid waste. Equitable healthcare concerns on consistent care quality across different subgroup of patient population. Quality of access refers to the delivery of care that is timely, geographically reasonable and appropriate to the medical need. Lastly, patient-centred approach emphasizes care that considers individual patient’s preferences, aspirations and the cultures of the community. Therefore, reviewing the notion of quality from these domains provides a multi-faceted approach to understand digital health and its roles to improve quality healthcare.

This understanding is important because the literature has reported innovative digital technology contributes towards quality healthcare in various ways. For example, Rahman et al. reported the use of Vis-Screen mobile application to widen population-based screening for visual impairment and blindness. They raised concern that there was a lack of awareness among certain group of population, especially those who were disadvantaged in terms of economy, education and remote areas of residence. In these population, late presentation of ophthalmologic conditions hindered timely intervention, resulting in dire consequences to the quality of life. Similarly, Yang et al. innovated digital neuroradiology imaging database to enhance retrospective research and prospective clinical trials in the field of radiology, neurosurgery, neurology, rehabilitation and others, for patients with brain tumour. The likely contribution on clinical care from application of this technology is reflected by Othman et al. who reported 386 new cases of primary brain tumour were registered within the period of 2013 to 2018 in a neurosurgery department of a tertiary hospital in Malaysia. The gravity of impact on quality care is further magnified by the potential similar findings among tertiary medical centres around the world. Thus, this variety of contributions indicate the rising interest, research and adoption of digital health for quality healthcare.

Paradoxically, the exponential rise of digital health adoption over the last two decades may have created a challenge to establish the extent of impact from digital health on quality healthcare. Challenges associated with digital health include ethical concern on information security, acceptability on new practice, and whether the technology really is practical and feasible to be implemented in real practice. In 13 November 2018, these challenges had prompted the European Union to sanction a public hearing, followed by an official report by expert panel on effective ways of investing in health (EXPH) to assess the impact of digital transformation on health service. In their summary finding, the 14-member expert panel highlighted broad perspectives should be taken in making the decision to adopt, employ or invest new digital health services. Therefore, aligning the evidence with the need of practice, policy and research may depart from eliciting the extent of evidence with the broader aspects of healthcare.

In response, we are conducting this systematic mapping of review studies to gain a wide-ranging perspective on evidence related to the digital health and quality medical care. A systematic mapping is also known as a scoping review as described by Arksey and O’Malley. However, systematic mapping does not appraise the quality of the selected study and consequently does not analyze the results of the selected studies. Instead, a mapping review focuses on systematic cataloguing of selected studies to derive new insight and understanding on the breadth, purpose and trend of research activities on the topic of interest. The importance of systematic mapping is increasingly recognized in the context of providing multi-faceted aspects of evidence including the literature descriptions of an intervention at different places, contexts, time and fields of practice. These broad perspectives of evidence may prove useful and important for complicated evidence-informed policy decision because every institution is unique in its experience, expertise and resources for healthcare quality improvement.

Therefore, this study adopts systematic mapping design as a robust methodological approach to establish the extent of review evidence on digital health for quality healthcare. The following sections of this study will outline the objective, methodology and results of this review. We will then narratively discuss the findings before concluding with the key findings for policies and practices.

Objective

To our knowledge, there is yet a study that reviews the evidence of review studies on digital health and aspects of quality medical care. The objective of this study is to systematically map these review studies to establish six endpoints: (1) general characteristics of review studies on digital health; (2) trend of research activities by year publication; (3) the aim and objective of digital health for quality medical care; (4) approaches to improve the effectiveness of intervention via digital health; (5) type and frequency of digital health interventions; and (6) predominant disciplines of medical practice and their topics for digital health.

Engaging with users of review study

Engaging key stakeholders allows a review study to gain users’ perspectives to help navigate clearer aims and
goals that are relevant and meaningful to inform policy and practice.\textsuperscript{14} However, this approach was not adopted due to practical challenges related to the COVID-19 lockdown period during the conduct of this study. Alternatively, the objectives of this review were derived through informal engagement with local key stakeholders. This informal engagement was achieved through one reviewer (HMY) who is currently a member of board of director of Universiti Sultan Zainal Abidin (UniSZA) teaching hospital, and another reviewer (RAM) who was a member of UniSZA centre of academic quality. Objectives (4), (5) and (6) were added following both authors’ experience as policymakers and regular engagement with various stakeholders.

**Methods**

**Search strategy**

We began by performing rapid synthesis of evidence with data mining via few keywords in PubMed databases such as ‘digital health’ and ‘medicine’.\textsuperscript{15} This exercise served as preliminary measures of exploring research activities in the fields of interest, thus guided a more targeted search by indicating arbitrary boundaries of review that was within the time and practical constraints of this study.\textsuperscript{16} Consequently, we derived three conceptual frameworks to guide structured searching for studies on digital health on quality medical care: digital health, medicine and review study.

Conducted in the PubMed database, we designed search strings for each conceptual framework to be based on title/abstract and MeSH term. The final Boolean search strings for this study were conducted on 2 June 2021.

**Study selection criteria**

Following rapid review of evidence, we developed criteria to define the focus and boundaries of this mapping review. The selection criteria were summarized in Table 1.

