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Quality measures of virtual care in ambulatory healthcare environments: A scoping review

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3 1 Quality measures of virtual care in ambulatory healthcare environments: A scoping
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Keywords: Quality Improvement; Quality Indicators, Health Care; Delivery of Health
Care; Virtual Medicine

ABSTRACT

Objectives: Delivery of virtual care - i.e., any interaction between patients and/or members of their circle of care occurring remotely using any form of communication or information technologies - increased throughout the COVID-19 pandemic and persisted after physical distancing measures were dropped. However, little is known about how best to measure the quality of virtual care, as extant measures focus on in-person care and may be not applicable for a virtual context. This scoping review aims to understand the connections between virtual care modalities and quality measures within the Quintuple Aim: provider experience, patient experience, per capita cost, population health, and health equity.

Design: Five databases and multiple grey literature sources were searched for publications that analysed virtual care in ambulatory settings. Indicators were extracted, double coded into the Quintuple Aim framework, and categorized based on the National Academy of Medicine quality framework (safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity). Sustainability was added to capture potential for continued use of virtual care.

Results: A total of 13,504 citations were double screened resulting in 631 full-text articles, of which 66 articles were included. Articles were mostly observational designs (n=30) and published in North America (n=29) or Europe (n=21). Common virtual care modalities included video or audio visits (n=43), remote monitoring (n=11), and mobile applications (n=11). The most reported type of quality indicator related to patient experience (n=58 articles), followed by provider experience (n=25), population health outcomes (n=23), and health system costs (n=19).

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3 55 **Conclusions:** The connection between virtual care modalities and quality domains
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5 56 identified through this review can inform clinicians, healthcare managers, and other
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7 57 decision makers, on how to monitor quality of virtual care, and inform quality
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9 58 improvement efforts. Next steps include the development of a prioritized subset of
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11 59 indicators within a balanced scorecard of virtual care quality indicators for ambulatory
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13 60 settings.
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16 17 61 **Strengths and limitations of this study**

- 18
19 62 • Literature search developed by an academic librarian and included sources from a
20
21 63 wide variety of medical and health policy databases, grey literature, and targeted
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23 64 web and journal searches
- 24
25 65 • Used established scoping review methods for literature search, study selection, data
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27 66 collection, coding, and reporting
- 28
29 67 • Applied established quality frameworks like the Quintuple Aim and the National
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31 68 Academy of Medicine quality domains to map existing quality indicators in virtual
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33 69 care
- 34
35 70 • Literature search was limited to articles published after 2015 and available in English
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37 71 language only
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39 72 • Categorization of indicators was complicated by the lack of reported detail that
40
41 73 required assumptions to be made in certain cases
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75 INTRODUCTION

76 Virtual care, defined as any interaction between patients and/or caregivers and their
77 healthcare providers (or “circle of care”) that occurs remotely and is facilitated through
78 digital communication or other information technologies (1), was largely underutilized for
79 delivering healthcare services in Canada prior to the COVID-19 pandemic (2). The
80 COVID-19 pandemic changed the global healthcare landscape and accelerated the
81 implementation of and access to virtual care for patients (2). The demands for virtual
82 care continue post-pandemic, with many patients appreciating the convenience and
83 want the option to receive care virtually(3,4). Healthcare providers also see the value of
84 virtual care in situations due to its’ potential to improve patient access to care, (i.e., for
85 those with mobility issues or living in rural/remote areas), convenience, and for
86 maintaining connections with patients in between in-person visits (5). The future of
87 healthcare delivery will require the integration of both virtual and in-person modalities
88 across the continuum of care (6), but we need to be able to better measure quality of
89 virtual care. Virtual care was introduced to reduce the risk of infectious disease
90 transmission during the COVID-19 pandemic, but its continued use should depend on
91 its impact on the quality of care and the experiences of patients, caregivers, and
92 healthcare providers.

93 Quality indicators are standardized, evidence-based measures that can be used to track
94 and compare health outcomes and performance over time and across different
95 organizations (7,8). Measurement of these indicators can identify gaps in care delivery
96 and inform quality improvement (QI) efforts within an organization, across health
97 systems, and across geographical boundaries. However, traditional indicators to assess

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3 98 quality in healthcare primarily focus on in-person care and may have limited applicability
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5 99 to care delivered virtually. While some literature on virtual care indicators have been
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8 100 published, most studies focus solely within a specific clinical area (e.g., obstetrics,
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10 101 cardiology, etc.) or few domains of interest (e.g., acceptability, satisfaction etc.), limiting
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12 102 the scope and applicability for healthcare organizations to evaluate what constitutes
13
14 103 “quality” in virtual care (9–11). Since virtual care can now be considered an integral
15
16 104 option for health care delivery, it is important to understand the breadth of domains of
17
18 105 quality related to virtual care in order to characterize and identifying individual quality
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20 106 indicators(12).

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24 107 As virtual care becomes an integrated part of a patient’s care journey via hybrid
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26 108 healthcare models, this review can help clinicians and decision makers understand how
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28 109 to measure quality of a virtual care in an appropriate and comprehensive fashion across
29
30 110 all relevant domains of quality. The aim of this scoping review is to determine the
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32 111 connections between virtual care modalities and quality domains within the Quintuple
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34 112 Aim framework in ambulatory/outpatient settings. This review contributes to this aim in
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36 113 three distinct ways. First, it is the first review to the author’s knowledge which
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38 114 systemically categorizes quality indicators of virtual care according to two separate
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40 115 existing quality frameworks: the Quintuple aim and the National Academy of Medicine’s
41
42 116 (NAM) quality framework. Second, this review was agnostic with regards to virtual care
43
44 117 modalities. Understanding that care is care, as outlined by the government of Canada in
45
46 118 a 2021 report, implies that all modalities of virtual care should be understood from a
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48 119 quality perspective, not just video-conferencing, for example(12). Lastly, the
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50 120 methodology used for this review was broad in scope, seeking to collate a
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3 121 comprehensive list of quality indicators reported in the literature. This work will provide
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5 122 the foundation for identification and categorization of quality indicators that can inform
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7 123 clinicians, healthcare managers, and other decision makers how best to monitor quality
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10 124 of virtual care, identify performance gaps, and target areas for future improvement
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12 125 efforts.

14 126 **METHODS**

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17 127 Our scoping review methodology was guided by the Joanna Briggs Institute (JBI)
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19 128 Manual for Evidence Synthesis (13) and by the World Health Organization's (WHO)
20
21 129 guide on rapid reviews (14). Reporting of methods and results was developed in
22
23 130 accordance with the PRISMA extension statement for scoping reviews (Supplemental
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25 131 Material 1) (15).

28 132 **Information sources and literature search**

30
31 133 A comprehensive literature search was developed in consultation with an academic
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33 134 librarian that included published academic and grey literature sources, as well as hand
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35 135 searches of relevant journals. Initial literature searches were conducted in June 2021
36
37 136 and were updated in August 2022. Databases searched included MEDLINE, EMBASE,
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39 137 PsycINFO, The Cochrane Library, and the JBI Evidence-based practice database
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41 138 (Supplemental Material 2 – Table 1). Keyword searches were also carried out in
42
43 139 selected websites, Google Scholar, Medrxiv, and Open Grey to identify grey literature
44
45 140 including policy documents, organizational strategies, and unpublished academic
46
47 141 literature (Supplemental Material 2 – Table 2). Specialty journals focused on
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49 142 virtual/digital care – Journal of Medical Internet Research, Lancet Digital Health, and
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51 143 Nature Digital Medicine – were hand searched from 2015 onwards.
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144 **Eligibility criteria**

145 The eligibility criteria were structured based on the “Population, Context, Concept”
146 (PCC) research framework(13) as follows:

- 147 • *Population*: adults receiving ambulatory/outpatient care through healthcare
148 organizations for chronic or acute/subacute conditions.
- 149 • *Context*: participation in virtual care, defined as “any interaction between patients
150 and/or members of their circle of care, occurring remotely, using any forms of
151 communication or information technologies”(1)
- 152 • *Concept*: within the Quintuple Aim framework (provider experience, patient
153 experience, per capita cost, population health, and health equity)(16), indicators are
154 based in the NAM’s quality framework (safety, effectiveness, patient-centeredness,
155 timeliness, efficiency and equity) and sustainability(17).

156 Studies that focused on only one domain in a specific population were excluded.

157 Disease specific publications were only included if they focused on two or more quality
158 domains. Due to changes in technology and the rapid increase in virtual care, we only
159 include studies published only in English from 2015-2022 to accommodate the rapid
160 timeline for the review and acknowledge the changes in virtual care over the past few
161 years.

162 **Study selection process**

163 The literature search results were uploaded into Covidence review manager and de-
164 duplicated prior to screening. Screening questions based on the eligibility criteria
165 (Supplemental Material 2 – Figure 1) were developed for both title/abstract and full-text
166 screening and pilot tested with rounds of randomly selected citations until satisfactory

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3 167 agreement (>75%) was reached between reviewers. Double screening of title/abstracts
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5 168 was conducted (by CL, PR, VK, and AS), followed by full text screening by a single
6
7 169 reviewer for a streamlined approach. After full text screening, all excluded citations or
8
9
10 170 articles were re-reviewed by an independent second reviewer (PR) to ensure accuracy.
11
12 171 A similar process was followed for the 2022 update with SP, PR and AS, as reviewers.
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14 172 **Data collection and management**

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17 173 Initially, to enable rapid review, data extraction was to be completed by a single
18
19 174 reviewer. However, with large heterogeneity across the types of papers, and the lack of
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21 175 standardization in reporting of quality indicators and domains, the team opted for a more
22
23 176 rigorous approach with two reviewers (two of CL, PR, VK, SP, and AS) independently
24
25 177 extracting each article. Any discrepancies in extracted data were reviewed and resolved
26
27 178 by an independent third reviewer. A standardized data extraction form was developed to
28
29 179 summarize and record the reviewed studies within Covidence review manager. Data
30
31 180 items included publication characteristics (year of publication, country, study design,
32
33 181 funding source, and sample size), intervention details (care setting, virtual care
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35 182 modality, primary condition/health concern), and details on reported quality indicators
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37 183 (definition, measurement/scoring tools, etc.).
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42 184 **Data Synthesis**

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44 185 Individual indicators were used to demonstrate the connections between virtual care
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46 186 modalities and the Quintuple Aim (16); patient experience and provider experience were
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48 187 further sub-coded into the NAM quality domains (17) along with sustainability, which
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50 188 was visualized through an alluvial (also known as Sankey) diagram. Although these
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52 189 individual indicators will be further refined through a future Delphi consensus process to
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3 190 narrow a subset of indicators across quality domains, the proportions provide valuable
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5 191 information regarding the types of quality domains and their corresponding modalities.
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8 192 **Risk of bias**

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10 193 As this was a scoping review intended to capture a collection of quality indicator items,
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12 194 rather than evaluate their effectiveness or appropriateness, risk of bias was not
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14 195 assessed based on current published guidelines (13).
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17 196 **Patient and Public Involvement Statement**

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19 197 Patients were involved in the conception and development of the scoping review as well
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21 198 as the presentation and dissemination of results through the Patient Experience
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23 199 Advisors program and the Community Liaison Advisory Council (CLAC) at Women's
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25 200 College Hospital. We intend to solicit further patient participation as well as general
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27 201 public involvement in future work developing a balanced scorecard based on the
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29 202 literature identified in this review.
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33 203 **RESULTS**

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35 204 The literature search resulted in a total of 18,395 citations that were imported into
36
37 205 Covidence. A total of 4,891 duplicate citations were removed leaving 13,504 citations
38
39 206 for title and abstract screening. After title and abstract screening a total of 814 full-text
40
41 207 articles were identified for retrieval but 183 reports, mostly conference abstracts and
42
43 208 commentaries, were not retrieved for full-text screening. After assessing the reports for
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45 209 eligibility, 66 articles were included for data extraction (Fig 1).
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51 211 **Figure 1: PRISMA study flow diagram**

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213 **Characteristics of Included Studies**

214 The included studies comprised 47 primary research studies (e.g., observational
 215 studies) and 21 secondary research articles (e.g., systematic reviews). Table 1
 216 summarizes the main characteristics of the included articles. The most frequent study
 217 design were observational studies (n=32), followed by systematic reviews (n=11),
 218 qualitative studies (n=5), and interventional trials (n=5). The majority of included studies
 219 were published between 2018 and 2020 (n=25) in North America (n=29) or Europe
 220 (n=22). Funding sources were mainly from public institutions (n=30), but a large
 221 proportion of studies also reported no external funding for their study (n=24).

222 **Table 1: Characteristics of included studies (n=66)**

	Primary Studies (n=45) [n (%)]	Secondary Studies (n=21) [n (%)]
Year of Publication		
2015-2017	13 (29)	7 (33)
2018-2020	18 (40)	7 (33)
2021-2022	14 (31)	7 (33)
Country of Publication		
Asia	1 (2)	3 (14)
Australia/South Pacific	4 (9)	2 (10)
Europe	14 (31)	7 (33)
North Africa and Middle East	4 (9)	1 (5)
North America	21 (47)	8 (38)
South America	1 (2)	--
Study Design		
Case report/series	1 (2)	--
Observational (cross-sectional, cohort)	30 (67)	--
Qualitative study	5 (11)	--
Mixed methods	3 (7)	--
Interventional (pre/post, controlled trial)	5 (11)	--

Cost/Cost-Effectiveness	1 (2)	--
Systematic Review	--	11 (53)
Scoping/Umbrella Review	--	4 (19)
Integrative Review	--	3 (14)
Environmental Scan	--	3 (14)
Funding Source		
Private	1 (2)	2 (10)
Public	22 (49)	8 (38)
Mixed	2 (5)	--
None	14 (31)	9 (42)
Not Reported	6 (13)	2 (10)
Number of participants		
Patients/Caregivers [median (IQR)]	115 (42-265)	--
Healthcare Providers [median (IQR)]	18 (13, 22)	--
Participant Age		
Patients/Caregivers [median (IQR)]	55.5 (47, 63)	--
Healthcare Providers [range]	22-76	--
Participant Gender (%)		
Patients/Caregivers [median]	Female: 53.7 Male: 50	--
Healthcare Providers [median]	Female: 61.3 Male: 38.7	--
Review Methods		
Number of included publications [median (IQR)]	--	17 (12, 22)
Reported inclusion/exclusion criteria	--	16 (76)
Limited search by language	--	10 (48)
Limited search by date	--	5 (24)
Age/publication date of included studies		
0-5 years prior	--	3 (14)
6-10 years prior	--	4 (19)
11+ years prior	--	9 (43)
Not reported	--	5 (24)

223

224 Interventions examined in the included studies covered a range of virtual care
 225 modalities (Table 2) including video and audio visits with clinicians (n=44), remote
 226 monitoring programs (n=13), mobile applications (n=12), self-monitoring and wearable
 227 devices (n=9), synchronous or asynchronous messaging with healthcare providers
 228 (n=13), or patient portals (n=10). Care settings (Table 2) ranged from ambulatory and
 229 outpatient clinics (n=41) to primary care (n=13), and home and community care settings
 230 (n=8). Patient populations (Table 2) included individuals with chronic noncommunicable
 231 conditions (n=19), cancer (n=7), and mental health conditions (n=5).

232 **Table 2: Summary of intervention and setting characteristics (n=66)**

	Value [n (%)]
Primary Condition/Health Concern	
Cancer	7 (11)
Cardiac conditions	3 (5)
Chronic pain/Musculoskeletal	3 (5)
Dermatologic conditions	4 (6)
Diabetes	5 (8)
Kidney disease	3 (5)
Mental Health	5 (8)
Palliative	3 (5)
Specialist Clinic*	8 (12)
Surgery - unspecified	3 (5)
Multiple conditions	11 (17)
Not applicable/unspecified	11 (17)
Setting/Context of care delivery	
Ambulatory care/outpatient clinic	40 (60)
Primary care	13 (20)
Home and Community care	7 (11)
Not applicable/not specified	6 (9)
Type of Virtual Care Modality**	
Virtual visit/telemedicine – video	43 (65)
Virtual visit/telemedicine – audio only	37 (56)
Remote monitoring	11 (17)
Mobile application	11 (17)
Self-monitoring/Wearables	8 (12)
Synchronous messaging	4 (6)

Asynchronous messaging	9 (14)
Patient Portals	10 (15)
Other/Not specified	7 (11)
Number of Interventions	
1 or 2	46 (70)
3 or 4	17 (25)
5 to 7	3 (5)
*medical specialties include ENT, Gastroenterology, Neurology, Gynecology, and Urology	
**percentage totals exceed 100 as studies included multiple modalities	

233

234 Connections between virtual care modalities (video visits etc.) within the Quintuple Aim

235 framework and NAM quality domains (effectiveness, patient centeredness etc.) are

236 visualized in Figure 2. Within the Quintuple Aim, the most reported category related to

237 patient experience (n=200 indicators), followed by provider experience (n=52),

238 population health outcomes (n=47), health system costs (n=22), and equity (n=7).

239 Virtual visits by phone and/or video (n=96) were the most common modality of virtual

240 care reported, and was strongly connected to patient experience, provider experience,

241 and population health outcomes (Fig 2). Virtual visits (video only) (n=60) and remote

242 monitoring (n=56) were the next most common, also connecting strongly to patient

243 experience, provider experience, and population health outcomes.

244 Within the NAM quality domains, the most common sub-coded domains included patient

245 centeredness (n=66), effectiveness (n=64), sustainability (n=36), and efficiency of care

246 (n=36) (Fig 2). Details regarding the frequency of indicators for NAM domains and

247 patient experience and provider experience are provided in Supplemental Material 2 –

248 Table 3, with examples of indicators and their stem groupings in Table 3.

249

Figure 2: Alluvial diagram connecting virtual care modalities to the Quintuple Aim and quality domains. Through the middle are the Quintuple Aim domains, with curved bars representing connection to the virtual care modality (left) and NAM quality domains (right). For example, the 59 mentions of remote monitoring (left) were mostly connected with patient experience, followed by population health outcomes, then provider experience. The thick vertical bars show the frequency compared to the other domains: virtual visits were the most common modality; patient experience was the most common Quintuple Aim domain; and effectiveness was the most common NAM quality domain.

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Table 3: Examples of indicator-stem groupings and indicators within the Quintuple Aim, specific to virtual care.

Examples of Indicator-Stem Grouping (NAM Quality Domain)	Examples of Individual Indicators	Examples of Indicator Measurement
Quintuple Aim domain: Patient Experience		
Patient satisfaction (<i>Patient centeredness</i>) Usability (<i>Efficient</i>)	Patient satisfaction of virtual care compared to in-person consultations	5-point Likert scale – proportion of positive responses: "The clinical care I received during a virtual visit was the same as a face-to-face visit" Telemedicine usability questionnaire: 18 items, 7-point Likert scale; higher mean score indicates higher satisfaction (usefulness, ease, interface quality, interaction quality, satisfaction and future use, reliability)
Effectiveness	Patient-perceived value of the virtual consultation.	Net promoter score – "recommend virtual visit to a friend" Virtual visits are more convenient than an office visit
Access to care (<i>Equitable</i>)	Ease of navigating access to a video appointment.	Proportion of patients requiring help with equipment Proportion of patients experiencing difficulty logging on to platform

	Support to patients to overcome technical issues.	
Quintuple Aim domain: Provider Experience		
Provider satisfaction and preference	Provider satisfaction compared to in-person consultations.	5-item questionnaire using 0-100 Visual Analog Scales – overall score calculated by averaging responses
Infrastructure/organizational capacity (<i>Sustainable</i>)	Perceptions of effectiveness.	Telehealth Usability Questionnaire
	Provider and clinic efficiency.	Reduction in ‘no-shows’ and cancelled appointments Decrease in wait times for patients
Provider-patient workload/workflow (Timely, efficiency)		
Physician perspective of effectiveness (<i>Effective</i>)	Ability to evaluate/examine patient.	Likert scales – proportion of physicians that agree: I was confident with my ability to diagnose/make recommendations. I was able to effectively inform my patient.
Quintuple Aim domain: Population Health & Outcomes		
Follow-up Care	30- or 90-day outpatient follow-up.	Number or proportion of patients seen in follow-up after virtual visit
	Emergency Department use after virtual visit.	Number or proportion of patients seeking emergency care after virtual visit
Access to Care	Program usage.	Proportion of participants engaging with the platform/completing program
Clinical outcomes and measures	Clinical effectiveness of care.	Changes in clinical outcomes/disease markers
	Quality of life.	Changes in QoL as measured by validated scales: EQ-5D*, WHO-QL**
	Patient safety.	Incidence of adverse clinical events
Quintuple Aim domain: Cost		
Health system costs	Cost reduction.	Cost of standard visit compared to virtual visit
Patient Costs	Cost-effectiveness.	Cost of telemedicine implementation and maintenance

	Cost-avoidance.	Patient travel savings compared to in-office visits
Quintuple Aim domain: Equity		
Accessibility	Equal access to care.	Availability of appropriate connectivity/ technical services in rural areas
Financial impact	Time saved by the patient	Reduction in travel time
*EQ-5D: EuroQol-5 Dimensions – health-related quality of life scale		
**WHO-QL: World Health Organization-Quality of Life scale		

261

262 Specific Instruments Measuring Quality

263 Throughout data extraction, several existing tools were mentioned for measuring quality
 264 of care. For patient experience tools included Telemedicine/Telehealth usability
 265 questionnaires (n=18 studies); Telemedicine Satisfaction and Usefulness Questionnaire
 266 (n=3); and Service user technology acceptability questionnaire (n=1). For provider
 267 experience the Telemedicine/Telehealth Usability Questionnaire (n=2) was used, while
 268 others only mention 5- and 10-point Likert scales with unique or custom question
 269 prompts. No specific measurement tools were mentioned for population health
 270 outcomes, costs, or health equity.

271 DISCUSSION

272 We conducted a scoping review on quality measures for virtual care and found that
 273 within the Quintuple Aim, the most reported category assessing quality of virtual care
 274 was related to patient experience, followed by provider experience, and population
 275 health outcomes. There was limited mention of health system costs, patient costs, and
 276 equity. The most frequently mentioned virtual care modality was virtual visits in video
 277 and/or audio, followed by video visits only, remote monitoring programs, mobile

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3 278 applications, and self-monitoring tools. Within the National Academies of Medicine
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5 279 domains of quality for patient and provider experience, effectiveness was most
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8 280 common, followed by patient centeredness and efficiency, with limited mention of
9
10 281 sustainability.

12 282 **Limited Attention on Equity, Sustainability and Cost**

14 283 Most quality indicators concentrated in specific domains such as patient experience
15
16 284 and/or satisfaction, provider experience and/or satisfaction, while the more complex
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18
19 285 indicators, such as equity, cost, and sustainability, were not as widely reported. The
20
21 286 limited attention on equity is consistent with published literature, such as a scoping
22
23
24 287 review of reviews highlighting the gaps of focus to equity assessments in virtual care
25
26 288 deployments (18). The lack of consideration of equity is a missed opportunity, since
27
28 289 virtual care has the potential to improve access to care for some typically underserved
29
30
31 290 populations and worsen access for others (19). Equity is often difficult to measure and
32
33 291 integrate into program evaluations, as it is difficult to assess within a few questions or
34
35 292 survey deployments that are pragmatic to measure, and may have been outside the
36
37
38 293 scope of QI projects or time-sensitive deployments (such as during the COVID-19
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40 294 pandemic) (20).

42 295 Our review also found a lack of focus on sustainability of virtual care. Sustainability can
43
44 296 be considered from multiple perspectives, including if the patient plans to continue to
45
46
47 297 use the virtual options, and if the organization has the means (infrastructure, IT support
48
49 298 etc.) to continue to deliver virtual care, particularly beyond the COVID-19 pandemic.
50
51 299 Further indicators are needed to monitor the continued need for and use of virtual care
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53
54 300 to assess if it remains a preferred and feasible option especially with hybrid-models of
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3 301 care delivery which includes both virtual and in person options. Considering
4
5 302 sustainability is important for Learning Health Systems (LHS) approaches being
6
7 303 implemented across healthcare organizations and systems (21). Sustainability needs to
8
9 304 be a key part of this systems-based approach, and thus quality indicators of virtual care
10
11 305 that consider sustainability are needed, yet there are few examples in the literature.
12
13
14 306 The limited focus on the Quintuple Aim domain of cost was also not noted; cost may be
15
16 307 difficult to measure and quantify in rapid virtual care deployments. This finding is
17
18 308 consistent with a 2020 scoping review which analyzed the cost-effectiveness of
19
20 309 telehealth to the healthcare system(22). Cost should be considered within quality
21
22 310 indicators, including in connection with sustainability of the service.
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26 311 **Evidence Synthesis of Virtual Care**

27
28 312 There has been considerable synthesis in analyzing virtual care. About a third of
29
30 313 literature included in this scoping review were reviews themselves, however, these
31
32 314 reviews usually focused on a specific service or modality of virtual care such as patient
33
34 315 portals (23), telehealth/phone visits (24,25) and video consultations (26,27). Very few
35
36 316 reviews assessed approaches or models for evaluating virtual care, or tools which
37
38 317 specifically measured quality as identified by the quintuple aim and NAM. Reviews that
39
40 318 did explore evaluation or quality did so on a limited basis. To the authors' knowledge,
41
42 319 this is the first review which specifically evaluates quality in virtual care with a
43
44 320 comprehensive approach in defining quality indicators and assessing their deployment
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46 321 in the extant literature against established quality frameworks.
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51 322 A report by the Canadian Agency for Drugs and Technology in Health (CADTH) which
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53 323 studied evaluations of virtual care was consistent with our findings (28). The CADTH
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3 324 report stated that evaluations should focus on ensuring the scope of the virtual care
4
5 325 visits was appropriate for the care being administered, be conducted systematically, and
6
7 326 that cost-analysis or cost-benefit evaluations be conducted with a specific viewpoint in
8
9
10 327 mind – such as a patient or provider (28). The findings of this scoping review support
11
12 328 these assertions from a quality perspective. A quality virtual care program is clear in its
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14
15 329 scope, has dedicated resources for cyclical evaluations, and specifically investigates the
16
17 330 impact of the program from the patient perspective, provider perspective, or both.

19 331 **Leveraging Review Results: Next Steps**

21 332 This review provides the foundational knowledge base of existing quality indicators of
22
23 333 virtual care across domains of quality and organized within established Quality
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25
26 334 frameworks. This knowledge base will be further refined and distilled through a modified
27
28 335 Delphi approach, which will collate and rank the existing indicators into a subset, which
29
30 336 can then be disseminated as a balanced score card for evaluating the quality of virtual
31
32 337 care. An understanding of quality domains in virtual care and the subsequent quality
33
34 338 indicators are key to the development and growth of a potential Learning health system
35
36 339 (LHS), which enables cycles of continuous learning and improvement to be routinised
37
38 340 and embedded across the healthcare system (29). A LHS is the combination of a health
39
40 341 system and research system that, at all levels, is anchored on patient's needs,
41
42 342 perspectives, and aspirations; driven by timely data and evidence; supported by
43
44 343 appropriate decision supports, aligned governance, financial and care delivery
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46
47 344 arrangements; and enabled with a culture of, and competencies for, rapid learning and
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49 345 improvement (30). Further, it is a system in which science, informatics, incentives, and
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52 346 culture are aligned for continuous improvement and innovation, and thus our domains of
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3 347 quality for virtual care can be integrated into this approach. Ideally, best practices,
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5 348 including best practices in virtual care, are seamlessly embedded in the delivery
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7 349 process, patients and families are active participants in all elements, and new
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9
10 350 knowledge capture is an integral by-product of delivery experience (29). Ultimately, the
11
12 351 deployment of virtual care should follow a Learning Health System approach, with
13
14 352 consistent revision and adjustment of virtual care initiatives to reflect dynamic contexts.
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16
17 353 Mapping the current knowledge base provides organizations quick references for
18
19 354 improving and iterating their virtual care program. Working towards true integration of
20
21 355 virtual care into a Learning Health System is subject to further research and
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23 356 implementation. A modified-Delphi consensus process is currently underway to confirm
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26 357 indicators based on feasibility, relevance, and utility which will lead to the development
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28 358 of a balanced scorecard of virtual care indicators across quality domains.
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31 359 This work provides the foundation for identification and refinement of selection of quality
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33 360 indicators in virtual care and highlights current gaps in assessment of virtual care
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35 361 performance indicators. Existing literature identified in this review had a focus on the
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37 362 effectiveness and patient satisfaction and/or experience of virtual care but has not
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39 363 explored cost or equity to the same degree. Further development of evaluation methods
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41 364 specifically analyzing the equitable and cost-efficient deployment of virtual care are
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43 365 needed to integrate virtual care into an LHS.
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47 366 Best practice guidelines for virtual care are required to realize integration of virtual care
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49 367 across health systems (31,32). Ensuring that virtual care is deployed in a satisfactory
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51 368 fashion for patients and providers requires a prioritization of quality, something that this
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53 369 scoping review provides a foundation for. Measurement of quality of virtual care will
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3 370 support understanding performance gaps, and targets for future quality improvement
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5 371 efforts and benchmarking efforts across organizations.
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7 372 **Strengths and Limitations**

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10 373 This scoping review used a wide range of published and grey sources, covered a vast
11
12 374 breadth of literature, and applied rigorous methods for data extraction and coding. The
13
14 375 body of literature included in this review also represents the current state of publications
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16 376 on virtual care, as the search was updated as the project progressed. However, our
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18 377 search strategy was limited to English only, and relying on the past seven years meant
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20 378 that foundational work on the implementation of virtual care may have been excluded.
21
22 379 A key strength of this work was our categorization of existing indicators across
23
24 380 established quality frameworks (NAM and sustainability, Quintuple Aim) to identify
25
26 381 which quality domains of virtual care are present and lacking within the current
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28 382 literature. Other published reviews did not categorize indicators and/or report
29
30 383 specifically tools that measure quality. However, there is considerable overlap between
31
32 384 the NAM domains for categorization and heterogeneity in the way indicators were
33
34 385 explained in the published studies, typically with very little detail. Indicators were
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36 386 regularly found to fit within more than one domain, and the lack of detail provided about
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38 387 each indicator means that some assumptions were made, leading to subjectivity with
39
40 388 current results but we dual-coded all indicators and resolved discrepancy with a third
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42 389 reviewer. The lack of reporting on how indicators were selected when measuring quality
43
44 390 of care, and the lack of reported knowledge user (patient, provider, management etc.)
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46 391 involvement, further highlighted the need for a consensus-based approach to finalize a
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48 392 concise list of virtual care quality indicators across all quality domains.
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3 393 **CONCLUSION**
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5 394 Patients and providers have expressed satisfaction and acceptability with virtual care
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7 395 and would prefer the option of hybrid approach of in-person and virtual care (3,4,33). To
8
9 396 ensure high quality virtual care, it is imperative to understand what we mean by “quality”
10
11 397 in virtual care. Before identifying a set of virtual care quality indicators, this review
12
13 398 highlights gaps in virtual care assessments across modalities. We noted that patient
14
15 399 experience is the most reported aspect of the Quintuple Aim, with effectiveness, patient
16
17 400 centeredness, and efficiency being the most common quality domains. The lack of
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19 401 indicators related to equity and sustainability highlight the need for development of new
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21 402 indicators, and a consensus-based process with knowledge users to create a prioritized
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23 403 list. This paper provides healthcare teams and organizations a collated list of virtual
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25 404 care quality indicators to reference in local implementations and evaluations. Further
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27 405 stratification of the quality indicators through a modified Delphi approach will provide
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29 406 decision-makers with a validated scorecard for the implementation of quality virtual care
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31 407 initiatives moving forward.
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3 408 **Author Contributions**
4

5 409 Conceptualization: Geetha Mukerji
6

7 410 Formal Analysis: Sam Petrie, Celia Laur, Patricia Rios
8

9 411 Funding Acquisition: Geetha Mukerji
10

11 412 Investigation: Sam Petrie, Celia Laur, Toni Makanjoula, Patricia Rios, Geetha Mukerji,
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13 413 Ally Suarez
14

15 414 Writing – Original Draft Preparation: Sam Petrie, Celia Laur
16

17 415 Writing – Reviewing & Editing: Celia Laur, Patricia Rios, Ally Suarez, Toni Makanjoula,
18

19 416 Geetha Mukerji, Onil Bhattacharyya, Emeraldalda Burke
20

21 417
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31

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34

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38

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45 427 **CONFLICT OF INTEREST**
46

47 428 The authors have no conflict of interest to declare.
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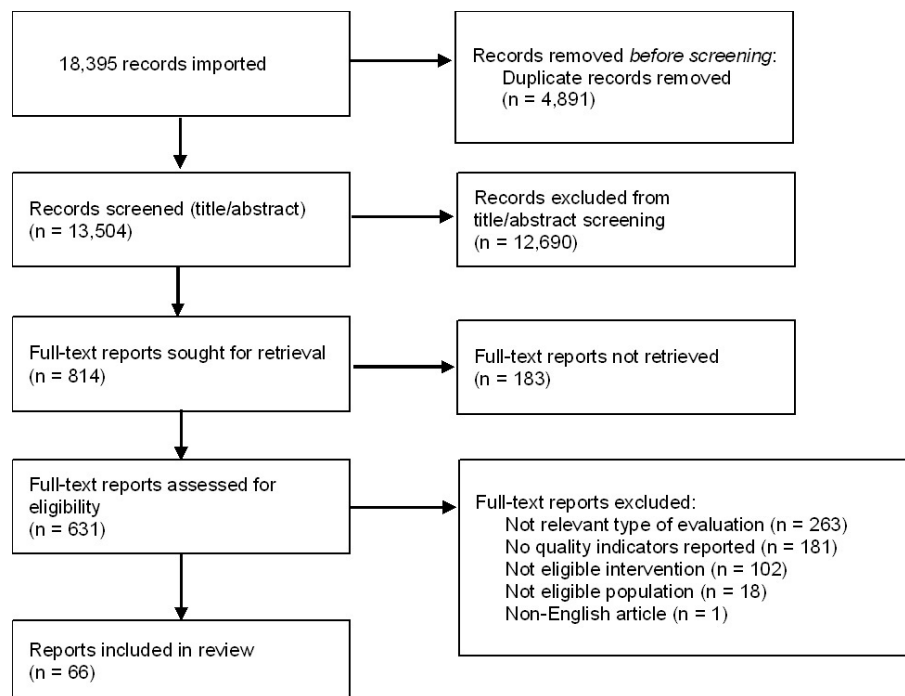


Figure 1: PRISMA study flow diagram

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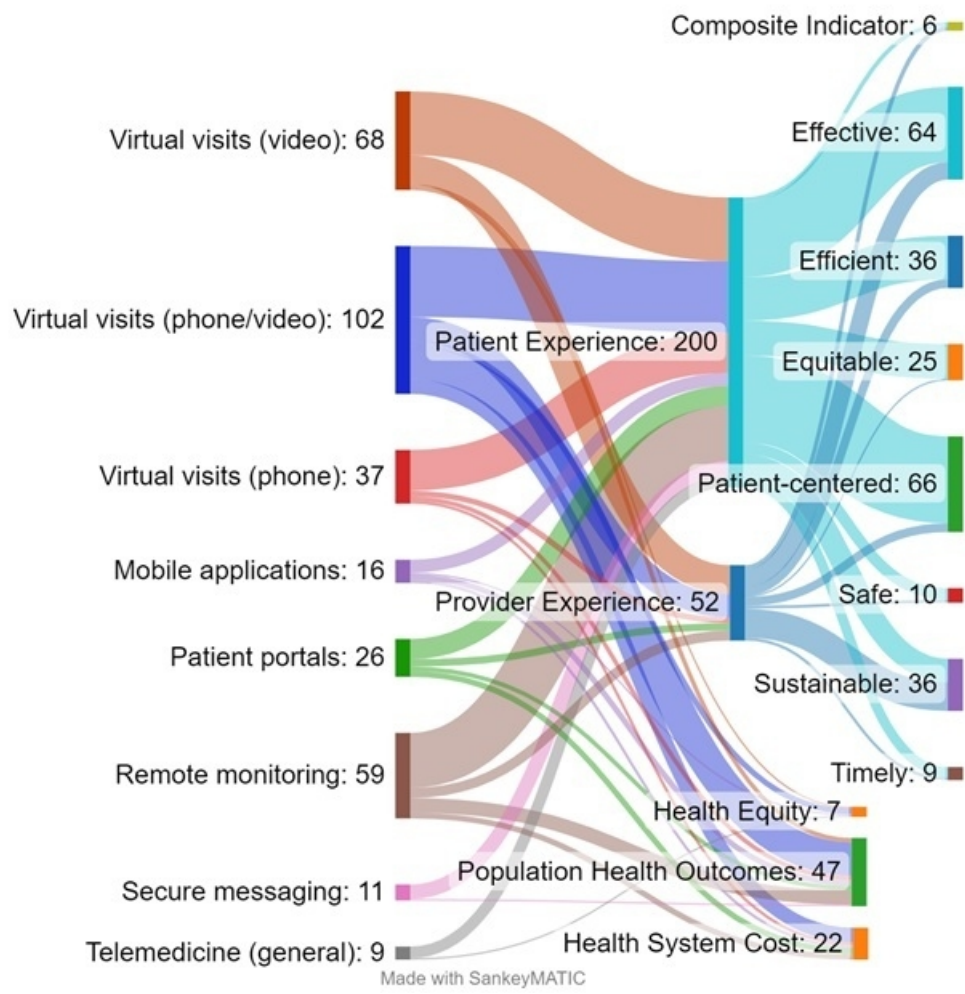


Figure 2: Alluvial diagram connecting virtual care modalities to the Quintuple Aim and quality domains.