**Selecting studies**

Selections were conducted by two independent reviewers (MSI and YIAB). Reviewers initially rejected irrelevant studies based on title and abstract. If there was any doubt for exclusion, studies were accepted for the full text screening. All discrepancies between reviewers were resolved by consensus.

### Table 1. Criteria for study selection.

| Inclusion criteria | Exclusion criteria |
|--------------------|-------------------|
| **Population**     | Studies of quality healthcare that include medical professionals were accepted. |
| **Language**       | Studies were conducted in English |
| **Study design**   | Studies were either systematic review, systematic mapping, or scoping review |
|                    | Original studies, review protocols, literature reviews, and review of review studies (overview, meta-review or umbrella review) |
| **Intervention**   | Studies were researching the use of digital technology to improve patient care. |
|                    | Reviews that were mainly focusing on: |
|                    | - Education of health practitioners on the use of digital technology |
|                    | - Evaluation or application of technology rather than directly on patient care |
| **Comparison**     | Studies with or without comparison of interventions were accepted |
| **Outcome**        | Studies reported results that feature any domain of quality care as its main finding or as one of the main findings. |
| **Timeframe**      | All publication dates were accepted |
|                    | Duplicates of the same study |
**Extracting studies**

All title and abstract of included studies were imported into reference manager Endnote 20. Then all details of the final included studies were extracted into a standardized data mining template in Microsoft Excel with structure as shown in Supplemental Appendix 1.

**Quality appraisal and search for grey literature**

Both quality appraisal and search for grey literature were not applicable for this study which aimed to systematically catalogue the research activities to achieve broad perspectives on the evidence in this field. Consequently, the results of the selected reviews were presented in the appendix section (Supplemental Appendix 2). This approach was adopted as a measure of good practice to avoid misleading the readers that the included reviews had been critically appraised.

**Data analysis**

PRISMA flowchart for the selection process and systematic mapping of all included reviews based on standardized data extraction tool were constructed. Data were analyzed and narratively summarized using descriptive statistics in tables or graphs for each objective of the study. Descriptive statistics were computed using Microsoft Excel while Microsoft Power BI was used for visualization of spatial data.

**Results**

**Search and selection**

The structured searching via search strings based on conceptual frameworks returned 4545 studies regarding digital health, 2,709,890 articles concerning medicine, and 199,138 publications on review study. The final Boolean search operation revealed a total of 155 studies that were relevant for all three conceptual frameworks. Table 2 provides summary of the structured search strategy used in this study.

From these 155 studies, no duplications were found. Subsequently, 64 studies were removed during first stage of selection via title and abstract. Further 37 studies were excluded following second stage selection by full text appraisal. Figure 1 summarizes the PRISMA flow diagram for the final 54 reviews for data extraction.

**Data mapping of included reviews**

Mapping of data by standardized data extraction tool for all 54 reviews established the extent of review evidence to answer all six endpoints of this study. Table 3 provides results of data mapping conducted in this study.

**Endpoints**

**Characteristics of review studies on digital health.** This study identified 13 scoping reviews, 20 systematic reviews with meta-analyses and 21 systematic reviews without meta-analyses. From the 54 reviews, institutions of the main author for the reviews were reported from 15 countries; United Kingdom (16), United States (7), Australia (7), Canada (5), Switzerland (4), China (4), Ireland (2), Netherlands (2), and one each for Brazil, Singapore, France, Turkey, Finland, Greece, Ethiopia (Figure 2).

**Publication year.** There was an increasing number of reviews from one publication in the year 2014 to 26 articles for the year 2020. Figure 3 displays the number of reviewed articles by year of publication.

**Domains of quality care.** Digital health had been reviewed to deliver all six domains of quality healthcare. From the 54

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### Table 2. Results of the structured searching.

| No. | Conceptual framework     | Search string                                                                 | Number of returned publications |
|-----|--------------------------|------------------------------------------------------------------------------|---------------------------------|
| #1  | Digital health           | (digital health[Title/Abstract]) OR (digital health[MeSH Terms])              | 4545                            |
| #2  | Medicine                 | ((((((medicine[Title/Abstract])) OR (medical[Title/Abstract])) OR (doctor[Title/Abstract])) OR (medicine[MeSH Terms])) OR (medical[MeSH Terms])) OR (doctor[MeSH Terms]) | 2,709,890                      |
| #3  | Review study             | (((((systematic review[Title/Abstract]) OR (scoping review[Title/Abstract])) OR (systematic mapping[Title/Abstract]) OR (systematic review[MeSH Terms])) OR (scoping review[MeSH Terms])) OR (systematic mapping[MeSH Terms])) | 199,138                         |
| #4  | Final search             | (#1) AND (#2) AND (#3)                                                      | 155                             |
reviews, evidence was mostly prevalent on the aspect of effective intervention (75.9%). Additionally, there were comparable extent of evidence on digital health for accessibility (33.3%), patient safety (31.5%) and efficiency (25.9%). However, there were considerably less number of reviews on digital health for patient-centred care (20.4%) and equitable healthcare (16.7%). Figure 4 summarizes the number of reviews on digital health by domains of quality of care.

Approaches for effective intervention. Digital health had been reviewed to deliver a more effective intervention via four distinct approaches. The targets of intervention included improving health behaviour (50.0%), enhancing clinical assessment (35.1%), supporting medication compliance or treatment engagement (33.3%) and strengthening coordination of care (24.1%) (Figure 5).