52x52mm (300 x 300 DPI)

S1 Table - Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5-6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	N/A
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary Material 2
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7-8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8-9
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	9-10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10-12
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	13-18
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	13-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-22
Limitations	20	Discuss the limitations of the scoping review process.	23
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	24
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467-473. doi: [10.7326/M18-0850](https://doi.org/10.7326/M18-0850).

Figure 1 – Screening Criteria

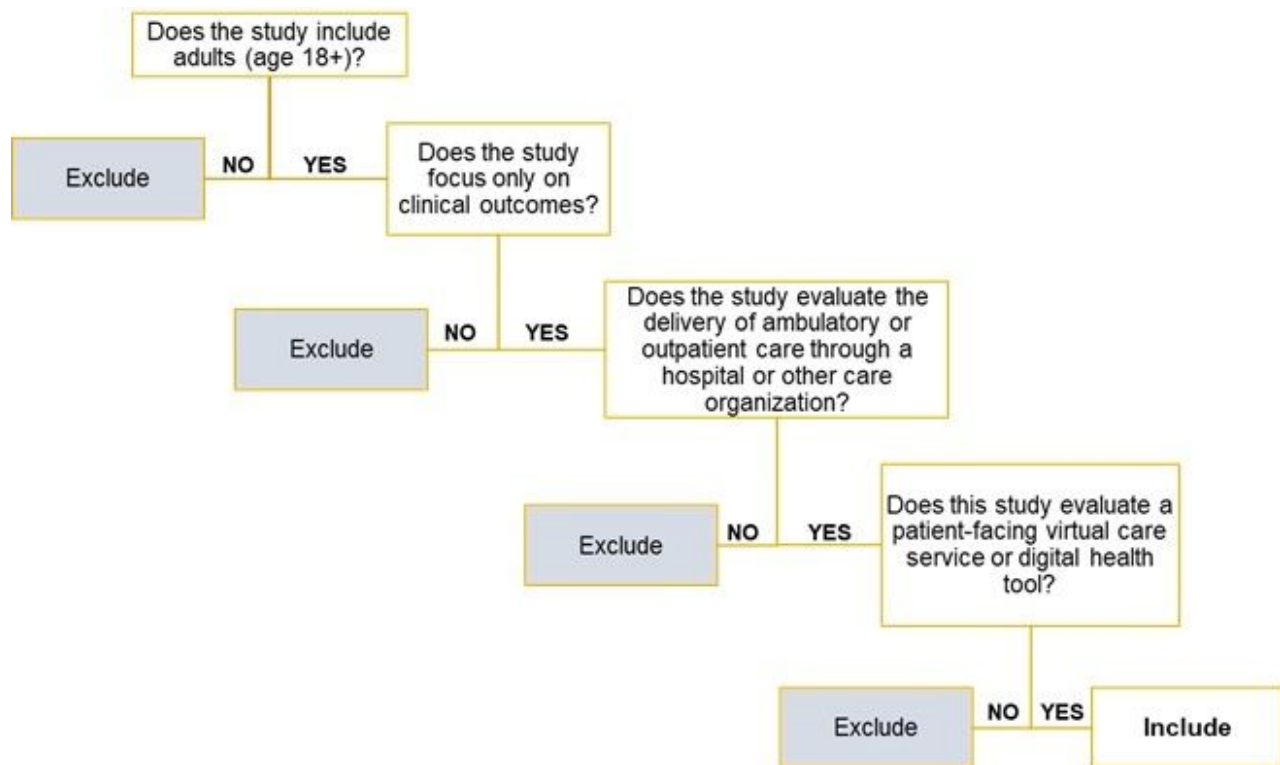


Table 1 – Medline Search strategy

Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE® 1946-Present

#	Query
1	exp telemedicine/
2	exp internet-based intervention/
3	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,kf.
4	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,kf.
5	(((((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)) and patient*).tw,kf.

6	((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,kf.
7	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kw,kf. or (virtual care or virtual health).tw,kf. or (rapid* adj3 virtual*).tw,kf.
8	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,kf.
9	(digital health or digital first).tw,kf.
10	("e health*" or ehealth* or evisit* or "e-visit*").tw,kf.
11	(online adj3 (healthcare or health care)).tw,kf.
12	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kf.
13	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or "tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or "tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,kf.
14	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
15	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or ediagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhEALTH or "M-HEALTH").tw,kf.
16	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or

	counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
17	(virtual* adj3 monitor*).tw,kf.
18	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,kf.
19	mobile health monitor*.tw,kf.
20	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19
21	"Outcome and Process Assessment, Health Care"/
22	Quality Assurance, Health Care/
23	Benchmarking/
24	Total Quality Management/
25	Quality Improvement/
26	Quality Indicators, Health Care/
27	"Utilization Review"/
28	Patient Outcome Assessment/
29	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,kf.
30	(quality adj3 (indicat* or metric* or standard* or measure*)).tw,kf.
31	21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
32	20 and 32
33	limit 33 to (english language and yr="2015 -Current")

Table 2 - Grey Literature Sources

Targeted Website Searches	
Organization name & website URL	Search strategy(s)/ terms searched
McMaster Health Forum www.healthsystemevidence.org	1. (virtual care OR digital health) AND quality 2. Telemedicine AND quality indicators
Publications Canada https://publications.gc.ca	1. Virtual care 2. Telemedicine

	3. eHealth
Health Quality Ontario http://www.hqontario.ca/Evidence-to-Improve-Care/Health-Technology-Assessment	1. Virtual care 2. Telemedicine 3. Telehealth
NICE www.nice.org.uk	1. Virtual care 2. Telemedicine 3. Telehealth 4. Digital care
AHRQ - EPC http://www.ahrq.gov/research/findings/evidence-based-reports/search.html	1. Virtual care 2. Telemedicine 3. Telehealth
AHRQ – EHC https://effectivehealthcare.ahrq.gov/products-tools/	1. Virtual care 2. Telemedicine 3. Telehealth
Canadian Medical Association www.cma.ca	1. Virtual care 2. Telemedicine 3. Telehealth
Institute for Healthcare Improvement – White Papers www.ihl.org	N/A – no search function, reviewed ‘Publications’ and ‘White Papers’ section of site
Health Quality Council of Alberta http://hqca.ca/studies-and-reviews/completed-reviews/	1. Virtual care 2. Telemedicine 3. Telehealth
INATHA Secretariat http://www.inahta.org/publications	1. Virtual care 2. Telemedicine 3. Telehealth
WHO Health Evidence Network http://www.euro.who.int/en/what-we-do/data-and-evidence/health-evidence-network-hen/publications/by-keyword	1. Virtual care 2. Telemedicine 3. Telehealth
Targeted Database Searches	
<i>Database name & URL</i>	<i>Search strategy(s)/ terms searched</i>
Google Scholar scholar.google.com	1. “virtual care” AND quality indicators 2. Telemedicine AND quality indicators 3. eHealth AND quality indicators
MedRXiv www.medrxiv.org	1. Virtual care quality indicator 2. Telemedicine quality indicator Results screened by 1 reviewer, 23 items selected for further screening
OpenGrey http://www.opengrey.eu/	1. Virtual care Telemedicine
Targeted Journal Search	
<i>Journal Name</i>	<i>Search strategy(s)/ terms searched</i>

Journal of Medical Internet Research	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Lancet Digital Health	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Nature Digital Medicine	Hand-searched (reviewed table of contents) of all editions in previous 2 years

Table 3: Frequency of NAM quality domain sub-codes.

<i>NAM Quality Domain</i>	Patient Experience (n=200)	Provider Experience (n=52)
<i>Effective (n=64) [n (%)]</i>	52 (81)	12 (19)
<i>Equitable (n=25) [n (%)]</i>	24 (96)	1 (4)
<i>Efficient (n=36) [n (%)]</i>	30 (83)	6 (17)
<i>Patient-centered (n=66) [n (%)]</i>	60 (91)	6 (9)
<i>Safe (n=10) [n (%)]</i>	8 (80)	2 (20)
<i>Timely (n=9) [n (%)]</i>	7 (78)	2 (22)
<i>Sustainable (n=36) [n (%)]</i>	16 (44)	20 (56)
<i>Composite (n=6) [n (%)]</i>	3 (50)	3 (50)
*Indicators that address more than one of the NAM quality domains		

BMJ Open

Quality measures of virtual care in ambulatory healthcare environments: A scoping review

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Secondary Subject Heading:	Evidence based practice
Keywords:	Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, Patient-Centered Care, Health Equity

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3 1 Quality measures of virtual care in ambulatory healthcare environments: A scoping
4 review
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Keywords: Quality Improvement; Quality Indicators, Health Care; Delivery of Health
Care; Virtual Medicine

ABSTRACT

Objectives: Delivery of virtual care increased throughout the COVID-19 pandemic and persisted after physical distancing measures ended. However, little is known about how to measure the quality of virtual care, as current measures focus on in-person care and may not apply to a virtual context. This scoping review aims to understand the connections between virtual care modalities used with ambulatory patient populations and quality measures across the Quintuple Aim (provider experience, patient experience, per capita cost, population health, and health equity).

Design: Virtual care was considered any interaction between patients and/or their circle of care occurring remotely using any form of information technology. Five databases (Medline, Embase, PsycInfo, Cochrane Library, JBI) and grey literature sources (11 websites, 3 search engines) were searched from 2015-June 2021 and again in August 2022 for publications that analysed virtual care in ambulatory settings. Indicators were extracted, double coded into the Quintuple Aim framework; patient and provider experience indicators were further categorized based on the National Academy of Medicine quality framework (safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity). Sustainability was added to capture potential for continued use of virtual care.

Results: 13,504 citations were double screened resulting in 631 full-text articles, 66 of which were included. Common modalities included video or audio visits (n=43), remote monitoring (n=11), and mobile applications (n=11). The most common quality indicators were related to patient experience (n=58 articles), followed by provider experience (n=25), population health outcomes (n=23), and health system costs (n=19).

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2
3 55 **Conclusions:** The connections between virtual care modalities and quality domains
4
5 56 identified here can inform clinicians, administrators, and other decision makers how to
6
7 57 monitor quality of virtual care and provides insights into gaps in current quality
8
9 58 measures. Next steps include development of a balanced scorecard of virtual care
10
11 59 quality indicators for ambulatory settings to inform quality improvement.
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17 61 **Strengths and limitations of this study**

- 19 62 • The methodology was broad in scope, seeking to collate a comprehensive list of
20
21 63 quality indicators of virtual care that included both published and grey literature
22
23
24 64 • Used established scoping review methods for literature search, study selection, data
25
26 65 collection, coding, and reporting
27
28
29 66 • Quality indicators were mapped and categorized into established quality frameworks
30
31 67 including the Quintuple Aim and the National Academy of Medicine quality domains
32
33 68 • Literature search was limited to articles published after 2015 and available in English
34
35 69 language only
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38 70 • Categorization of indicators was complicated by the lack of reported detail
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72 INTRODUCTION

73 Virtual care is defined as any interaction between patients and/or caregivers and their
74 healthcare providers (or “circle of care”) that occurs remotely and is facilitated through
75 digital communication or other information technologies (1). Prior to the COVID-19
76 pandemic, virtual care was largely underutilized for delivering healthcare services in
77 Canada (2). The COVID-19 pandemic changed the global healthcare landscape and
78 accelerated the implementation and access to virtual care for many patients (2).
79 Although utilization of virtual care decreased after pandemic restrictions eased, the
80 demands for the option to virtual care persist with many patients and/or caregivers
81 appreciating the convenience that virtual care affords(3,4). Healthcare providers also
82 see the value of virtual care in specific situations due to its’ potential to improve patient
83 access to care especially for those with mobility issues or living in rural/remote areas,
84 and for maintaining connections with patients in between in-person visits (5). The future
85 of healthcare delivery will require the integration of both virtual and in-person modalities
86 across the continuum of care (6). To meet these needs, virtual care needs to be
87 accessible and high quality; however, there is little understanding of what constitutes a
88 ‘quality’ encounter through virtual care for both patients and providers. Continued use
89 and integration of virtual care into standard practice, in part, depends on its impact on
90 the quality of care and the experiences of patients, caregivers, and healthcare
91 providers.

92
93 Quality indicators are standardized, evidence-based measures that can be used to track
94 and compare health outcomes and performance over time and across different

1
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3 95 organizations (7,8). Measurement of these indicators can identify gaps in care delivery
4
5 96 and inform quality improvement (QI) efforts within an organization, across health
6
7 97 systems, and across geographical boundaries. However, traditional indicators to assess
8
9 98 quality in healthcare primarily focus on in-person care and may have limited applicability
10
11 99 to care delivered virtually. While some literature on virtual care indicators have been
12
13 100 published, most studies focus solely within a specific clinical area (e.g., obstetrics,
14
15 101 cardiology, etc.) or few domains of interest (e.g., acceptability, satisfaction etc.), limiting
16
17 102 the scope and applicability for healthcare organizations to evaluate what constitutes
18
19 103 “quality” in virtual care (9–11).
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26 105 This scoping review was conducted with the aim to characterize existing quality
27
28 106 indicators used to evaluate modalities of virtual care and categorize the indicators
29
30 107 across the Quintuple Aim framework and National Academy of Medicine (NAM) quality
31
32 108 framework (safety, effectiveness, patient-centeredness, timeliness, efficiency, and
33
34 109 equity). Sustainability was added to capture potential for continued use of virtual care.
35
36 110 Our review focused on ambulatory patients as virtual care has a considerable role for
37
38 111 access to care; hospitalized in-patients have unique characteristics with higher acuity
39
40 112 rendering higher need for in-person care and therefore not included in this review.
41
42
43 113 This work will provide the foundation for identification and categorization of quality
44
45 114 indicators that can inform clinicians, healthcare managers, and other decision makers
46
47 115 how best to monitor quality of virtual care, identify performance gaps, and target areas
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49 116 for future improvement efforts.
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118 **METHODS**

119 The scoping review methodology used in the study was guided by the Joanna Briggs
120 Institute (JBI) Manual for Evidence Synthesis (12). Reporting of methods and results
121 was developed in accordance with the PRISMA extension statement for scoping
122 reviews (Supplementary File 1) (13).

124 **Information sources and literature search**

125 A comprehensive literature search was developed in consultation with an academic
126 librarian that included published academic and grey literature sources, as well as hand
127 searches of relevant journals. Initial literature searches were conducted in June 2021
128 and were updated in August 2022. Databases searched included MEDLINE, Embase,
129 PsycInfo, The Cochrane Library, and the JBI Evidence-based practice database
130 (Supplementary File 2). Keyword searches were also carried out in selected websites,
131 Google Scholar, Medrxiv, and Open Grey to identify grey literature including policy
132 documents, organizational strategies, and unpublished academic literature
133 (Supplementary File 2). Specialty journals focused on virtual/digital care including
134 Journal of Medical Internet Research, Lancet Digital Health, and Nature Digital
135 Medicine, were hand searched from 2015 to June 2022.

137 **Eligibility criteria**

138 The eligibility criteria were structured based on the “Population, Context, Concept”
139 (PCC) research framework(12) as follows:

- 1
2
3 140 • *Population*: adults (over 18 years of age) receiving ambulatory/outpatient care
4
5
6 141 through healthcare organizations for chronic or acute/subacute conditions.
7
8 142 • *Context*: participation in virtual care, defined as “any interaction between patients
9
10 143 and/or members of their circle of care, occurring remotely, using any forms of
11
12 144 communication or information technologies”(1)
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14
15 145 • *Concept*: within the Quintuple Aim framework (provider experience, patient
16
17 146 experience, per capita cost, population health, and health equity)(14), indicators are
18
19 147 based in the NAM’s quality framework (safety, effectiveness, patient-centeredness,
20
21 148 timeliness, efficiency and equity) and sustainability(15).

22
23
24 149 All modalities of virtual care were included such as video conferencing, remote
25
26 150 monitoring, and patient portals. Included papers must have addressed multiple domains
27
28 151 within the Quintuple Aim, or a domain with the Quintuple Aim and NAM quality
29
30 152 framework. Studies that focused on only one domain in a specific population were
31
32 153 excluded. Disease specific publications were only included if they focused on two or
33
34 154 more quality domains. Due to changes in technology and the rapid increase in virtual
35
36 155 care only studies published in English from 2015-2022 were included.
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41 42 157 **Study selection process**

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44
45 158 The literature search results were uploaded into Covidence review manager and de-
46
47 159 duplicated prior to screening(16). Screening questions based on the eligibility criteria
48
49 160 (Supplementary File 3) were developed for both title/abstract and full-text screening and
50
51 161 pilot tested with rounds of randomly selected citations until satisfactory agreement
52
53 162 (>75%) was reached between reviewers. Double screening of title/abstracts was
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3 163 conducted (by CL, PR, VK, and AS), followed by full text screening by a single reviewer
4
5 164 for a streamlined approach. Conflicts were resolved through group discussion with the
6
7
8 165 reviewers and confirmed by (GM). After full text screening, all excluded citations or
9
10 166 articles were re-reviewed by an independent second reviewer (PR) to ensure accuracy.
11
12 167 A similar process was followed for the 2022 update with SP, PR and AS, as reviewers.
13
14
15 168

17 169 **Data collection and management**

18
19 170 Due to the large heterogeneity across the types of papers, and the lack of
20
21 171 standardization in reporting of quality indicators and domains, the team opted for a
22
23 172 rigorous approach with two reviewers (two of CL, PR, VK, SP, and AS) independently
24
25 173 extracting each article. Any discrepancies in extracted data were reviewed and resolved
26
27 174 by an independent third reviewer. A standardized data extraction form was developed to
28
29 175 summarize and record the reviewed studies within Covidence review manager.
30
31

32
33 176 Extraction was piloted in two rounds using 3 studies per round, and the extraction form
34
35 177 revised accordingly. Data items included publication characteristics (year of publication,
36
37 178 country, study design, funding source, and sample size), intervention details (care
38
39 179 setting, virtual care modality, primary condition/health concern), and details on reported
40
41 180 quality indicators (definition, measurement/scoring tools, etc.).
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46 47 182 **Data Synthesis**

48
49 183 Individual indicators were used to demonstrate the connections between virtual care
50
51 184 modalities and the Quintuple Aim (14); patient experience and provider experience were
52
53 185 further sub-coded into the NAM quality domains (15) along with sustainability. These
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3 186 connections were visualized through an alluvial (also known as Sankey) diagram.
4
5 187 Although these individual indicators will be further refined through a future Delphi
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7 188 consensus process to narrow a subset of indicators across quality domains, the
8
9 189 proportions provide valuable information regarding the types of quality domains and
10
11 190 their corresponding modalities.
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16 191 17 192 **Risk of bias**

18
19 193 As this was a scoping review intended to capture a collection of quality indicator items,
20
21 194 rather than evaluate their effectiveness or appropriateness, risk of bias was not
22
23 195 assessed based on current published guidelines (12).
24
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26 196

27 28 197 **Patient and Public Involvement Statement**

29
30 198 People with lived experience were involved in the conception and development of the
31
32 199 scoping review as well as the presentation and dissemination of results through the
33
34 200 Patient Experience Advisors program and the Community Liaison Advisory Council
35
36 201 (CLAC) at Women's College Hospital. We intend to solicit further patient participation as
37
38 202 well as general public involvement in future work developing a balanced scorecard
39
40 203 based on the literature identified in this review. Working with patients helped to ensure
41
42 204 quality indicators that were extracting from the literature were relevant to patient
43
44 205 concerns and provided guidance on the mapping of indicators to the Quintuple Aim and
45
46 206 NAM quality framework. Patient advisors also helped to identify gaps, including the lack
47
48 207 of focus on equity, and will further input to addressing these gaps through development
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50 208 of the scorecard.
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210 RESULTS

211 The literature search resulted in a total of 18,395 citations from databases and grey
212 literature searching that were imported into Covidence; no additional citations were
213 identified through hand-searching journals. A total of 4,891 duplicate citations were
214 removed leaving 13,504 citations for title and abstract screening. After title and abstract
215 screening, 814 full-text articles were identified for retrieval and 183 reports, mostly
216 conference abstracts and commentaries, were further excluded. After assessing the
217 reports for eligibility, 66 articles were included for data extraction (Fig 1).

218

219 Figure 1: PRISMA study flow diagram

220

221 Characteristics of Included Studies

222 The included studies comprised 45 primary research studies (e.g., observational
223 studies) and 21 secondary research articles (e.g., systematic reviews). Table 1
224 summarizes the main characteristics of the included articles. The most frequent study
225 designs were observational studies (n=32), followed by systematic reviews (n=11),
226 qualitative studies (n=5), and interventional trials (n=5). The majority of included studies
227 were published between 2018 and 2020 (n=25) in North America (n=29) or Europe
228 (n=22). Funding sources were mainly from public institutions (n=30), but a large
229 proportion of studies also reported no external funding for their study (n=24).

230

231 Table 1: Characteristics of included studies (n=66)

	Primary Studies (n=45) [n (%)]	Secondary Studies (n=21) [n (%)]
Year of Publication		
2015-2017	13 (29)	7 (33)
2018-2020	18 (40)	7 (33)
2021-2022	14 (31)	7 (33)
Country of Publication		
Asia	1 (2)	3 (14)
Australia/South Pacific	4 (9)	2 (10)
Europe	14 (31)	7 (33)
North Africa and Middle East	4 (9)	1 (5)
North America	21 (47)	8 (38)
South America	1 (2)	--
Study Design		
Case report/series	1 (2)	--
Observational (cross-sectional, cohort)	30 (67)	--
Qualitative study	5 (11)	--
Mixed methods	3 (7)	--
Interventional (pre/post, controlled trial)	5 (11)	--
Cost/Cost-Effectiveness	1 (2)	--
Systematic Review	--	11 (53)
Scoping/Umbrella Review	--	4 (19)
Integrative Review	--	3 (14)
Environmental Scan	--	3 (14)
Funding Source		
Private	1 (2)	2 (10)
Public	22 (49)	8 (38)
Mixed	2 (5)	--
None	14 (31)	9 (42)
Not Reported	6 (13)	2 (10)
Number of participants		
Patients/Caregivers [median (IQR)]	115 (42-265)	--
Healthcare Providers [median (IQR)]	18 (13, 22)	--
Participant Age		

Patients/Caregivers [median (IQR)]	55.5 (47, 63)	--
Healthcare Providers [range]	22-76	--
Participant Gender (%)		
Patients/Caregivers [median]	Female: 53.7 Male: 50	--
Healthcare Providers [median]	Female: 61.3 Male: 38.7	--
Review Methods		
Number of included publications [median (IQR)]	--	17 (12, 22)
Reported inclusion/exclusion criteria	--	16 (76)
Limited search by language	--	10 (48)
Limited search by date	--	5 (24)
Age/publication date of included studies		
0-5 years prior	--	3 (14)
6-10 years prior	--	4 (19)
11+ years prior	--	9 (43)
Not reported	--	5 (24)

Interventions examined in the included studies covered a range of virtual care modalities (Table 2) including video and audio visits with clinicians (n=44), remote monitoring programs (n=13), mobile applications (n=12), self-monitoring and wearable devices (n=9), synchronous or asynchronous messaging with healthcare providers (n=13), or patient portals (n=10). Care settings (Table 2) ranged from ambulatory and outpatient clinics (n=41) to primary care (n=13), and home and community care settings (n=8). Patient populations (Table 2) included individuals with chronic noncommunicable conditions (n=19), cancer (n=7), and mental health conditions (n=5).

241

Table 2: Summary of intervention and setting characteristics (n=66)

	Value
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	[n (%)]
Primary Condition/Health Concern	
Cancer	7 (11)
Cardiac conditions	3 (5)
Chronic pain/Musculoskeletal	3 (5)
Dermatologic conditions	4 (6)
Diabetes	5 (8)
Kidney disease	3 (5)
Mental Health	5 (8)
Palliative	3 (5)
Specialist Clinic*	8 (12)
Surgery - unspecified	3 (5)
Multiple conditions	11 (17)
Not applicable/unspecified	11 (17)
Setting/Context of care delivery	
Ambulatory care/outpatient clinic	40 (60)
Primary care	13 (20)
Home and Community care	7 (11)
Not applicable/not specified	6 (9)
Type of Virtual Care Modality**	
Virtual visit/telemedicine – video	43 (65)
Virtual visit/telemedicine – audio only	37 (56)
Remote monitoring	11 (17)
Mobile application	11 (17)
Self-monitoring/Wearables	8 (12)
Synchronous messaging	4 (6)
Asynchronous messaging	9 (14)
Patient Portals	10 (15)
Other/Not specified	7 (11)
Number of Interventions	
1 or 2	46 (70)
3 or 4	17 (25)
5 to 7	3 (5)
*medical specialties include ENT, Gastroenterology, Neurology, Gynecology, and Urology	
**percentage totals exceed 100 as studies included multiple modalities	

243

244 Connections between virtual care modalities within the Quintuple Aim framework and
 245 NAM quality domains are visualized in Figure 2. Within the Quintuple Aim, the most
 246 reported category related to patient experience (n=200 indicators), followed by provider

247 experience (n=52), population health outcomes (n=47), health system costs (n=22), and
 248 equity (n=7). Virtual visits by phone and/or video (n=96) were the most common
 249 modality of virtual care reported, and was strongly connected to patient experience,
 250 provider experience, and population health outcomes (Fig 2). Virtual visits (video only)
 251 (n=60) and remote monitoring (n=59) were the next most common, also connecting
 252 strongly to patient experience, provider experience, and population health outcomes.
 253
 254 Within the NAM quality domains, the most common sub-coded domains included patient
 255 centeredness (n=66), effectiveness (n=64), sustainability (n=36), and efficiency of care
 256 (n=36) (Fig 2). Details regarding the frequency of indicators for NAM domains and
 257 patient experience and provider experience are provided in Supplementary File 4, with
 258 examples of indicators and their stem groupings in Table 3.

260 **Figure 2: Alluvial diagram connecting virtual care modalities to the Quintuple Aim**
 261 **and quality domains.** Through the middle are the Quintuple Aim domains, with curved
 262 bars representing connection to the virtual care modality (left) and NAM quality domains
 263 (right). For example, the 59 mentions of remote monitoring (left) were mostly connected
 264 with patient experience, followed by population health outcomes, then provider
 265 experience. The thick vertical bars show the frequency compared to the other domains:
 266 virtual visits were the most common modality; patient experience was the most common
 267 Quintuple Aim domain; and patient-centredness was the most common NAM quality
 268 domain.

270 **Table 3: Examples of indicator-stem groupings and indicators within the**
 271 **Quintuple Aim, specific to virtual care.**

Examples of Indicator-Stem Grouping (NAM Quality Domain)	Examples of Individual Indicators	Examples of Indicator Measurement
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Quintuple Aim domain: Patient Experience		
<p>Patient satisfaction (<i>Patient centeredness</i>)</p> <p>Usability (<i>Efficient</i>)</p>	<p>Patient satisfaction of virtual care compared to in-person consultations</p>	<p>5-point Likert scale – proportion of positive responses: “The clinical care I received during a virtual visit was the same as a face-to-face visit.”</p> <p>Telemedicine usability questionnaire: 18 items, 7-point Likert scale; higher mean score indicates higher satisfaction (usefulness, ease, interface quality, interaction quality, satisfaction and future use, reliability)</p>
<p>Effectiveness</p>	<p>Patient-perceived value of the virtual consultation.</p>	<p>Net promoter score – “recommend virtual visit to a friend”</p> <p>Virtual visits are more convenient than an office visit</p>
<p>Access to care (<i>Equitable</i>)</p>	<p>Ease of navigating access to a video appointment.</p> <p>Support to patients to overcome technical issues.</p>	<p>Proportion of patients requiring help with equipment</p> <p>Proportion of patients having trouble logging on to platform</p>
Quintuple Aim domain: Provider Experience		
<p>Provider satisfaction and preference</p>	<p>Provider satisfaction compared to in-person consultations.</p>	<p>5-item questionnaire using 0-100 Visual Analog Scales – overall score calculated by averaging responses</p>
<p>Infrastructure/organizational capacity (<i>Sustainable</i>)</p>	<p>Perceptions of effectiveness.</p>	<p>Telehealth Usability Questionnaire</p>
<p>Provider-patient workload/workflow (<i>Timely, efficiency</i>)</p>	<p>Provider and clinic efficiency.</p>	<p>Reduction in ‘no-shows’ and cancelled appointments</p> <p>Decrease in wait times for patients</p>
<p>Physician perspective of effectiveness (<i>Effective</i>)</p>	<p>Ability to evaluate/examine patient.</p>	<p>Likert scales – proportion of physicians that agree: I was confident with my ability to diagnose/make recommendations. I was able to effectively inform my patient.</p>
Quintuple Aim domain: Population Health & Outcomes		

Follow-up Care	30- or 90-day outpatient follow-up.	Number or proportion of patients seen in follow-up after virtual visit
	Emergency Department use after virtual visit.	Number or proportion of patients seeking emergency care after virtual visit
Access to Care	Program usage.	Proportion of participants engaging with the platform/completing program
Clinical outcomes and measures	Clinical effectiveness of care.	Changes in clinical outcomes/disease markers
	Quality of life.	Changes in QoL as measured by validated scales: EQ-5D*, WHO-QL**
	Patient safety.	Incidence of adverse clinical events
Quintuple Aim domain: Cost		
Health system costs	Cost reduction.	Cost of standard visit compared to virtual visit
	Cost-effectiveness.	Cost of telemedicine implementation and maintenance
Patient Costs	Cost-avoidance.	Patient travel savings compared to in-office visits
Quintuple Aim domain: Equity		
Accessibility	Equal access to care.	Availability of appropriate connectivity/ technical services in rural areas
Financial impact	Time saved by the patient	Reduction in travel time
*EQ-5D: EuroQol-5 Dimensions – health-related quality of life scale		
**WHO-QL: World Health Organization-Quality of Life scale		

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274 Specific Instruments Measuring Quality

275 Throughout data extraction, several existing tools were mentioned for measuring quality
 276 of care. For patient experience, tools included Telemedicine/Telehealth usability
 277 questionnaires (n=18 studies); Telemedicine Satisfaction and Usefulness Questionnaire
 278 (n=3); and Service User Technology Acceptability Questionnaire (n=1). For provider
 279 experience the Telemedicine/Telehealth Usability Questionnaire (n=2) was used, while

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3 280 others only mention 5- and 10-point Likert scales with unique or custom question
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5 281 prompts. No specific measurement tools were mentioned for population health
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7 282 outcomes, costs, or health equity.
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11 284 **DISCUSSION**

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14 285 This scoping review on quality measures for ambulatory virtual care found that within
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16 286 the Quintuple Aim, the most reported category assessing quality of virtual care was
17
18 287 related to patient experience, followed by provider experience, and population health
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20 288 outcomes. There was limited mention of health system costs, patient costs, or equity.
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23 289 The most frequently mentioned virtual care modality was virtual visits in video and/or
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25 290 audio, followed by video visits only, remote monitoring programs, mobile applications,
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27 291 and self-monitoring tools. Within the NAM domains of quality for patient and provider
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29 292 experience, effectiveness was most common, followed by patient centeredness and
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31 293 efficiency, with limited mention of sustainability.
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37 295 Best practice guidelines for virtual care are required to realize integration of virtual care
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39 296 across health systems (17,18). This review provides the foundation for identification and
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41 297 refinement of quality indicators in virtual care and highlights current gaps in assessment
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43 298 of virtual care performance indicators. Results indicate that further development of
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45 299 evaluation methods specifically analyzing the equitable and cost-efficient deployment of
46
47 300 virtual care are needed. Measurement of quality of virtual care will support
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49 301 understanding performance gaps, and targets for future quality improvement efforts and
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51 302 benchmarking efforts across organizations.
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304 Limited Attention on Equity, Sustainability, and Cost

305 It was noted that the majority of quality indicators were concentrated in specific domains
306 such as patient experience and/or satisfaction, or provider experience and/or
307 satisfaction, while the more complex indicators, such as equity, cost, and sustainability,
308 were not as widely reported. The limited attention on equity is consistent with published
309 literature, such as the scoping review of reviews which highlights the lack of focus on
310 equity assessments in virtual care deployments (19). Equity may have been more
311 challenging to measure and integrate into program evaluation and may have been
312 considered outside the scope of QI projects or time-sensitive deployments (such as
313 during the COVID-19 pandemic) (20). This lack of consideration of equity is concerning,
314 as virtual care has the potential to improve access to care for some typically
315 underserved populations and worsen access for others (21), making it an essential
316 consideration in understanding quality of care.

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318 Our review also noted limited attention in evaluations around sustainability of virtual
319 care delivery. Sustainability may be considered from multiple perspectives, including if
320 the patient plans to continue to use virtual options, or if the organization has the means
321 (infrastructure, IT support etc.) to continue to deliver virtual care after the COVID-19
322 pandemic restrictions lessened. Further indicators are needed to monitor the continued
323 need for and use of virtual care to assess if it remains a preferred and feasible option,
324 especially within hybrid models of care delivery which includes both virtual and in
325 person options. Considering sustainability is also important while taking a Learning

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3 326 Health Systems (LHS) approach across healthcare organizations and systems where
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5 327 the focus is on continuous learning and iterative advancement (22). Sustainability needs
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7 328 to be a key part of this systems-based approach, and thus quality indicators of virtual
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9 329 care that consider sustainability are needed.

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14 331 Indicators within the Quintuple Aim domain of cost were also rarely reported in the
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16 332 literature, for either patient costs or health system costs. This limited inclusion may
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18 333 partly be as cost can be difficult to measure and quantify in rapid virtual care
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20 334 deployments. This finding is consistent with a 2020 scoping review which analyzed the
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22 335 cost-effectiveness of telehealth to the healthcare system, which also highlighted this
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24 336 gap (23). Cost needs to be considered as part of evaluation of quality of virtual care,
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26 337 including in connection with sustainability of the service and the cost implications for
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28 338 patients, which also ties back to the topic of health equity and access to virtual care.

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32 33 34 35 340 **Evidence Synthesis of Virtual Care**

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37 341 There has been a considerable amount of work published about virtual care, and
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39 342 synthesis of that work. About a third of literature included in this scoping review were
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41 343 reviews themselves; however, these reviews usually were limited and focused on a
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43 344 specific service or modality of virtual care such as patient portals (24), telehealth/phone
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45 345 visits (25,26) and video consultations (27,28). Few reviews assessed approaches or
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47 346 models for evaluating virtual care, or tools which specifically measured quality across
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49 347 multiple domains as identified by the Quintuple Aim and NAM frameworks. To the
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51 348 authors' knowledge, this is the first review which specifically evaluates quality in virtual
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3 349 care with a comprehensive approach in defining quality indicators and assessing their
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5 350 use against established quality frameworks.
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10 352 A report by the Canadian Agency for Drugs and Technology in Health (CADTH) which
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12 353 studied evaluations of virtual care was consistent with our findings (29). The CADTH
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14 354 report stated that evaluations should focus on ensuring the scope of the virtual care
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16 355 visits was appropriate for the care being administered, be conducted systematically, and
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18 356 that cost-analysis or cost-benefit evaluations be conducted with a specific viewpoint in
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20 357 mind – such as a patient or provider (29). The findings of this scoping review support
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22 358 these assertions from a quality perspective. A quality virtual care program is clear in its
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24 359 scope, has dedicated resources for ongoing evaluations, and specifically investigates
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26 360 the impact of the program from the patient perspective, provider perspective, or both.
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32 33 362 **Leveraging Review Results: Next Steps**

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35 363 This review provides the foundational knowledge base of existing quality indicators of
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37 364 virtual care across domains of quality and organized within established quality
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39 365 frameworks. This knowledge base will be further refined and distilled through a modified
40
41 366 Delphi approach with key knowledge users and decision makers, including patients,
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43 367 healthcare professionals, virtual care experts, and policymakers, to help add indicators
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45 368 to address gaps, and rate and rank existing indicators based on feasibility, relevance,
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47 369 and utility. A subset of high-ranked indicators across quality domains will then be
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49 370 translated into a balanced score card for evaluating the quality of virtual care.
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3 372 An understanding of how to define quality in virtual care and measure performance is
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5 373 key to the development and growth of a potential LHS, which aims to enable cycles of
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7 374 continuous learning and improvement to be routinised and embedded across the
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9 375 healthcare system (30). A LHS is the combination of a health system and research
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11 376 system that, at all levels, is anchored on patient's needs, perspectives, and aspirations;
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13 377 driven by timely data and evidence; supported by appropriate decision supports, aligned
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15 378 governance, financial and care delivery arrangements; and enabled with a culture of,
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17 379 and competencies for, rapid learning and improvement (31). Further, it is a system in
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19 380 which science, informatics, incentives, and culture are aligned for continuous
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21 381 improvement and innovation, and thus our domains of quality for virtual care can be
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23 382 integrated into this approach. Ideally, best practices, including best practices in virtual
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25 383 care, are seamlessly embedded in the delivery process, patients and families are active
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27 384 participants in all elements, and new knowledge capture is an integral by-product of
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29 385 delivery experience (30). Ultimately, the deployment of virtual care should follow an LHS
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31 386 approach, with consistent revision and adjustment of virtual care initiatives to reflect
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33 387 dynamic contexts and adapt based on new evidence. Mapping the current knowledge
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35 388 base aims to provide organizations quick references for improving and iterating their
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37 389 virtual care program. Working towards true integration of virtual care into a LHS is
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39 390 subject to further research and implementation.
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392 **Strengths and Limitations**