Types of digital health interventions. The data mapping also revealed 15 unique categories of digital health for quality healthcare. Mobile apps and computer-based programs were the most reported digital health intervention. Videocassette, electronic medication container, endoscope-equipped smartphone and IoT each were least applied. Figure 6 presents 15 distinct digital applications used for health interventions reported in the 54 reviews.

Predominant disciplines of medical practice and their topics. Most topic of reviews on digital health for quality healthcare were multidisciplinary in nature (32). However, for single main field of discipline, topics related to psychiatric care emerged as the commonest (11). Table 4 shows predominant disciplines being addressed by the digital health reviews and their topics.

Discussion

To the best of our knowledge, this is the first study to systematically search, select and map review studies on digital health for quality healthcare. A total of 54 reviews are included, ranged from the year 2014 to 2021 with increasing trend till the end of 2020 (Graph 1). From these reviews, a total of 15 distinct digital health interventions are identified (Graph 4) with findings which encapsulate all six domains of quality healthcare (Graph 2), 12 identified group of practices (graph 5), with 51 unique topics of healthcare (Table 3). Therefore, the systematic mapping of compilations of review studies on digital health create new evidence, insight and understanding on quality...
Table 3. Data mapping for 54 reviews on digital health for quality healthcare.

| No | Author                  | Type of review | Topic of review                        | No. of studies | Main field of discipline | Mobile apps | Computer-based | Sensor-based technology | Electronic-Record-based | A.I. | Telemedicine | Wearable device | Game Consoles | Internet of Thing (IoT) | AR / VR | Endoscope-equipped smartphone | Electronic Medication Container | Videocassette | Telephone Consult | Telephone Safety | Patient Safety | Access to healthcare | Patient-centred Care | Equity | Effective use of resources | Treatment compliance | Enhanced Clinical Assessment | Better Care Coordination |
|----|------------------------|----------------|----------------------------------------|----------------|--------------------------|-------------|----------------|------------------------|------------------------|------|-------------|----------------|---------------|------------------------|----------|-----------------------------|-----------------------------|----------------|----------------|----------------|----------------|-------------------------|----------------|-----------------|----------------------|----------------|----------------------|-------------------|-----------------|------------------------|
| 1  | Aapro et al.           | Sys.R          | Supportive care in Oncology            | 52             | Oncology                | X           | X             | X                       | X                      | X    | X           |                            |                            | X                      | X          |                            |                            | X             | X           |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 2  | Robbins et al.         | Sys.R          | Healthy Aging                          | 51             | Multidisciplinary        | X           | X             | X                       | X                      | X    | X           |                            |                            | X                      |            |                            |                            | X             | X           |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 3  | Slattery et al.        | Sys.R + MA     | Chronic Pain                           | 30             | Multidisciplinary        | X           | X             | X                       | X                      | X    | X           |                            |                            | X                      |            |                            |                            | X             | X           |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 4  | El Morr & Layal        | Sys.R          | Intimate Partner Violence              | 25             | Multidisciplinary        | X           | X             |                        |                        |      |              |                            |                            |                        |            |                            |                            | X             | X           |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 5  | Beleigoli et al.       | Sys.R + MA     | Obesity                                | 11             | Multidisciplinary        | X           | X             |                        |                        |      |              |                            |                            |                        |            |                            |                            |                |              |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 6  | Davies et al.          | Sys.R + MA     | Depression, Anxiety, and psychological well-being | 17             | Psychiatry               | X           | X             |                        |                        |      |              |                            |                            |                        |            |                            |                            |                |              |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 7  | Biagianti et al.       | Sys.R          | Psychosis                              | 8              | Psychiatry               | X           | X             |                        |                        |      |              |                            |                            |                        |            |                            |                            |                |              |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| 8  | Rose et al.            | Sys.R + MA     | Adolescent health                      | 27             | Psychiatry               | X           | X             |                        |                        |      |              |                            |                            |                        |            |                            |                            |                |              |                            |                            |                       |                            |                      |                  |                        |                    |                  |
| No | Author                          | Type of review | Topic of review                     | No. of studies | Main field of discipline | Digital health identified in the review | Domain of quality medical care | Effective intervention |
|----|--------------------------------|----------------|-------------------------------------|----------------|--------------------------|----------------------------------------|---------------------------------|------------------------|
|    |                                |                |                                     |                |                          | Mobile apps* | Computer-based Technology* | Electronic-Record-based* | A.I.* | Telemedicine* | Wearable device | SMS | Game Consoles | Internet of Thing (IoT) | Endoscopic Medication Container | Telephone Consult | Patient Safety | Access to healthcare | Patient-centred Care | Equity | Improved Health Behaviour | Enhanced Clinical Assessment | Better Care Coordination |
| 9  | Lau et al.                     | Sys.R + MA     | Youth with chronic illness          | 16             | Psychiatry               | X | X | X                         |                             |                          |                          | Diet and healthy behaviour |
| 10 | Gandrup et al.                 | Sys.R          | Remote symptom monitoring           | 12             | Multidisciplinary        | X | X | X                         |                             |                          |                          |                             |
| 11 | Rollin et al.                  | Sys.R          | Melanoma                            | 5              | Multidisciplinary        | X | X | X | X                         |                             |                          |                          |                             |
| 12 | Sharma et al.                  | Sys.R + MA     | Renal transplantation               | 18             | Renal medicine           | X | X | X | X | X |                           |                          |                          |                             |
| 13 | Farnood et al.                 | Sys.R          | Online self-diagnosing              | 25             | Multidisciplinary        | X | X | X | X | X |                           |                          |                          |                             |
| 14 | Escriva Boulley et al.         | Sys.R          | Care for patients with cancer       | 23             | Multidisciplinary        | X | X | X | X | X |                           |                          |                          |                             |
| 15 | Zhou & Parmanto,36            | Sys.R          | Rehabilitation in underserved areas | 10             | Rehabilitation medicine  | X | X | X | X | X | X |                           |                          |                          |                             |
| 16 | Yadav et al.                   | Sys.R + MA     | Fragility fracture recovery          | 15             | Multidisciplinary        | X | X | X | X | X | X | X | X | X |                           |                          |                          |                             |