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52 393 This scoping review used a wide range of published and grey sources, covered a vast
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54 394 breadth of literature, and applied rigorous methods for data extraction and coding. The
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3 395 body of literature included in this review also represents the current state of publications
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5 396 on virtual care, as the search was updated as the project progressed. However, our
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7 397 search strategy was limited to English only, and relying on the past seven years meant
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9 398 that foundational work on the implementation of virtual care may have been excluded.
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11 399 A key strength of this work was our categorization of existing indicators across
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13 400 established quality frameworks (NAM and sustainability, Quintuple Aim) to identify
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15 401 which quality domains of virtual care are present and lacking within the current
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17 402 literature. However, there is considerable overlap between the NAM domains for
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19 403 categorization, and extensive differences in the way indicators were explained in the
20
21 404 published studies, typically with very little detail. Indicators could overlap and routinely fit
22
23 405 within more than one quality domain, and the lack of detail provided about each
24
25 406 indicator meant that some assumptions were made, leading to subjectivity with current
26
27 407 results. For example, patient-centered care was used very differently across studies,
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29 408 with some having it synonymous with patient satisfaction, while others acknowledged
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31 409 the multiple factors and complexity in delivery patient-centered care. To address this
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33 410 limitation we dual-coded all indicators, resolved discrepancy with a third reviewer and
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35 411 will be working with interprofessional decision makers and persons with lived
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37 412 experience as we develop the balanced scorecard. The lack of reporting on how
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39 413 indicators were selected when measuring quality of care, the lack of detail provided, and
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41 414 the lack of reported knowledge user (patient, provider, management etc.) involvement,
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43 415 further highlighted the need for a consensus-based approach to finalize a concise list of
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45 416 virtual care quality indicators across all quality domains.
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3 418 **CONCLUSION**
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5 419 To ensure appropriate delivery of virtual care, it is imperative to understand how to
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7 420 define “quality” in virtual care. By identifying and mapping indicators of quality of virtual
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9 421 care to the Quintuple Aim and the NAM framework, we deepened our understanding of
10
11 422 these indicators and identified gaps. The most reported category assessing quality of
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13 423 virtual care was related to patient experience, followed by provider experience, and
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15 424 population health outcomes. There was limited mention of health system costs, patient
16
17 425 costs, or equity, which limits our understanding of quality of virtual care initiatives. This
18
19 426 highlights the need for development of new indicators to address the gaps, and a
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21 427 consensus-based process with knowledge users to create a prioritized list of relevant
22
23 428 quality indicators to monitor virtual care. Future work will further refine the quality
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25 429 indicators through a modified Delphi approach, with the aim to provide decision-makers
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27 430 with a balanced scorecard to monitor and improve quality of virtual care moving forward.
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3 433 **Author Contributions**
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5 434 Conceptualization: Geetha Mukerji
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8 435 Formal Analysis: Sam Petrie, Celia Laur, Patricia Rios
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10 436 Funding Acquisition: Geetha Mukerji
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12 437 Investigation: Sam Petrie, Celia Laur, Toni Mankanjuola, Patricia Rios, Geetha Mukerji,
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14 438 Ally Suarez
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17 439 Writing – Original Draft Preparation: Sam Petrie, Celia Laur
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19 440 Writing – Reviewing & Editing: Celia Laur, Patricia Rios, Ally Suarez, Toni Mankanjuola,
20
21 441 Geetha Mukerji, Onil Bhattacharyya, Emeraldalda Burke
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41 450 004).
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48 452 **CONFLICT OF INTEREST**
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50 453 The authors have no conflict of interest to declare.
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3 455 **DATA AVAILABILITY STATEMENT**
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5 456 No additional data available.
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39 555 [responses/creating-rapid-learning-health-systems-in-canada.pdf?sfvrsn=4](https://www.mcmasterforum.org/docs/default-source/product-documents/rapid-responses/creating-rapid-learning-health-systems-in-canada.pdf?sfvrsn=4)

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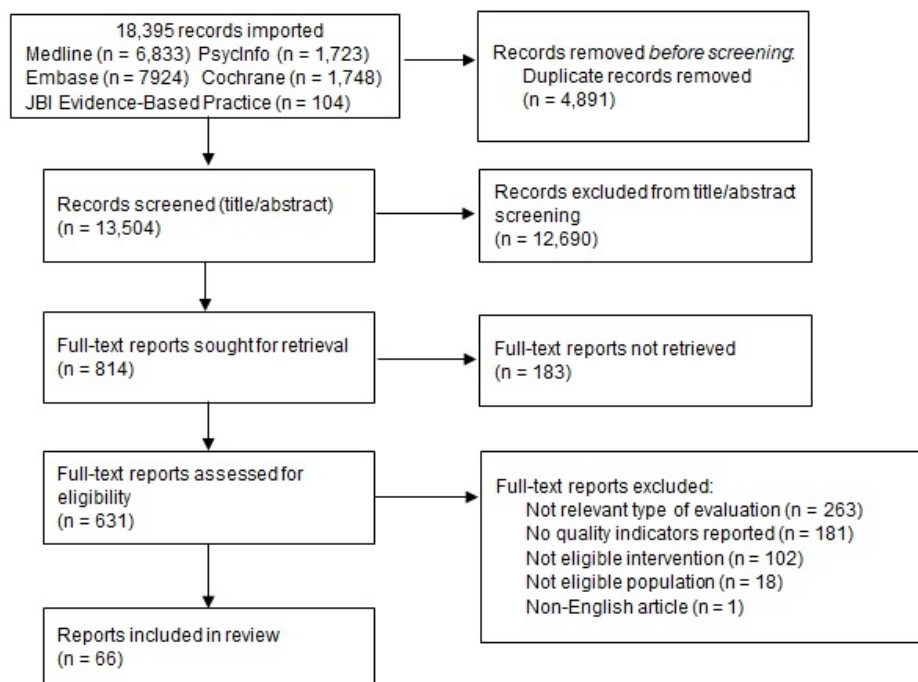


Figure 1: PRISMA study flow diagram

54x39mm (300 x 300 DPI)

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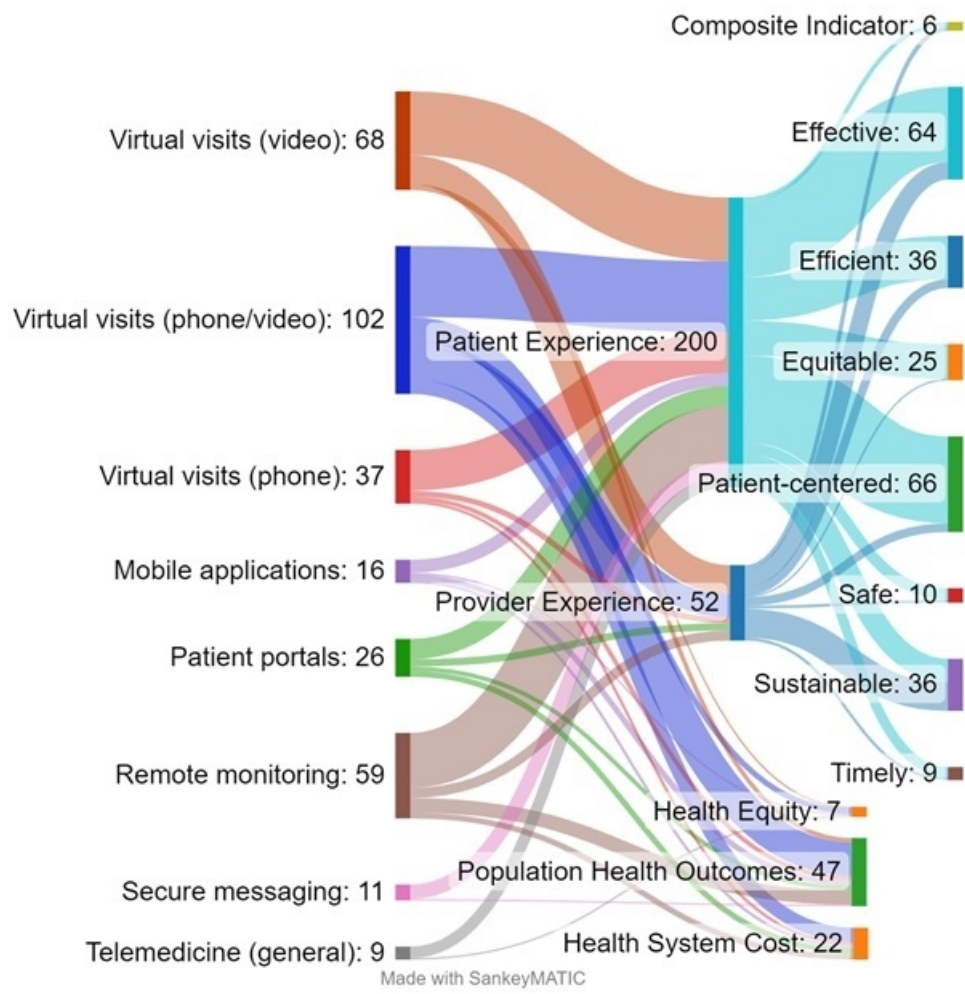


Figure 2: Alluvial diagram connecting virtual care modalities to the Quintuple Aim and quality domains.

52x52mm (300 x 300 DPI)

S1 Table - Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5-6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	No protocol registered
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary Material 2
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7-8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8-9
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	9-10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10-12
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	13-18
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	13-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-22
Limitations	20	Discuss the limitations of the scoping review process.	23
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	24
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	23

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: [10.7326/M18-0850](https://doi.org/10.7326/M18-0850).

Table 1 - Database search strategies

Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE® 1946-Present	
#	Query
1	exp telemedicine/
2	exp internet-based intervention/
3	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,kf.
4	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,kf.
5	(((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)) and patient*).tw,kf.
6	(((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,kf.
7	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kw,kf. or (virtual care or virtual health).tw,kf. or (rapid* adj3 virtual*).tw,kf.
8	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,kf.
9	(digital health or digital first).tw,kf.
10	("e health*" or ehealth* or evisit* or "e-visit").tw,kf.
11	(online adj3 (healthcare or health care)).tw,kf.
12	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kf.
13	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or "tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or

	"tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,kf.
14	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
15	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or edagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhEALTH or "M-HEALTH").tw,kf.
16	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
17	(virtual* adj3 monitor*).tw,kf.
18	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,kf.
19	mobile health monitor*.tw,kf.
20	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19
21	"Outcome and Process Assessment, Health Care"/
22	Quality Assurance, Health Care/
23	Benchmarking/
24	Total Quality Management/
25	Quality Improvement/
26	Quality Indicators, Health Care/
27	"Utilization Review"/
28	Patient Outcome Assessment/

29	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,kf.
30	(quality adj3 (indicat* or metric* or standard* or measure*)).tw,kf.
31	21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
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33	limit 33 to (english language and yr="2015 -Current")
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1	telecommunication/
2	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,kw.
3	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,kw.
4	((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)).tw,kw. and patient*.tw, kw.
5	((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,kw.
6	((virtual* or digital*) adj3 (healthcare or health care or health strategy)) or (virtual care or virtual health) or (rapid* adj3 virtual*).tw,kw.
7	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,kw.
8	(digital health or digital first).tw,kw.
9	("e health*" or ehealth* or evisit* or "e-visit*").tw,kw.
10	(online adj3 (healthcare or health care)).tw,kw.
11	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kw.

12	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or "tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or telepileps* or "tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,kw.
13	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kw.
14	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or edagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhHEALTH or "M-HEALTH").tw,kw.
15	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kw.
16	(virtual* adj3 monitor*).tw,kw.
17	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,kw.
18	mobile health monitor*.tw,kw.
19	wearable computer/
20	or/1-19
21	Health care quality/
22	Benchmarking/
23	Total quality management/
24	"utilization review"/

25	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,kw
26	(quality adj2 (indicat* or metric* or standard* or measure*)).tw,kw.
27	Or/21-26
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1	exp telemedicine/
2	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,sh.
3	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,sh.
4	((((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)) and patient*).tw,sh.
5	((((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,sh.
6	((((virtual* or digital*) adj3 (healthcare or health care or health strategy)) or (virtual care or virtual health) or (rapid* adj3 virtual*)).tw,sh.
7	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,sh.
8	(digital health or digital first).tw,sh.
9	("e health*" or ehealth* or evisit* or "e-visit*").tw,sh.
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	"tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or "tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,sh.
12	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,sh.
13	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or ediagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhEALTH or "M-HEALTH").tw,sh.
14	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,sh.
15	(virtual* adj3 monitor*).tw,sh.
16	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,sh.
17	mobile health monitor*.tw,sh.
18	(online adj3 (healthcare or health care)).tw,sh.
19	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
20	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,sh.
21	(quality adj3 (indicat* or metric* or standard* or measure*)).tw,sh.
22	exp "quality of services"/
23	exp "Quality of Care"/
24	exp Program Evaluation/

25	20 or 21 or 22 or 23 or 24
26	19 and 25
27	limit 26 to (english language and yr="2015 - 2021")
	Cochrane Library
#1	MeSH descriptor: [Telemedicine] explode all trees
#2	MeSH descriptor: [Internet-Based Intervention] explode all trees
#3	(remote consult*) or (remote interact*) pr (remote diagnos*) or (remote monitor*) or (remote treat*) or (remote therap*) or (remote care):ti,ab,kw
#4	(virtual health*) or (digital health*) or (online health*) or (ehealth*) or (mobile health*):ti,ab, kw
#5	#1 or #2 or #3 or #4
#6	MeSH descriptor: [Quality of Health Care] this term only
#7	MeSH descriptor: [Outcome and Process Assessment, Health Care] this term only
#8	MeSH descriptor: [Quality Assurance, Health Care] this term only
#9	MeSH descriptor: [Benchmarking] this term only
#10	MeSH descriptor: [Total Quality Management] this term only
#11	MeSH descriptor: [Quality Improvement] this term only
#12	MeSH descriptor: [Quality Indicators, Health Care] this term only
#13	MeSH descriptor: [Utilization Review] this term only
#14	MeSH descriptor: [Patient Outcome Assessment] this term only
#15	(quality indicat*) or (quailty metric*) or (quality standard*) or (quality measure*) or (quality report*) or (performance measure*) or (performance metric*) or (usability) or (care evaluation) or (scorecard) or (balanced scorecard) or (logic model):ti,ab,kw
#16	#6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15
#17	#5 and #16 with Cochrane Library publication date Between Jan 2015 and Present

Table 2 - Grey Literature Search

Targeted Website Searches

<i>Organization name & website URL</i>	<i>Search strategy(s)/ terms searched</i>
McMaster Health Forum www.healthsystemevidence.org	1. (virtual care OR digital health) AND quality 2. Telemedicine AND quality indicators
Publications Canada https://publications.gc.ca	1. Virtual care 2. Telemedicine 3. eHealth
Health Quality Ontario http://www.hqontario.ca/Evidence-to-Improve-Care/Health-Technology-Assessment	1. Virtual care 2. Telemedicine 3. Telehealth
NICE www.nice.org.uk	1. Virtual care 2. Telemedicine 3. Telehealth 4. Digital care
AHRQ - EPC http://www.ahrq.gov/research/findings/evidence-based-reports/search.html	1. Virtual care 2. Telemedicine 3. Telehealth
AHRQ – EHC https://effectivehealthcare.ahrq.gov/products-tools/	1. Virtual care 2. Telemedicine 3. Telehealth
Canadian Medical Association www.cma.ca	1. Virtual care 2. Telemedicine 3. Telehealth
Institute for Healthcare Improvement – White Papers www.ihq.org	N/A – no search function, reviewed ‘Publications’ and ‘White Papers’ section of site
Health Quality Council of Alberta http://hqca.ca/studies-and-reviews/completed-reviews/	1. Virtual care 2. Telemedicine 3. Telehealth
INATHA Secretariat http://www.inahta.org/publications	1. Virtual care 2. Telemedicine 3. Telehealth
WHO Health Evidence Network http://www.euro.who.int/en/what-we-do/data-and-evidence/health-evidence-network-hen/publications/by-keyword	1. Virtual care 2. Telemedicine 3. Telehealth
Targeted Database Searches	
<i>Database name & URL</i>	<i>Search strategy(s)/ terms searched</i>
Google Scholar scholar.google.com	1. “virtual care” AND quality indicators 2. Telemedicine AND quality indicators 3. eHealth AND quality indicators
MedRXiv www.medrxiv.org	1. Virtual care quality indicator 2. Telemedicine quality indicator Results screened by 1 reviewer, 23 items selected for further screening

OpenGrey http://www.opengrey.eu/	1. Virtual care Telemedicine
Targeted Journal Search	
<i>Journal Name</i>	<i>Search strategy(s)/ terms searched</i>
Journal of Medical Internet Research	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Lancet Digital Health	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Nature Digital Medicine	Hand-searched (reviewed table of contents) of all editions in previous 2 years

Screening Criteria

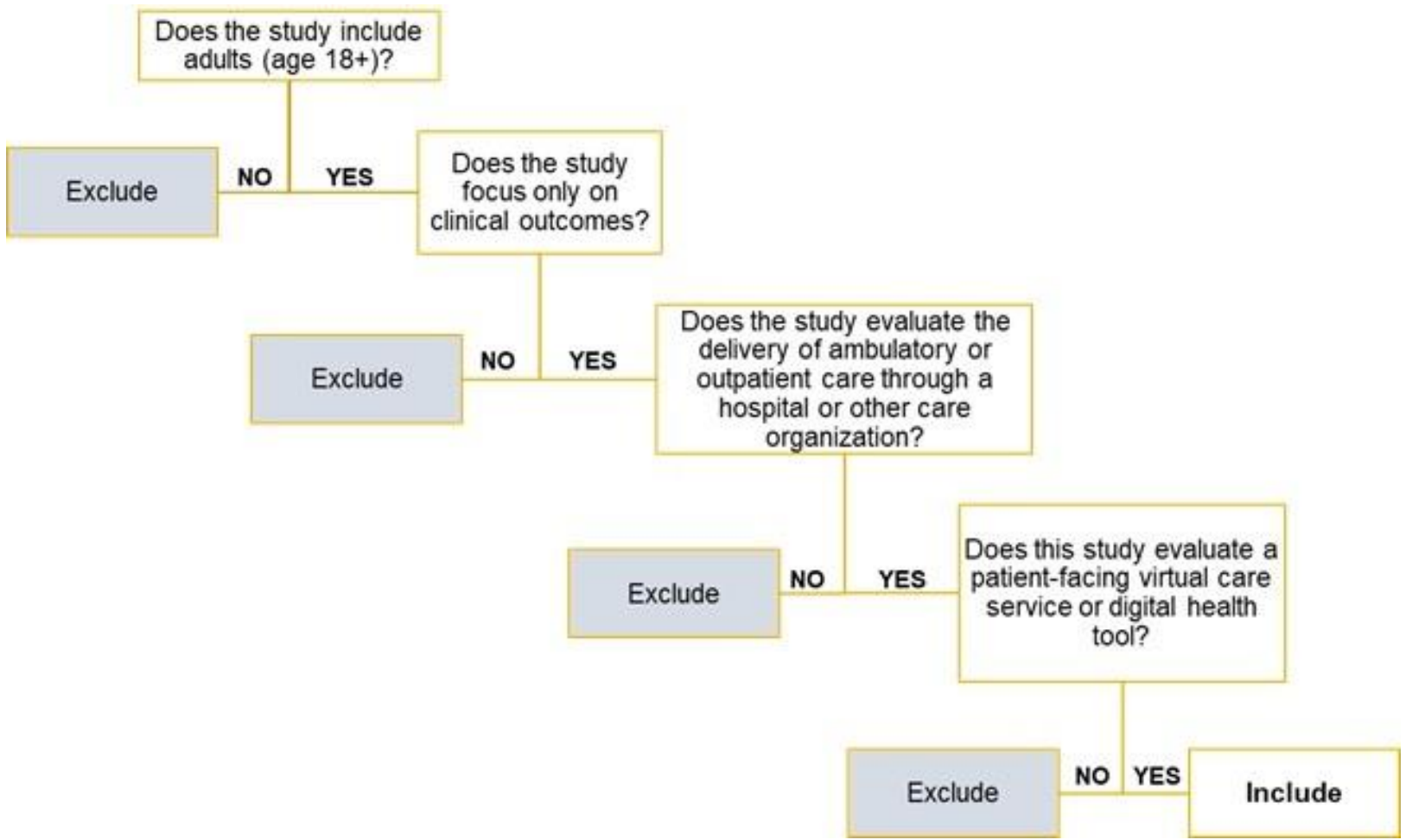


Table: Frequency of NAM quality domain sub-codes.

<i>NAM Quality Domain</i>	Patient Experience (n=200)	Provider Experience (n=52)
<i>Effective (n=64) [n (%)]</i>	52 (81)	12 (19)
<i>Equitable (n=25) [n (%)]</i>	24 (96)	1 (4)
<i>Efficient (n=36) [n (%)]</i>	30 (83)	6 (17)
<i>Patient-centered (n=66) [n (%)]</i>	60 (91)	6 (9)
<i>Safe (n=10) [n (%)]</i>	8 (80)	2 (20)
<i>Timely (n=9) [n (%)]</i>	7 (78)	2 (22)
<i>Sustainable (n=36) [n (%)]</i>	16 (44)	20 (56)
<i>Composite (n=6) [n (%)]</i>	3 (50)	3 (50)
*Indicators that address more than one of the NAM quality domains		

BMJ Open

Quality measures of virtual care in ambulatory healthcare environments: A scoping review

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Primary Subject Heading:	Health services research
Secondary Subject Heading:	Evidence based practice
Keywords:	Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, Patient-Centered Care, Health Equity

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3 1 Quality measures of virtual care in ambulatory healthcare environments: A scoping
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Keywords: Quality Improvement; Quality Indicators, Health Care; Delivery of Health
Care; Virtual Medicine

ABSTRACT

Objectives: Delivery of virtual care increased throughout the COVID-19 pandemic and persisted after physical distancing measures ended. However, little is known about how to measure the quality of virtual care, as current measures focus on in-person care and may not apply to a virtual context. This scoping review aims to understand the connections between virtual care modalities used with ambulatory patient populations and quality measures across the Quintuple Aim (provider experience, patient experience, per capita cost, population health, and health equity).

Design: Virtual care was considered any interaction between patients and/or their circle of care occurring remotely using any form of information technology. Five databases (Medline, Embase, PsycInfo, Cochrane Library, JBI) and grey literature sources (11 websites, 3 search engines) were searched from 2015-June 2021 and again in August 2022 for publications that analysed virtual care in ambulatory settings. Indicators were extracted, double coded into the Quintuple Aim framework; patient and provider experience indicators were further categorized based on the National Academy of Medicine quality framework (safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity). Sustainability was added to capture potential for continued use of virtual care.

Results: 13,504 citations were double screened resulting in 631 full-text articles, 66 of which were included. Common modalities included video or audio visits (n=43), remote monitoring (n=11), and mobile applications (n=11). The most common quality indicators were related to patient experience (n=58 articles), followed by provider experience (n=25), population health outcomes (n=23), and health system costs (n=19).

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2
3 55 **Conclusions:** The connections between virtual care modalities and quality domains
4
5 56 identified here can inform clinicians, administrators, and other decision makers how to
6
7 57 monitor quality of virtual care and provides insights into gaps in current quality
8
9 58 measures. Next steps include development of a balanced scorecard of virtual care
10
11 59 quality indicators for ambulatory settings to inform quality improvement.
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17 61 **Strengths and limitations of this study**

- 19 62 • The methodology used for this review was broad in scope, seeking to collate a
20
21 63 comprehensive list of quality indicators of virtual care and included both published
22
23 64 and grey literature
- 25 65 • Used established scoping review methods for literature search, study selection, data
26
27 66 collection, coding, and reporting
- 29 67 • to the quality indicators were mapped and categorized into established quality
30
31 68 frameworks including the Quintuple Aim and the National Academy of Medicine
32
33 69 quality domains
- 35 70 • Literature search was limited to articles published after 2015 and available in English
36
37 71 language only
- 39 72 • Categorization of indicators was complicated by the lack of reported detail
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74 INTRODUCTION

75 Virtual care is defined as any interaction between patients and/or caregivers and their
76 healthcare providers (or “circle of care”) that occurs remotely and is facilitated through
77 digital communication or other information technologies (1). Prior to the COVID-19
78 pandemic, virtual care was largely underutilized for delivering healthcare services in
79 Canada (2). The COVID-19 pandemic changed the global healthcare landscape and
80 accelerated the implementation and access to virtual care for many patients (2).
81 Although utilization of virtual care decreased after pandemic restrictions eased, the
82 demands for the option to virtual care persist with many patients and/or caregivers
83 appreciating the convenience that virtual care affords(3,4). Healthcare providers also
84 see the value of virtual care in specific situations due to its’ potential to improve patient
85 access to care especially for those with mobility issues or living in rural/remote areas,
86 and for maintaining connections with patients in between in-person visits (5). The future
87 of healthcare delivery will require the integration of both virtual and in-person modalities
88 across the continuum of care (6). To meet these needs, virtual care needs to be
89 accessible and high quality; however, there is little understanding of what constitutes a
90 ‘quality’ encounter through virtual care for both patients and providers. Continued use
91 and integration of virtual care into standard practice, in part, depends on its impact on
92 the quality of care and the experiences of patients, caregivers, and healthcare
93 providers.

94
95 Quality indicators are standardized, evidence-based measures that can be used to track
96 and compare health outcomes and performance over time and across different

1
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3 97 organizations (7,8). Measurement of these indicators can identify gaps in care delivery
4
5 98 and inform quality improvement (QI) efforts within an organization, across health
6
7 99 systems, and across geographical boundaries. However, traditional indicators to assess
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9
10 100 quality in healthcare primarily focus on in-person care and may have limited applicability
11
12 101 to care delivered virtually. While some literature on virtual care indicators have been
13
14 102 published, most studies focus solely within a specific clinical area (e.g., obstetrics,
15
16 103 cardiology, etc.) or few domains of interest (e.g., acceptability, satisfaction etc.), limiting
17
18 104 the scope and applicability for healthcare organizations to evaluate what constitutes
19
20 105 “quality” in virtual care (9–11).
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26 107 This scoping review was conducted with the aim to characterize existing quality
27
28 108 indicators used to evaluate modalities of virtual care and categorize the indicators
29
30 109 across the Quintuple Aim framework and National Academy of Medicine (NAM) quality
31
32 110 framework (safety, effectiveness, patient-centeredness, timeliness, efficiency, and
33
34 111 equity). Sustainability was added to capture potential for continued use of virtual care.
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36
37 112 Our review focused on ambulatory patients as virtual care has a considerable role for
38
39 113 access to care; hospitalized in-patients have unique characteristics with higher acuity
40
41 114 rendering higher need for in-person care and therefore not included in this review.
42
43
44 115 This work will provide the foundation for identification and categorization of quality
45
46 116 indicators that can inform clinicians, healthcare managers, and other decision makers
47
48 117 how best to monitor quality of virtual care, identify performance gaps, and target areas
49
50 118 for future improvement efforts.
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54 119

120 **METHODS**

121 The scoping review methodology used in the study was guided by the Joanna Briggs
122 Institute (JBI) Manual for Evidence Synthesis (12). Reporting of methods and results
123 was developed in accordance with the PRISMA extension statement for scoping
124 reviews (see Supplementary File 1 for the PRISMA reporting checklist. see
125 Supplementary File 2 for inclusions/exclusion protocols.) (13).

127 **Information sources and literature search**

128 A comprehensive literature search was developed in consultation with an academic
129 librarian that included published academic and grey literature sources, as well as hand
130 searches of relevant journals. Initial literature searches were conducted in June 2021
131 and were updated in August 2022. Databases searched included MEDLINE, Embase,
132 PsycInfo, The Cochrane Library, and the JBI Evidence-based practice database
133 (Supplementary File 3 – Table 1). Keyword searches were also carried out in selected
134 websites, Google Scholar, Medrxiv, and Open Grey to identify grey literature including
135 policy documents, organizational strategies, and unpublished academic literature
136 (Supplementary File 3 – Table 2). Specialty journals focused on virtual/digital care
137 including Journal of Medical Internet Research, Lancet Digital Health, and Nature Digital
138 Medicine, were hand searched from 2015 to June 2022.

140 **Eligibility criteria**

141 The eligibility criteria were structured based on the “Population, Context, Concept”
142 (PCC) research framework(12) as follows:

- 1
2
3 143 • *Population*: adults (over 18 years of age) receiving ambulatory/outpatient care
4
5 144 through healthcare organizations for chronic or acute/subacute conditions.
6
7
8 145 • *Context*: participation in virtual care, defined as “any interaction between patients
9
10 146 and/or members of their circle of care, occurring remotely, using any forms of
11
12 147 communication or information technologies”(1)
13
14
15 148 • *Concept*: within the Quintuple Aim framework (provider experience, patient
16
17 149 experience, per capita cost, population health, and health equity)(14), indicators are
18
19 150 based in the NAM’s quality framework (safety, effectiveness, patient-centeredness,
20
21 151 timeliness, efficiency and equity) and sustainability(15).

22
23
24 152 All modalities of virtual care were included such as video conferencing, remote
25
26 153 monitoring, and patient portals. Included papers must have addressed multiple domains
27
28 154 within the Quintuple Aim, or a domain with the Quintuple Aim and NAM quality
29
30 155 framework. Studies that focused on only one domain in a specific population were
31
32 156 excluded. Disease specific publications were only included if they focused on two or
33
34 157 more quality domains. Due to changes in technology and the rapid increase in virtual
35
36 158 care only studies published in English from 2015-2022 were included.
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43 160 **Study selection process**

44
45 161 The literature search results were uploaded into Covidence review manager and de-
46
47 162 duplicated prior to screening(16). Screening questions based on the eligibility criteria
48
49 163 (Supplementary File 2 – Figure 1) were developed for both title/abstract and full-text
50
51 164 screening and pilot tested with rounds of randomly selected citations until satisfactory
52
53 165 agreement (>75%) was reached between reviewers. Double screening of title/abstracts
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3 166 was conducted (by CL, PR, VK, and AS), followed by full text screening by a single
4
5 167 reviewer for a streamlined approach. Conflicts were resolved through group discussion
6
7 168 with the reviewers and confirmed by (GM). After full text screening, all excluded
8
9
10 169 citations or articles were re-reviewed by an independent second reviewer (PR) to
11
12 170 ensure accuracy. A similar process was followed for the 2022 update with SP, PR and
13
14
15 171 AS, as reviewers.
16
17 172

19 173 **Data collection and management**

21 174 Due to the large heterogeneity across the types of papers, and the lack of
22
23 175 standardization in reporting of quality indicators and domains, the team opted for a
24
25 176 rigorous approach with two reviewers (two of CL, PR, VK, SP, and AS) independently
26
27 177 extracting each article. Any discrepancies in extracted data were reviewed and resolved
28
29 178 by an independent third reviewer. A standardized data extraction form was developed to
30
31 179 summarize and record the reviewed studies within Covidence review manager.
32
33 180 Extraction was piloted in two rounds using 3 studies per round, and the extraction form
34
35 181 revised accordingly. Data items included publication characteristics (year of publication,
36
37 182 country, study design, funding source, and sample size), intervention details (care
38
39 183 setting, virtual care modality, primary condition/health concern), and details on reported
40
41 184 quality indicators (definition, measurement/scoring tools, etc.).
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49 186 **Data Synthesis**

51 187 Individual indicators were used to demonstrate the connections between virtual care
52
53 188 modalities and the Quintuple Aim (14); patient experience and provider experience were
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3 189 further sub-coded into the NAM quality domains (15) along with sustainability. These
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5 190 connections were visualized through an alluvial (also known as Sankey) diagram.
6
7 191 Although these individual indicators will be further refined through a future Delphi
8
9 192 consensus process to narrow a subset of indicators across quality domains, the
10
11 193 proportions provide valuable information regarding the types of quality domains and
12
13 194 their corresponding modalities.
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19 196 **Risk of bias**

20
21 197 As this was a scoping review intended to capture a collection of quality indicator items,
22
23 198 rather than evaluate their effectiveness or appropriateness, risk of bias was not
24
25 199 assessed based on current published guidelines (12).
26
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30 201 **Patient and Public Involvement Statement**

31
32 202 People with lived experience were involved in the conception and development of the
33
34 203 scoping review as well as the presentation and dissemination of results through the
35
36 204 Patient Experience Advisors program and the Community Liaison Advisory Council
37
38 205 (CLAC) at Women's College Hospital. We intend to solicit further patient participation as
39
40 206 well as general public involvement in future work developing a balanced scorecard
41
42 207 based on the literature identified in this review. Working with patients helped to ensure
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44 208 quality indicators that were extracting from the literature were relevant to patient
45
46 209 concerns and provided guidance on the mapping of indicators to the Quintuple Aim and
47
48 210 NAM quality framework. Patient advisors also helped to identify gaps, including the lack
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211 of focus on equity, and will further input to addressing these gaps through development
212 of the scorecard.

213

214 **RESULTS**

215 The literature search resulted in a total of 18,395 citations from databases and grey
216 literature searching that were imported into Covidence; no additional citations were
217 identified through hand-searching journals. A total of 4,891 duplicate citations were
218 removed leaving 13,504 citations for title and abstract screening. After title and abstract
219 screening, 814 full-text articles were identified for retrieval and 183 reports, mostly
220 conference abstracts and commentaries, were further excluded. After assessing the
221 reports for eligibility, 66 articles were included for data extraction (Fig 1).

222

223 **Figure 1: PRISMA study flow diagram**

224

225 **Characteristics of Included Studies**

226 The included studies comprised 45 primary research studies (e.g., observational
227 studies) and 21 secondary research articles (e.g., systematic reviews). Table 1
228 summarizes the main characteristics of the included articles. The most frequent study
229 designs were observational studies (n=32), followed by systematic reviews (n=11),
230 qualitative studies (n=5), and interventional trials (n=5). The majority of included studies
231 were published between 2018 and 2020 (n=25) in North America (n=29) or Europe
232 (n=22). Funding sources were mainly from public institutions (n=30), but a large
233 proportion of studies also reported no external funding for their study (n=24).

234

235 **Table 1: Characteristics of included studies (n=66)**

	Primary Studies (n=45) [n (%)]	Secondary Studies (n=21) [n (%)]
Year of Publication		
2015-2017	13 (29)	7 (33)
2018-2020	18 (40)	7 (33)
2021-2022	14 (31)	7 (33)
Country of Publication		
Asia	1 (2)	3 (14)
Australia/South Pacific	4 (9)	2 (10)
Europe	14 (31)	7 (33)
North Africa and Middle East	4 (9)	1 (5)
North America	21 (47)	8 (38)
South America	1 (2)	--
Study Design		
Case report/series	1 (2)	--
Observational (cross-sectional, cohort)	30 (67)	--
Qualitative study	5 (11)	--
Mixed methods	3 (7)	--
Interventional (pre/post, controlled trial)	5 (11)	--
Cost/Cost-Effectiveness	1 (2)	--
Systematic Review	--	11 (53)
Scoping/Umbrella Review	--	4 (19)
Integrative Review	--	3 (14)
Environmental Scan	--	3 (14)
Funding Source		
Private	1 (2)	2 (10)
Public	22 (49)	8 (38)
Mixed	2 (5)	--
None	14 (31)	9 (42)
Not Reported	6 (13)	2 (10)
Number of participants		

Patients/Caregivers [median (IQR)]	115 (42-265)	--
Healthcare Providers [median (IQR)]	18 (13, 22)	--
Participant Age		
Patients/Caregivers [median (IQR)]	55.5 (47, 63)	--
Healthcare Providers [range]	22-76	--
Participant Gender (%)		
Patients/Caregivers [median]	Female: 53.7 Male: 50	--
Healthcare Providers [median]	Female: 61.3 Male: 38.7	--
Review Methods		
Number of included publications [median (IQR)]	--	17 (12, 22)
Reported inclusion/exclusion criteria	--	16 (76)
Limited search by language	--	10 (48)
Limited search by date	--	5 (24)
Age/publication date of included studies		
0-5 years prior	--	3 (14)
6-10 years prior	--	4 (19)
11+ years prior	--	9 (43)
Not reported	--	5 (24)

236

237 Interventions examined in the included studies covered a range of virtual care

238 modalities (Table 2) including video and audio visits with clinicians (n=44), remote

239 monitoring programs (n=13), mobile applications (n=12), self-monitoring and wearable

240 devices (n=9), synchronous or asynchronous messaging with healthcare providers

241 (n=13), or patient portals (n=10). Care settings (Table 2) ranged from ambulatory and

242 outpatient clinics (n=41) to primary care (n=13), and home and community care settings

243 (n=8). Patient populations (Table 2) included individuals with chronic noncommunicable

244 conditions (n=19), cancer (n=7), and mental health conditions (n=5).