(continued)
| No | Author                  | Type of review | Topic of review                                                                 | No. of studies | Main field of discipline | Digital health identified in the review | Domain of quality medical care |
|----|-------------------------|----------------|---------------------------------------------------------------------------------|----------------|--------------------------|----------------------------------------|-------------------------------|
|    |                         |                |                                                                                 |                |                          |                                        |                               |
| 17 | Robinson et al.³⁸       | Sys.R          | Health Behavior and support for patients undergoing elective surgery            | 18             | Multidisciplinary         | X                                      | X X X X X                      |
| 18 | Gunasekeran et al.³⁹    | Sc.R           | COVID-19 public health responses                                                | 247            | Public Health             | X X X X X                             | X X X X X                      |
| 19 | Milne-Ives et al.⁴⁰     | Sys.R + MA     | Physical Activity, Diet, Drug and Alcohol use. Mental Health                    | 52             | Psychological medicine    | X                                      | X                             |
| 20 | Stogios et al.⁴¹        | Sys.R + MA     | Hypertension                                                                     | 17             | Multidisciplinary         | X                                      | X X                           |
| 21 | Wang et al.³²           | Sys.R + MA     | Rehabilitation after Total Knee or Hip Replacement                              | 19             | Rehabilitation medicine   | X X X X X X                           | X X X X X X                    |
| 22 | Choutou et al.³³        | Sc.R           | Remote care during COVID-19                                                       | 6              | Multidisciplinary         | X X X X X                             | X X X X                       |
| 23 | Kemp et al.³⁴           | Sc.R           | Mental health                                                                     | 37             | Psychological Medicine    | X                                      | X X X X                       |

(continued)
| No. | Author                  | Type of review | Topic of review                                      | No. of studies | Main field of discipline | Digital health identified in the review | Domain of quality medical care | Effective intervention |
|-----|-------------------------|----------------|-----------------------------------------------------|----------------|--------------------------|----------------------------------------|-------------------------------|------------------------|
| 24  | Forbes et al.           | Sys.R          | Supportive care for prostate cancer survivor        | 16             | Multidisciplinary         | X X X X                                 | X X X X X X X X X             |                        |
| 25  | Lee et al.              | Sc.R           | Tuberculosis                                         | 14             | Multidisciplinary         | X X X X                                 | X X X X X X X X X             |                        |
| 26  | Liu et al.              | Sys.R + MA     | Stroke                                               | 13             | Neurology                | X                                       | X X X X X X X X X             |                        |
| 27  | Cao et al.              | Sc.R           | STI and HIV                                           | 21             | Multidisciplinary         | X X X X                                 | X X X X X X X X X             |                        |
| 28  | Widmer et al.           | Sys.R + MA     | Cardiovascular disease (general)                     | 51             | Multidisciplinary         | X X X X                                 | X X X X X X X X X             |                        |
| 29  | Rhodes et al.           | Sys.R + MA     | Diet, Physical Activity and Weigh Gain in Pregnancy  | 11             | Multidisciplinary         | X X X X                                 | X X X X X X X X X             |                        |
| 30  | Bergin et al.           | Sc.R           | Mental health for children and young people          | 30             | Psychiatry                | X X X X                                 | X X X X X X X X X             |                        |
| 31  | Nanah & Bayoumi         | Sys.R          | effective communication in neurosurgical care        | 13             | Neurosurgery              | X X X X                                 | X X X X X X X X X             |                        |

(continued)
| No | Author | Type of review* | Topic of review | No. of studies | Main field of discipline | Digital health identified in the review | Domain of quality medical care | Effective intervention |
|----|--------|----------------|----------------|----------------|--------------------------|----------------------------------------|-------------------------------|-----------------------|
| 32 | Tornivuori et al. | Sys.R + MA | Transition of care among adolescent with chronic illness | 12 | Multidisciplinary | X | X | X | X |
| 33 | Tully et al. | Sc.R | Paediatric Weight Management | 42 | Paediatric | X | X | X | |
| 34 | Hewitt et al. | Sys.R + MA | Musculoskeletal conditions | 19 | Multidisciplinary | X | X | | |
| 35 | Bempong et al. | Sc.R | Infectious disease control | 82 | Multidisciplinary | X | X | X | X |
| 36 | Robotham et al. | Sys.R + MA | Clinic Attendance | 25 | Multidisciplinary | X | X | | X |
| 37 | Seppen et al. | Sc.R | Rheumatoid arthritis | 10 | Rheumatology | X | X | X | X |
| 38 | Wang et al. | Sys.R + MA | mental health and quality of life among cancer patients | 7 | Psychiatry | X | X | | X |

(continued)
| No | Author | Type of review* | Topic of review | No. of studies | Main field of discipline | Digital health identified in the review | Domain of quality medical care | Effective intervention |
|----|--------|----------------|----------------|----------------|--------------------------|----------------------------------------|--------------------------------|------------------------|
| 39 | Nwolise et al. | Sys.R | Preconception care women with diabetes | 12 | Multidisciplinary | X | | X X | |
| 40 | Triantafyllidis et al. | Sys.R | Childhood obesity | 17 | Multidisciplinary | X X X X | | X X | |
| 41 | Brigden et al. | Sys.R | Children with chronic condition | 17 | Multidisciplinary | X X X X | X | X X |
| 42 | Li et al. | Sys.R + MA | adverse drug reaction reporting | 13 | Multidisciplinary | X X | | X X | |
| 43 | Taj et al. | Sc.R | Health Behaviour | 631 | Psychological Medicine | X X X X | | X | |
| 44 | Tilahun et al. | Sc.R | Neglected tropical diseases | 6 | Infectious Disease | X X X X | X X X X | |
| 45 | Ngwatu et al. | Sys.R | Tuberculosis | 6 | Multidisciplinary | X X X | | X | |
| 46 | Patel et al. | Sys.R + MA | Obesity | 15 | Multidisciplinary | X X X X | | X X | |
| 47 | Jones et al. | Sc.R | PTSD | 38 | Psychiatry | X X X X X | X X X X X | |

*Digital health identified in the review: Mobile apps*, Computer-based*, Sensor-based*, Electronic-Record-based, A.I.*, Telemedicine*, Wearable device, SMS, Game Consoles, Internet of Thing (IoT), AR / VR, Endoscope-equipped smartphone, Electronic Medication Container, Videocassette, Telephone Consult, Patient Safety, Efficient use of resources, Access to healthcare, Patient-centred Care, Equity, Improving Health Behaviour, Treatment compliance, Enhanced Clinical Assessment, Better Care Coordination.
Table 3. Continued.

| No. | Author          | Type of review   | Topic of review         | No. of studies | Main field of discipline | Mobile apps* | Computer-based* | Sensor-based Technology | Electronic-Record-based | A.I.* | Telemedicine* | Wearable device | Game Consoles | Internet of Thing (IoT) | AR / VR | Endoscopic-equipped smartphone | Electronic Medication Container | Videocassette | Telephone Consult | Medical Emergency Response Service | Effective intervention |
|-----|-----------------|------------------|-------------------------|----------------|--------------------------|--------------|------------------|------------------------|-------------------------|--------|----------------|----------------|---------------|---------------------------|---------|-----------------------------|-----------------------------|----------------|----------------|-----------------------------|-------------------------|
| 48  | Batra et al.69   | Sys.R            | Mental Health           | 18             | Psychiatry               | X            | X                | X                      | X                       |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 49  | Nicholl et al.70 | Sys.R + MA       | Low Back Pain           | 6              | Multidisciplinary        | X            | X                |                        |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 50  | Austin et al.71  | Sys.R            | Anticoagulation therapy | 27             | Multidisciplinary        | X            | X                |                        |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 51  | Godinho et al.72 | Sys.R            | Patient-centred care service delivery | 39             | Multidisciplinary        | X            | X                |                        |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 52  | Jiang et al.73   | Sys.R            | Cardiovacular diseases  | 14             | Multidisciplinary        | X            | X                | X                      |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 53  | Yin et al.74     | Sc.R             | Inflammatory Bowel Disease | 68             | Gastroenterology         | X            |                  |                         |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |
| 54  | Tighe et al.75   | Sys.R            | Noncommunicable disease | 7              | Multidisciplinary        | X            | X                |                         |                         |        |                |                 |               |                           |         |                             |                             |               |                |                             | Effective intervention |

*Notes. Sys.R + MA: systematic review with meta-analyses; Sys.R: systematic review without meta-analyses; Sc.R: scoping review; AR: augmented reality; VR: virtual reality. Mobile apps exclude telemedicine. Computer-based include web-based program, emails and offline use of computer program. Artificial intelligence include use of Big Data. AI-based robotics and prediction modelling. Telemedicine include remote video monitoring.
healthcare which otherwise would have been impossible to derive from individual review.

**Effective intervention**

The new perspective is evident on the use of digital health primarily to deliver more effective intervention especially via improved health behaviour. For example, to improve diet and physical activities among adolescents, Rose, Barker reported 15 studies were employing web-based program, four were using short messaging system (SMS), three were using gaming approach, and one each was adopting email and other digital platform. All these technologies were primarily used as a medium to deliver educational intervention by providing information and step-by-step guide on how to achieve and maintain healthy diet and physical activities. Similarly, Milne-Ives et al. identified 17 RCTs which targeted the use of mobile apps to drive changes in health behaviour related to diet, alcohol and mental health. In a slightly different context, Stogios et al. identified 17 RCTs which investigate the use of digital-based counselling for behaviour change to reduce systolic blood pressure (SBP). Although each review focuses on unique topic of care, all 21 reviews share similar findings of consistent strategy which capitalized the intimate digital technology engagement among mass population to engineer behaviour change for favourable clinical outcomes.