245

246 **Table 2: Summary of intervention and setting characteristics (n=66)**

	Value [n (%)]
Primary Condition/Health Concern	
Cancer	7 (11)
Cardiac conditions	3 (5)
Chronic pain/Musculoskeletal	3 (5)
Dermatologic conditions	4 (6)
Diabetes	5 (8)
Kidney disease	3 (5)
Mental Health	5 (8)
Palliative	3 (5)
Specialist Clinic*	8 (12)
Surgery - unspecified	3 (5)
Multiple conditions	11 (17)
Not applicable/unspecified	11 (17)
Setting/Context of care delivery	
Ambulatory care/outpatient clinic	40 (60)
Primary care	13 (20)
Home and Community care	7 (11)
Not applicable/not specified	6 (9)
Type of Virtual Care Modality**	
Virtual visit/telemedicine – video	43 (65)
Virtual visit/telemedicine – audio only	37 (56)
Remote monitoring	11 (17)
Mobile application	11 (17)
Self-monitoring/Wearables	8 (12)
Synchronous messaging	4 (6)
Asynchronous messaging	9 (14)
Patient Portals	10 (15)
Other/Not specified	7 (11)
Number of Interventions	
1 or 2	46 (70)
3 or 4	17 (25)
5 to 7	3 (5)
*medical specialties include ENT, Gastroenterology, Neurology, Gynecology, and Urology	
**percentage totals exceed 100 as studies included multiple modalities	

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248 Connections between virtual care modalities within the Quintuple Aim framework and

249 NAM quality domains are visualized in Figure 2. Within the Quintuple Aim, the most

250 reported category related to patient experience (n=200 indicators), followed by provider
 251 experience (n=52), population health outcomes (n=47), health system costs (n=22), and
 252 equity (n=7). Virtual visits by phone and/or video (n=96) were the most common
 253 modality of virtual care reported, and was strongly connected to patient experience,
 254 provider experience, and population health outcomes (Fig 2). Virtual visits (video only)
 255 (n=60) and remote monitoring (n=59) were the next most common, also connecting
 256 strongly to patient experience, provider experience, and population health outcomes.

257
 258 Within the NAM quality domains, the most common sub-coded domains included patient
 259 centeredness (n=66), effectiveness (n=64), sustainability (n=36), and efficiency of care
 260 (n=36) (Fig 2). Details regarding the frequency of indicators for NAM domains and
 261 patient experience and provider experience are provided in Supplementary File 4, with
 262 examples of indicators and their stem groupings in Table 3.

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 264 **Figure 2: Alluvial diagram connecting virtual care modalities to the Quintuple Aim**
 265 **and quality domains.** Through the middle are the Quintuple Aim domains, with curved
 266 bars representing connection to the virtual care modality (left) and NAM quality domains
 267 (right). For example, the 59 mentions of remote monitoring (left) were mostly connected
 268 with patient experience, followed by population health outcomes, then provider
 269 experience. The thick vertical bars show the frequency compared to the other domains:
 270 virtual visits were the most common modality; patient experience was the most common
 271 Quintuple Aim domain; and patient-centredness was the most common NAM quality
 272 domain.

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 274 **Table 3: Examples of indicator-stem groupings and indicators within the**
 275 **Quintuple Aim, specific to virtual care.**

Examples of Indicator-Stem Grouping	Examples of Individual Indicators	Examples of Indicator Measurement
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(NAM Quality Domain)		
Quintuple Aim domain: Patient Experience		
Patient satisfaction (<i>Patient centeredness</i>) Usability (<i>Efficient</i>)	Patient satisfaction of virtual care compared to in-person consultations	5-point Likert scale – proportion of positive responses: “The clinical care I received during a virtual visit was the same as a face-to-face visit.” Telemedicine usability questionnaire: 18 items, 7-point Likert scale; higher mean score indicates higher satisfaction (usefulness, ease, interface quality, interaction quality, satisfaction and future use, reliability)
Effectiveness	Patient-perceived value of the virtual consultation.	Net promoter score – “recommend virtual visit to a friend” Virtual visits are more convenient than an office visit
Access to care (<i>Equitable</i>)	Ease of navigating access to a video appointment. Support to patients to overcome technical issues.	Proportion of patients requiring help with equipment Proportion of patients having trouble logging on to platform
Quintuple Aim domain: Provider Experience		
Provider satisfaction and preference	Provider satisfaction compared to in-person consultations.	5-item questionnaire using 0-100 Visual Analog Scales – overall score calculated by averaging responses
Infrastructure/organizational capacity (<i>Sustainable</i>)	Perceptions of effectiveness.	Telehealth Usability Questionnaire
Provider-patient workload/workflow (<i>Timely, efficiency</i>)	Provider and clinic efficiency.	Reduction in ‘no-shows’ and cancelled appointments Decrease in wait times for patients
Physician perspective of effectiveness (<i>Effective</i>)	Ability to evaluate/examine patient.	Likert scales – proportion of physicians that agree: I was confident with my ability to diagnose/make recommendations. I was able to effectively inform my patient.

Quintuple Aim domain: Population Health & Outcomes		
Follow-up Care	30- or 90-day outpatient follow-up.	Number or proportion of patients seen in follow-up after virtual visit
	Emergency Department use after virtual visit.	Number or proportion of patients seeking emergency care after virtual visit
Access to Care	Program usage.	Proportion of participants engaging with the platform/completing program
Clinical outcomes and measures	Clinical effectiveness of care.	Changes in clinical outcomes/disease markers
	Quality of life.	Changes in QoL as measured by validated scales: EQ-5D*, WHO-QL**
	Patient safety.	Incidence of adverse clinical events
Quintuple Aim domain: Cost		
Health system costs	Cost reduction.	Cost of standard visit compared to virtual visit
	Cost-effectiveness.	Cost of telemedicine implementation and maintenance
Patient Costs	Cost-avoidance.	Patient travel savings compared to in-office visits
Quintuple Aim domain: Equity		
Accessibility	Equal access to care.	Availability of appropriate connectivity/ technical services in rural areas
Financial impact	Time saved by the patient	Reduction in travel time
*EQ-5D: EuroQol-5 Dimensions – health-related quality of life scale		
**WHO-QL: World Health Organization-Quality of Life scale		

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278 **Specific Instruments Measuring Quality**

279 Throughout data extraction, several existing tools were mentioned for measuring quality
 280 of care. For patient experience, tools included Telemedicine/Telehealth usability
 281 questionnaires (n=18 studies); Telemedicine Satisfaction and Usefulness Questionnaire
 282 (n=3); and Service User Technology Acceptability Questionnaire (n=1). For provider

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3 283 experience the Telemedicine/Telehealth Usability Questionnaire (n=2) was used, while
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5 284 others only mention 5- and 10-point Likert scales with unique or custom question
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7 285 prompts. No specific measurement tools were mentioned for population health
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9 286 outcomes, costs, or health equity.
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14 288 **DISCUSSION**

16
17 289 This scoping review on quality measures for ambulatory virtual care found that within
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19 290 the Quintuple Aim, the most reported category assessing quality of virtual care was
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21 291 related to patient experience, followed by provider experience, and population health
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23 292 outcomes. There was limited mention of health system costs, patient costs, or equity.
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26 293 The most frequently mentioned virtual care modality was virtual visits in video and/or
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28 294 audio, followed by video visits only, remote monitoring programs, mobile applications,
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30 295 and self-monitoring tools. Within the NAM domains of quality for patient and provider
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32 296 experience, effectiveness was most common, followed by patient centeredness and
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34 297 efficiency, with limited mention of sustainability.
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40 299 Best practice guidelines for virtual care are required to realize integration of virtual care
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42 300 across health systems (17,18). This review provides the foundation for identification and
43
44 301 refinement of quality indicators in virtual care and highlights current gaps in assessment
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46 302 of virtual care performance indicators. Results indicate that further development of
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48 303 evaluation methods specifically analyzing the equitable and cost-efficient deployment of
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50 304 virtual care are needed. Measurement of quality of virtual care will support
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3 305 understanding performance gaps, and targets for future quality improvement efforts and
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5 306 benchmarking efforts across organizations.
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10 308 **Limited Attention on Equity, Sustainability, and Cost**

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12 309 It was noted that the majority of quality indicators were concentrated in specific domains
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14 310 such as patient experience and/or satisfaction, or provider experience and/or
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16 311 satisfaction, while the more complex indicators, such as equity, cost, and sustainability,
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18 312 were not as widely reported. The limited attention on equity is consistent with published
19
20 313 literature, such as the scoping review of reviews which highlights the lack of focus on
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22 314 equity assessments in virtual care deployments (19). Equity may have been more
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24 315 challenging to measure and integrate into program evaluation and may have been
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26 316 considered outside the scope of QI projects or time-sensitive deployments (such as
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28 317 during the COVID-19 pandemic) (20). This lack of consideration of equity is concerning,
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30 318 as virtual care has the potential to improve access to care for some typically
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32 319 underserved populations and worsen access for others (21), making it an essential
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34 320 consideration in understanding quality of care.
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42 322 Our review also noted limited attention in evaluations around sustainability of virtual
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44 323 care delivery. Sustainability maybe considered from multiple perspectives, including if
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46 324 the patient plans to continue to use the virtual options, or if the organization has the
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48 325 means (infrastructure, IT support etc.) to continue to deliver virtual care after the COVID-
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50 326 19 pandemic restrictions lessened. Further indicators are needed to monitor the
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52 327 continued need for and use of virtual care to assess if it remains a preferred and
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3 328 feasible option, especially within hybrid models of care delivery which includes both
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5 329 virtual and in person options. Considering sustainability is also important while taking a
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7 330 Learning Health Systems (LHS) approach across healthcare organizations and systems
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9 331 where the focus is on continuous learning and iterative advancement (22). Sustainability
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11 332 needs to be a key part of this systems-based approach, and thus quality indicators of
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13 333 virtual care that consider sustainability are needed.
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19 335 Indicators within the Quintuple Aim domain of cost were also rarely reported in the
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21 336 literature, for either patient costs or health system costs (This limited inclusion may
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23 337 partly be as cost can be difficult to measure and quantify in rapid virtual care
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25 338 deployments. This finding is consistent with a 2020 scoping review which analyzed the
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27 339 cost-effectiveness of telehealth to the healthcare system, which also highlighted this
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29 340 gap (23). Cost needs to be considered as part of evaluation of quality of virtual care,
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31 341 including in connection with sustainability of the service and the cost implications for
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33 342 patients, which also ties back to the topic of health equity and access to virtual care.
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40 344 **Evidence Synthesis of Virtual Care**

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42 345 There has been a considerable amount of work published about virtual care, and
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44 346 extensive synthesis of that work. About a third of literature included in this scoping
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46 347 review were reviews themselves, however, these reviews usually were limited and
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48 348 focused on a specific service or modality of virtual care such as patient portals (24),
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50 349 telehealth/phone visits (25,26) and video consultations (27,28). Few reviews assessed
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52 350 approaches or models for evaluating virtual care, or tools which specifically measured
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3 351 quality across multiple domains as identified by the Quintuple Aim and NAM
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5 352 frameworks. To the authors' knowledge, this is the first review which specifically
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7 353 evaluates quality in virtual care with a comprehensive approach in defining quality
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9 354 indicators and assessing their use against established quality frameworks.
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11 355 A report by the Canadian Agency for Drugs and Technology in Health (CADTH) which
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13 356 studied evaluations of virtual care was consistent with our findings (29). The CADTH
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15 357 report stated that evaluations should focus on ensuring the scope of the virtual care
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17 358 visits was appropriate for the care being administered, be conducted systematically, and
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19 359 that cost-analysis or cost-benefit evaluations be conducted with a specific viewpoint in
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21 360 mind – such as a patient or provider (29). The findings of this scoping review support
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23 361 these assertions from a quality perspective. A quality virtual care program is clear in its
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25 362 scope, has dedicated resources for ongoing evaluations, and specifically investigates
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27 363 the impact of the program from the patient perspective, provider perspective, or both.
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35 365 **Leveraging Review Results: Next Steps**

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37 366 This review provides the foundational knowledge base of existing quality indicators of
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39 367 virtual care across domains of quality and organized within established quality
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41 368 frameworks. This knowledge base will be further refined and distilled through a modified
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43 369 Delphi approach with key knowledge users and decision makers, including patients,
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45 370 healthcare professionals, virtual care experts, and policymakers, to help add indicators
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47 371 to address gaps, and rate and rank existing indicators based on feasibility, relevance,
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49 372 and utility.
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3 373 A subset of high-ranked indicators across quality domains will then be translated into a
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5 374 balanced score card for evaluating the quality of virtual care.
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11 376 An understanding of how to define quality in virtual care and measure performance is
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13 377 key to the development and growth of a potential LHS, which aims to enable cycles of
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15 378 continuous learning and improvement to be routinised and embedded across the
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17 379 healthcare system (30). A LHS is the combination of a health system and research
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19 380 system that, at all levels, is anchored on patient's needs, perspectives, and aspirations;
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21 381 driven by timely data and evidence; supported by appropriate decision supports, aligned
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23 382 governance, financial and care delivery arrangements; and enabled with a culture of,
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25 383 and competencies for, rapid learning and improvement (31). Further, it is a system in
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27 384 which science, informatics, incentives, and culture are aligned for continuous
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29 385 improvement and innovation, and thus our domains of quality for virtual care can be
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31 386 integrated into this approach. Ideally, best practices, including best practices in virtual
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33 387 care, are seamlessly embedded in the delivery process, patients and families are active
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35 388 participants in all elements, and new knowledge capture is an integral by-product of
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37 389 delivery experience (30). Ultimately, the deployment of virtual care should follow an LHS
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39 390 approach, with consistent revision and adjustment of virtual care initiatives to reflect
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41 391 dynamic contexts and adapt based on new evidence. Mapping the current knowledge
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43 392 base aims to provide organizations quick references for improving and iterating their
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45 393 virtual care program. Working towards true integration of virtual care into a LHS is
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47 394 subject to further research and implementation.
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396 **Strengths and Limitations**

397 This scoping review used a wide range of published and grey sources, covered a vast
398 breadth of literature, and applied rigorous methods for data extraction and coding. The
399 body of literature included in this review also represents the current state of publications
400 on virtual care, as the search was updated as the project progressed. However, our
401 search strategy was limited to English only, and relying on the past seven years meant
402 that foundational work on the implementation of virtual care may have been excluded.
403 A key strength of this work was our categorization of existing indicators across
404 established quality frameworks (NAM and sustainability, Quintuple Aim) to identify
405 which quality domains of virtual care are present and lacking within the current
406 literature. However, there is considerable overlap between the NAM domains for
407 categorization, and extensive differences in the way indicators were explained in the
408 published studies, typically with very little detail. Indicators could overlap and routinely fit
409 within more than one quality domain, and the lack of detail provided about each
410 indicator meant that some assumptions were made, leading to subjectivity with current
411 results. For example, patient-centered care was used very differently across studies,
412 with some having it synonymous with patient satisfaction, while others acknowledged
413 the multiple factors and complexity in delivery patient-centered care. To address this
414 limitation we dual-coded all indicators, resolved discrepancy with a third reviewer and
415 will be working with interprofessional decision makers and persons with lived
416 experience as we develop the balanced scorecard. The lack of reporting on how
417 indicators were selected when measuring quality of care, the lack of detail provided, and
418 the lack of reported knowledge user (patient, provider, management etc.) involvement,

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3 419 further highlighted the need for a consensus-based approach to finalize a concise list of
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5 420 virtual care quality indicators across all quality domains.
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10 422 **CONCLUSION**

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12 423 To ensure delivery of high quality virtual care, it is imperative to understand what is
13
14 424 “quality” in virtual care. By identifying and mapping indicators of quality of virtual care to
15
16 425 the Quintuple Aim and the NAM framework, we aim to deepen our understanding of
17
18 426 these indicators and identify gaps. The most reported category assessing quality of
19
20 427 virtual care was related to patient experience, followed by provider experience, and
21
22 428 population health outcomes. There was limited mention of health system costs, patient
23
24 429 costs, or equity, which limits our understanding of quality of virtual care initiatives, these
25
26 430 gaps highlight the need for development of new indicators, and a consensus-based
27
28 431 process with knowledge users to create a prioritized list. Future work will add and
29
30 432 further refine the quality indicators through a modified Delphi approach, with the aim to
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32 433 provide decision-makers with a balanced scorecard for the implementation of quality
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34 434 virtual care initiatives moving forward.
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3 437 **Author Contributions**
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5 438 Conceptualization: Geetha Mukerji
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8 439 Formal Analysis: Sam Petrie, Celia Laur, Patricia Rios
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10 440 Funding Acquisition: Geetha Mukerji
11

12 441 Investigation: Sam Petrie, Celia Laur, Toni Makanjoula, Patricia Rios, Geetha Mukerji,
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14 442 Ally Suarez
15

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17 443 Writing – Original Draft Preparation: Sam Petrie, Celia Laur
18

19 444 Writing – Reviewing & Editing: Celia Laur, Patricia Rios, Ally Suarez, Toni Makanjoula,
20
21 445 Geetha Mukerji, Onil Bhattacharyya, Emeraldalda Burke
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27

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33 450
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35 451 **CONFLICT OF INTEREST**
36