Similar strategy for effective intervention has been extended for technology-enhanced clinical assessment with heightened treatment compliance and engagement. For example, to determine how digital health aids the screening, diagnosis and management of intimate partner violence (IPV), El Morr and Layal have researched 16 RCTs and nine non-RCTs; four pre-post design studies, two cross-sectional studies, two prospective studies and one diagnostic case-control study. The research interest was centred on elucidating the evidence on how the use of desktop computer, laptop, tablet and phone could assist
women with IPV to initiate contact and subsequent access to help and care.\(^{25}\) In comparison, the scoping review on tuberculosis control by Lee et al.\(^{46}\) identified a total of 43 primary studies which employ various adherence-technologies such as video-observed therapy to encourage patients’ compliance on medication. Likewise, Batra et al.\(^{69}\) investigated 18 studies which report the use of smart electronic pill container and personal digital record which can provide cues and alerts to improve treatment compliance in hospital setting among patients with serious mental health illness. Thus, the varying intricacy and practices denote how dynamic application of digital health could push the boundaries of conventional approach to improve assessment and treatment compliance.

Setting a new height of more effective intervention is further exemplified in the coordination of complex care. An insightful review by Yadav et al.\(^{37}\) had compiled evidence from 15 studies from the year 2003 to 2016 on the use of digital health to enhance care on patients with fragility fracture. They reported digital health has been employed at various aspects of care including assisting recovery, education and compliance, treatment engagement, risk reduction for secondary prevention, and communication with the treating team. Yet, common to these aspects of care was the use of digital technology to systematically stage, organize and execute varying duty of care.\(^{37}\) The tasks include the delivery of digital-based educational package, scheduled phone call by registered nurses, electronic reminder to the treating physician, and systematic collection of clinical history, test results, progress, previous and current treatment regimen for osteoporosis including bisphosphonates and alternatives such as calcitonin and hormone replacement raloxifene.\(^{37}\) In a more recent context, the scoping review by Gunasekeran et al.\(^{39}\) has analyzed 247 studies to understand the use of digital health to coordinate the COVID-19 public health responses. Artificial intelligence, telemedicine and big data constitute the main technology being employed. Interestingly, the surge of technology-enhanced coordinated response was justified by the unprecedented scale of impact from the pandemic. Despite the 247 studies were only being conducted since the time of the pandemic in late 2019,\(^{76}\) the volume of publication of the primary studies in a short period of time highlighted strong commitment for new strategies to address the evolving challenges of care. Therefore, the emerging needs of practice appeared had invigorated the adoption of digital health for effective care coordination and potentially more efficient health intervention.

**Other domains of quality healthcare**

Unfortunately, complicated aspects of care may have hindered reviews from concluding the use of digital health for cost efficiency. For example, in reviewing the use of digital health for anticoagulation therapy, Austin, Barras\(^{71}\) reported one study on the use of computerized physician order entry (CPOE) for enoxaparin injection. Yet, deducing cost-effectiveness of digital health for anticoagulation therapy such as CPOE was limited due to scarce availability of primary studies.\(^{71}\) For similar reason, most reviews which explicitly reported results on cost-effectiveness was reporting this aspect of quality care only as peripheral findings with limited depth to derive a concrete aggregation of results.\(^{22,29,36,39,45,52,65}\) In comparison, Jiang et al.\(^{73}\) was focusing on the cost effectiveness of employing digital health for cardiovascular diseases (CVDs). All 15 studies identified in the review reported predominant use of telemedicine and wearable devices to achieve cost-efficiency. Yet, heterogeneity of the included studies had limited their conclusion on these digital health to deliver higher quality-adjusted lifeyears or improved clinical outcomes at a lower cost than the standard care.\(^{73}\) Therefore, despite a huge volume of empirical research and review studies on digital health, the multifaceted aspects of cost-effectiveness may have incurred complex challenges resulting in the gaps of evidence to establish the magnitude of impact, the mechanism and the fidelity of implementation on digital health for cost-efficient healthcare.

Nonetheless, the lack of concrete evidence on cost-efficiency does not negate the strong research interest on accessible, safe and patient-centred care through digital health. For example, Rollin et al.\(^{32}\) have reviewed five studies on the use of digital health for melanoma care in rural areas and remote communities of Australia. The use of telemedicine has been attributed to improve early detection of skin lesion, facilitate patients’ decision-making, reduced their stress, and empower communication and education. This is in addition of being convenient and save the time for travel. The use of telemedicine has brought fundamental access to quality melanoma care, in addition to reduce the disparity between care in rural and urban areas.\(^{32}\) Likewise, Godinho et al.\(^{72}\) have reviewed 39 studies on the use of mHealth to deliver multiple aspects of patient-oriented care including accessibility, equitable care and timely intervention which minimizes risks and harms. The comprehensive review found the use of mHealth such as text messages, mobile apps, phone call...
and video communication for people-centred care have primarily been used for community-based health issues. These issues include medication compliance, lifestyle activities, diabetes, CVDs and smoking cessation. In these studies, mHealth enhances quality care by enabling patients to bypass gatekeepers for a direct access to healthcare, increasing affordability, empower governance of care, more robust evaluation on safety and strengthening the scheduling and navigation of services. Thus, adoption of digital health for quality healthcare may not only be reactively motivated by the emerging needs of care, but also proactively committed via ongoing determination to set a new benchmark of quality on existing practice.

**Trend of review activities on digital health**

This motivation is reflected by the large number in each type of reviews. The 13 scoping reviews and 21 systematic reviews without meta-analyses provide meaningful shortcut evidence to the literature. Under the same theme or topic of interest, these reviews illuminate the breadth, purpose and extent of research activities while establish what is known and gaps of evidence. In contrast, the 20 systematic reviews with meta-analyses vigorously search, select, appraise research quality and aggregate evidence from varying contexts and fields of practice to deduce with statistical certainty on the effectiveness of the digital health intervention of interest. Therefore, the increasing number of review studies reflects an escalating motivation to harvest new understanding from these cluster of research to attain deeper insight, broader perspectives and more robust information for decision making.

As a result, the increasing volume of reviews and their diversity in objectives, context, types and topics of interest reflect the heightened interests to establish evidence-informed policies and practices. This trend of reviews is consistent with the increasing trend in the original studies related to the digital health. Compiling digital health research from 2000 until 2018, the review by Taj et al. reported an exponential growth of publications since 2009 attributable to the revolution in smartphone innovation. Supporting this evidence is the result of this study which shows smartphone-based intervention is the most prominent digital health being employed for quality care. Mobile apps, phone calls, video conference and telemedicine and web-based intervention are categories of digital health which can all be delivered via smartphones. Interestingly, smartphones have been available for mostly corporate users since 1993. It is likely the transition of technology users from a niche market to mass population may have served as the key factor that explains the impact and motivation to aggregate research for evidence in this field.

Consequently, the popular smartphone-based digital health to improve health behaviour may elucidate psychiatry as the single field of medical practice most featured in this study. The intrinsic association between favourable change of behaviour and mental health issues may have influenced many aspects of psychiatric care. These aspects include depression, dietary issue, adolescent mental health, substance abuse disorder, psychotic disorder, anxiety and general mental health conditions which made multiple appearance as the focus of reviews on digital health. Cognitive behavioural therapy, mental health examination, timely risk assessment, regular consultations and many other managements of psychiatric

| Approach to Improve Health Intervention | Number of Reviews | Percentage |
|----------------------------------------|-------------------|------------|
| Improving Health Behaviour             | 43 (79.6%)        |
| Enhancing Clinical Assessment          | 43 (79.6%)        |
| Medication Compliance or treatment engagement | 23 (42.6%)     |
| Better Care Coordination               | 21 (38.9%)        |
| Electronic-Record-based                | 13 (24.1%)        |
| Wearable device                        | 8 (14.8%)         |
| A.I.                                   | 7 (13.0%)         |
| AR/VR                                 | 7 (13.0%)         |
| Telephone Consult                      | 6 (11.3%)         |
| Game Consoles                          | 4 (5.6%)          |
| IoT                                    | 1 (1.9%)          |
| Endoscope-equipped smartphone          | 1 (1.9%)          |
| Electronic Medication Container        | 1 (1.9%)          |
| Videocassette                          | 1 (1.9%)          |

*Figure 5.* Bar chart illustrating the frequency of reviews by reported approaches to improve the effectiveness of health intervention ($n = 54$).

*Figure 6.* Bar chart providing the information of 15 distinct digital health interventions and the number of reviews reporting their use to improve quality healthcare ($n = 54$).
Table 4. Predominant disciplines being addressed by the digital health reviews and their topics (n = 54).

| No. | Main discipline       | Number of reviews | Topic of review                                                                 |
|-----|-----------------------|-------------------|--------------------------------------------------------------------------------|
| 1   | Multidisciplinary      | 32                | Healthy aging, Chronic pain, Intimate partner violence, Obesity (2 reviews), Remote symptom monitoring, Melanoma, Online self-diagnosing, Care for patients with cancer, Fragility fracture recovery, Health behaviour and support for patients undergoing elective surgery, Hypertension, Remote care during COVID-19, Supportive care for prostate cancer survivor, STI and HIV, Diet, physical activity and weigh gain in pregnancy, Transition of care among adolescent with chronic illness, Musculoskeletal conditions, Infectious disease control, Clinic Attendance, Noncommunicable disease, Preconception care women with diabetes, Childhood obesity, Children with chronic condition, Adverse drug reaction reporting, Tuberculosis (2 reviews), Low back pain, Anticoagulation therapy, Patient-centred care service delivery, Cardiovascular diseases (2 reviews) |
| 2   | Psychiatry            | 11                | Depression, anxiety, and psychological well-being, Psychosis, Adolescent health - Diet and healthy behaviour, Youth with chronic illness, Mental health for children and young people, Mental health and quality of life among cancer patients, PTSD, Physical Activity, Diet, Drug and alcohol use and mental health, Mental health - General (2 reviews), Health behaviour |
| 3   | Rehabilitation care   | 2                 | Rehabilitation in underserved areas, Rehabilitation after total knee or hip replacement, Clinic Attendance |
| 4   | Oncology              | 1                 | Supportive care in oncology, Clinic Attendance |
| 5   | Nephrology            | 1                 | Renal transplantation care, Clinic Attendance |
| 6   | Public Health         | 1                 | COVID-19 public health responses, Clinic Attendance |
| 7   | Neurology             | 1                 | Stroke, Clinic Attendance |
| 8   | Neurosurgery          | 1                 | Effective communication in neurosurgical care, Clinic Attendance |
| 9   | Paediatric            | 1                 | Paediatric weight management, Clinic Attendance |
| 10  | Rheumatology          | 1                 | Rheumatoid arthritis, Clinic Attendance |
| 11  | Infectious disease    | 1                 | Neglected tropical diseases, Clinic Attendance |
| 12  | Gastroenterology      | 1                 | Inflammatory bowel disease, Clinic Attendance |

patient can directly be enhanced via digital health. Hence, it is likely this association has driven strong advocacy to review digital health to improve clinical outcomes among patients in psychiatric care. This connection also suggests a strong association between research on digital technology, health behaviour and the nature of field of practice.
**Table 5.** Summary of considerations for policy and practice.

|   | Consideration                                                                                     |
|---|-----------------------------------------------------------------------------------------------|
| 1 | Smartphone-based intervention is the commonest digital health for quality healthcare.            |
| 2 | Digital health is mainly researched to attain more effective health intervention through improved health behaviour, better medication compliance or treatment engagement, more comprehensive clinical assessment, and enhanced coordination of care. |
| 3 | More empirical and review of evidence is necessary to better-inform the use of digital health for cost-efficient and equitable healthcare. |
| 4 | Most review of evidence on the use of digital health focus on topics related to psychiatric care. |
| 5 | Technology-enhanced quality healthcare may be benefited from research on the association between fields of health practices and the tendency to adopt or research digital health to improve care. |
| 6 | Complex policy decision-making for technology-enhanced quality healthcare may be benefited from the wide-ranging perspectives of evidence via methodologically robust and transparent mapping of digital health interventions at various time, contexts, fields of practice, categories of technology and types of evidence for all six domains of quality healthcare. |

**Suggestion for future direction of reviews on digital health studies**

There are notable gaps of evidence on the use of digital health for equitable healthcare, which is the least domain of quality being reviewed (Figure 4). Equitable healthcare addresses reliable services against varying sociodemographic factors such as ethnicity, religion, gender, income and geographic location. Hence, improving equitable care transgress beyond mere improving accessibility. These concerns were highlighted by Bergin et al. whose review reported studies among children on mental health commonly did not include ethnicity and socio-economic status when investigating issue of access to care. Furthermore, improving access and equitable care may be achieved without any change to the routine treatment protocol. Unlike introducing a new strategy, there is less burden of proof to substantiate the effectiveness and safety profile of existing treatments. In contrast, digital health may eliminate or minimize various factors which have disadvantaged certain subgroup of population from otherwise receive a quality healthcare. This is in addition to the surge of technology-users over the last few decades. Therefore, expanding the aggregative and configurative review evidence of digital health for equitable and accessible healthcare, from this aspect, would prove meaningful and impactful due to the scale of target population.

**Limitations**

There are several limitations of this study. Firstly, the notion of quality is hugely debated, and it is possible that some aspects of quality is not adequately represented in this study. For example, Bate et al. proposed that quality improvement needs to be viewed from social movement approach which comprise both programmatic ‘top-down’ and internally driven ‘bottom-up’ approaches. Grol, in contrast, emphasized the change of culture as a precursor to initiate the culture of change. Tenets of these change of culture include the promotion of reflective practitioners, the power of peers, and patients as partners instead of mere client. Loffler meanwhile insightfully articulated the notion of quality that are essentially evolutionary, rather than static and fragmented in domains. The arguments rewind back to the history of quality from the public sector that transitioned from quality being understood as meeting the expected norms and routines, into effective in meeting the purpose, and finally in fulfilling and exceeding clients’ satisfaction. Understanding the notion of quality from these lenses of perspectives may illuminate unique insight on the roles and evidence of digital health to improve quality care. Nonetheless, expanding the philosophical context of quality and evidence of reviews on digital health require more resources that is beyond the scope of this study.

Secondly, categories of interest are inherently overlap. For example, telemedicine has been referred as remote communication either via voice, or video or both. Yet, these features have also been reported as mobile apps in other reviews. To be transparent, whenever there is an overlap between descriptions of digital health intervention, this mapping study consistently catalogue based on how the intervention was described by the review. Therefore, the systematic mapping remains robust and transparent despite possible slight variations due to inherent overlapping spectrum of types of digital health and practices.

**Conclusion**

This study has systematically searched, selected and catalogued review studies on digital health and quality care. Table 5 summarizes key considerations from this study for policy and practice. Majority of reviews describe improved health behaviour, enhanced assessment, treatment compliance and better coordination as the main approach of quality improvement via digital health. Topics related to psychiatry and smartphone-based intervention are the most featured field of practice and the type of digital health respectively. Future studies may investigate the association between field of practice and tendency to adopt and research the use of digital health to improve care. Further reviews may also aggregate evidence
on how digital health exerts broader impact on quality care especially in the domain of cost effectiveness and equitable healthcare.

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