37 452 The authors have no conflict of interest to declare.
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3 458 **DATA AVAILABILITY STATEMENT**
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5 459 No additional data available.
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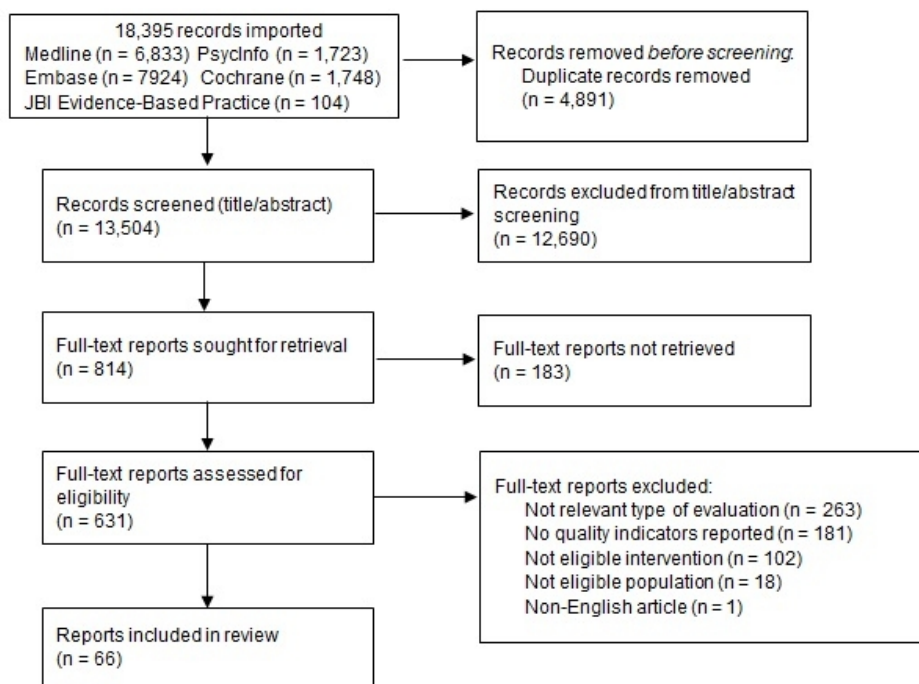
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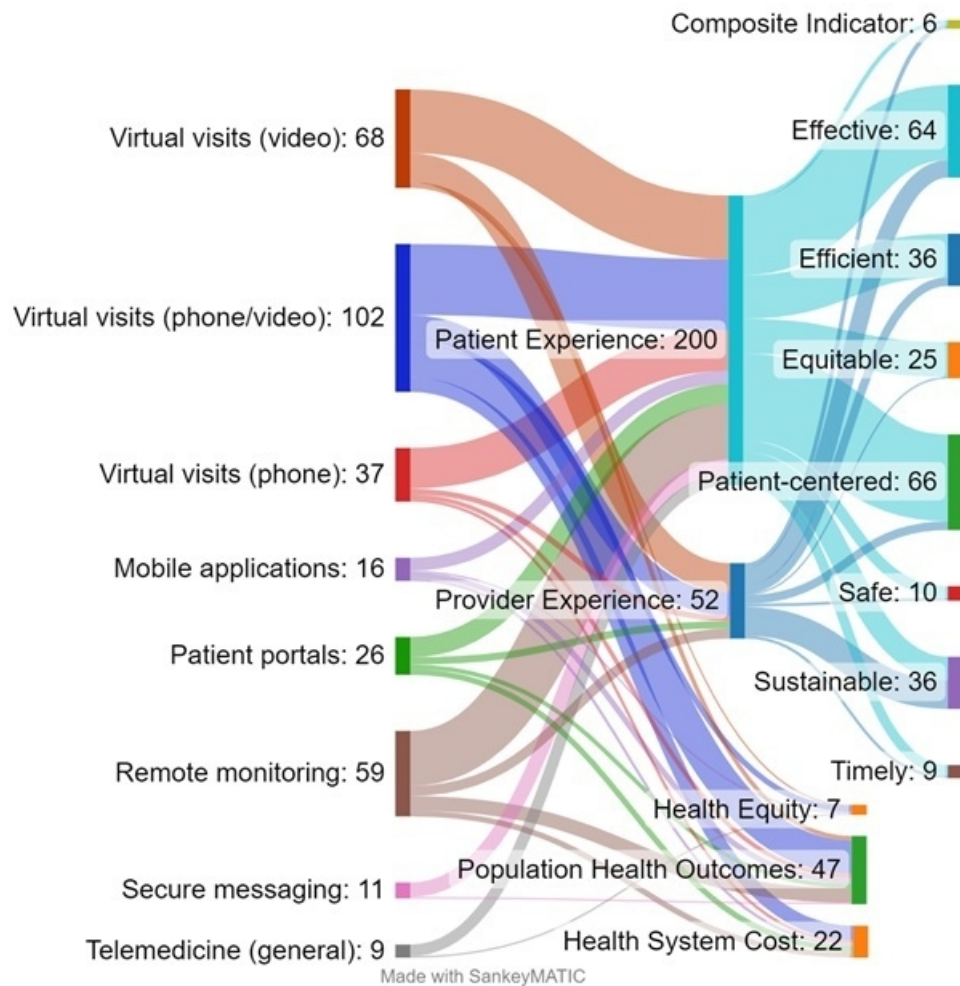
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31 576 30. Best Care at Lower Cost: The Path to Continuously Learning Health Care in
32 577 America [Internet]. Washington, D.C.: National Academies Press; 2013 [cited 2023
33 578 May 5]. Available from: <http://www.nap.edu/catalog/13444>
- 34
35 579 31. Lavis JN, Gauvin FP, Mattison CA, Moat KA, Waddell K, Wilson MG, et al. Rapid
36 580 synthesis: Creating rapid-learning health systems in Canada [Internet]. Hamilton,
37 581 Canada: McMaster Health Forum; 2018 Dec p. 36. Available from:
38 582 [https://www.mcmasterforum.org/docs/default-source/product-documents/rapid-](https://www.mcmasterforum.org/docs/default-source/product-documents/rapid-responses/creating-rapid-learning-health-systems-in-canada.pdf?sfvrsn=4)
39 583 [responses/creating-rapid-learning-health-systems-in-canada.pdf?sfvrsn=4](https://www.mcmasterforum.org/docs/default-source/product-documents/rapid-responses/creating-rapid-learning-health-systems-in-canada.pdf?sfvrsn=4)

584



PRISMA study flow diagram

54x39mm (300 x 300 DPI)



Alluvial diagram connecting virtual care modalities to the Quintuple Aim and quality domains. Through the middle are the Quintuple Aim domains, with curved bars representing connection to the virtual care modality (left) and NAM quality domains (right). For example, the 59 mentions of remote monitoring (left) were mostly connected with patient experience, followed by population health outcomes, then provider experience. The thick vertical bars show the frequency compared to the other domains: virtual visits were the most common modality; patient experience was the most common Quintuple Aim domain; and patient-centredness was the most common NAM quality domain.

52x52mm (300 x 300 DPI)

S1 Table - Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5-6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	No protocol registered
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	7
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary Material 2
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	7-8
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8-9
Critical appraisal of individual	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe	N/A

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
sources of evidence§		the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	9
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	9-10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	10-12
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	13-18
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	13-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-22
Limitations	20	Discuss the limitations of the scoping review process.	23
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	24
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	23

JB1 = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. doi: [10.7326/M18-0850](https://doi.org/10.7326/M18-0850).

Screening Criteria

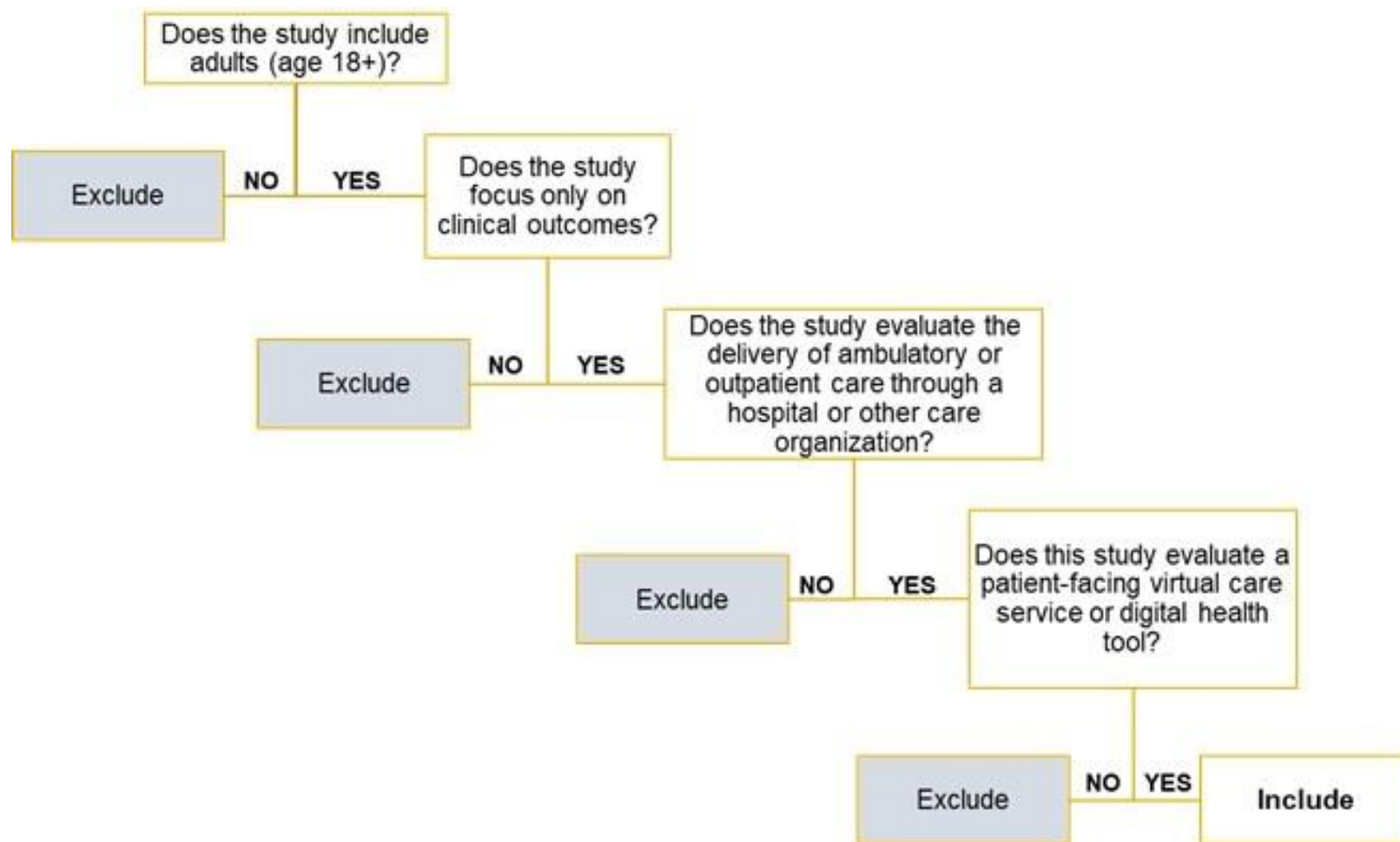


Table 1 - Database search strategies

Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE® 1946-2022	
#	Query
1	exp telemedicine/
2	exp internet-based intervention/
3	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,kf.
4	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,kf.
5	(((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)) and patient*).tw,kf.
6	(((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,kf.
7	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kw,kf. or (virtual care or virtual health).tw,kf. or (rapid* adj3 virtual*).tw,kf.
8	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,kf.
9	(digital health or digital first).tw,kf.
10	("e health*" or ehealth* or evisit* or "e-visit").tw,kf.
11	(online adj3 (healthcare or health care)).tw,kf.
12	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kf.
13	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or "tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or

	"tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,kf.
14	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
15	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or ediagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhEALTH or "M-HEALTH").tw,kf.
16	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kf.
17	(virtual* adj3 monitor*).tw,kf.
18	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,kf.
19	mobile health monitor*.tw,kf.
20	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19
21	"Outcome and Process Assessment, Health Care"/
22	Quality Assurance, Health Care/
23	Benchmarking/
24	Total Quality Management/
25	Quality Improvement/
26	Quality Indicators, Health Care/
27	"Utilization Review"/
28	Patient Outcome Assessment/

29	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,kf.
30	(quality adj3 (indicat* or metric* or standard* or measure*)).tw,kf.
31	21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
32	20 and 32
33	limit 33 to (english language and yr="2015 -Current")
Embase Classic+Embase 1947 to 2022	
1	telecommunication/
2	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,kw.
3	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,kw.
4	((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)).tw,kw. and patient*.tw, kw.
5	((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,kw.
6	((virtual* or digital*) adj3 (healthcare or health care or health strategy)) or (virtual care or virtual health) or (rapid* adj3 virtual*).tw,kw.
7	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,kw.
8	(digital health or digital first).tw,kw.
9	("e health*" or ehealth* or evisit* or "e-visit*").tw,kw.
10	(online adj3 (healthcare or health care)).tw,kw.
11	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,kw.

12	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or "tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or "tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,kw.
13	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kw.
14	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or edagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhHEALTH or "M-HEALTH").tw,kw.
15	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,kw.
16	(virtual* adj3 monitor*).tw,kw.
17	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,kw.
18	mobile health monitor*.tw,kw.
19	wearable computer/
20	or/1-19
21	Health care quality/
22	Benchmarking/
23	Total quality management/
24	"utilization review"/

25	(quality indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,kw
26	(quality adj2 (indicat* or metric* or standard* or measure*)).tw,kw.
27	Or/21-26
28	20 and 27
29	limit 28 to (english language and yr="2015 - 2021")
PsycInfo	
1	exp telemedicine/
2	(remot* adj2 (consult* or interact* or diagnos* or monitor* or treat* or therap* or care)).tw,sh.
3	(telemonitor* or telemedicine* or telecommunication* or telehealth*).tw,sh.
4	((((remote or online or video* or text message* or telephone* or phone or phones or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (communicat* or engag* or discuss* or care or interact* or clinical guidance)) and patient*).tw,sh.
5	((((remote or online or electronic* or video* or text message* or telephone* or phone* or email* or technolog* or virtual* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or whatsapp or skype or zoom or instant messag* or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj3 (consult* or appointment* or meet or meeting* or visit*)) or virtual tool*).tw,sh.
6	((((virtual* or digital*) adj3 (healthcare or health care or health strategy)) or (virtual care or virtual health) or (rapid* adj3 virtual*)).tw,sh.
7	((online or digital* or virtual*) adj3 (doctor* or physician* or clinic or clinics or nurse or nurses or nursing or medicine or medical)).tw,sh.
8	(digital health or digital first).tw,sh.
9	("e health*" or ehealth* or evisit* or "e-visit*").tw,sh.
10	((virtual* or digital*) adj3 (healthcare or health care or health strategy)).tw,sh.
11	(teleassist* or "tele-assist*" or teleaudiolog* or "tele-audiolog*" or telebased or "tele-based" or telecancer or "tele-cancer" or "tele-cardiolo*" or telecardiolog* or teleconsult* or "tele-consult*" or telecounselling or "tele-counselling" or telecounseling or "tele-counseling" or teledental or

	"tele-dental" or telederm* or "tele-derm*" or telediagnos* or "tele-diagnos*" or teledialysis or "tele-dialysis" or teleecho* or "tele-echo*" or teleemerg* or "tele-emerg*" or teleepileps* or "tele-epileps*" or telefollow* or "tele-follow*" or teleguidance or "tele-guidance" or "tele-health*" or telehome* or "tele-home*" or teleICU or "tele-ICU" or teleintervention* or "tele-intervention*" or telemanag* or "tele-manag*" or telemedicine or "tele-medicine" or telemental* or "tele-mental*" or telemonitor* or "tele-monitor*" or telenurs* or "tele-nurs*" or teleoncolo* or "tele-oncolo*" or teleophthalm* or "tele-ophthalm*" or telepalliat* or "tele-palliat*" or "tele-patholog*" or teleprocedu* or "tele-procedu*" or telepsych* or "tele-psych*" or teleradiol* or "tele-radiol*" or telerefer* or "tele-refer*" or telerehab* or "tele-rehab*" or telesurger* or "tele-surger*" or telesurgic* or "tele-surgic*" or teletherap* or "tele-therap*" or teletreat* or "tele-treat*" or teletriage or "tele-triage").tw,sh.
12	(tele adj (care or counselling or counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,sh.
13	("e-care" or ecare or "e-consult*" or econsult* or "e-diagnos*" or ediagnosis* or "e-medicine" or emedicine or "e-nurse*" or enurse* or "e-nursing" or enursing or "e-physician*" or ephysician* or "e-psych*" or epsych* or "e-therapy" or etherapy or mhEALTH or "M-HEALTH").tw,sh.
14	((online or video* or text message* or telephone* or phon* or email* or virtual* or technolog* or iphone* or smartphone* or mobile application* or mobile app* or teleconferenc* or messenger or instant messag* or whatsapp or skype or zoom or tablet* or e-mail* or asynchronous messag* or synchronous messag* or Videoconferenc* or hotline* or helpline* or call center*) adj2 (care or counselling or Counseling or diagnos* or health* or intervention* or manag* or therap* or treat* or medicine or medical or nursing)).tw,sh.
15	(virtual* adj3 monitor*).tw,sh.
16	((implant* sensor* or body sensor*) adj4 (diagnost* or monitor* or report*)).tw,sh.
17	mobile health monitor*.tw,sh.
18	(online adj3 (healthcare or health care)).tw,sh.
19	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (quality
20	indicat* or quality metric or quality standard* or quality measure* or quality report* or performance measure* or metric or performance metric or usability or care evaluation or benchmark* or scorecard or balanced scorecard or logic model).tw,sh.
21	(quality adj3 (indicat* or metric* or standard* or measure*)).tw,sh.
22	exp "quality of services"/
23	exp "Quality of Care"/
24	exp Program Evaluation/

25	20 or 21 or 22 or 23 or 24
26	19 and 25
27	limit 26 to (english language and yr="2015 - 2021")
	Cochrane Library
#1	MeSH descriptor: [Telemedicine] explode all trees
#2	MeSH descriptor: [Internet-Based Intervention] explode all trees
#3	(remote consult*) or (remote interact*) pr (remote diagnos*) or (remote monitor*) or (remote treat*) or (remote therap*) or (remote care):ti,ab,kw
#4	(virtual health*) or (digital health*) or (online health*) or (ehealth*) or (mobile health*):ti,ab, kw
#5	#1 or #2 or #3 or #4
#6	MeSH descriptor: [Quality of Health Care] this term only
#7	MeSH descriptor: [Outcome and Process Assessment, Health Care] this term only
#8	MeSH descriptor: [Quality Assurance, Health Care] this term only
#9	MeSH descriptor: [Benchmarking] this term only
#10	MeSH descriptor: [Total Quality Management] this term only
#11	MeSH descriptor: [Quality Improvement] this term only
#12	MeSH descriptor: [Quality Indicators, Health Care] this term only
#13	MeSH descriptor: [Utilization Review] this term only
#14	MeSH descriptor: [Patient Outcome Assessment] this term only
#15	(quality indicat*) or (quailty metric*) or (quality standard*) or (quality measure*) or (quality report*) or (performance measure*) or (performance metric*) or (usability) or (care evaluation) or (scorecard) or (balanced scorecard) or (logic model):ti,ab,kw
#16	#6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15
#17	#5 and #16 with Cochrane Library publication date Between Jan 2015 and Present

Table 2 - Grey Literature Search

Targeted Website Searches

<i>Organization name & website URL</i>	<i>Search strategy(s)/ terms searched</i>
McMaster Health Forum www.healthsystemevidence.org	1. (virtual care OR digital health) AND quality 2. Telemedicine AND quality indicators
Publications Canada https://publications.gc.ca	1. Virtual care 2. Telemedicine 3. eHealth
Health Quality Ontario http://www.hqontario.ca/Evidence-to-Improve-Care/Health-Technology-Assessment	1. Virtual care 2. Telemedicine 3. Telehealth
NICE www.nice.org.uk	1. Virtual care 2. Telemedicine 3. Telehealth 4. Digital care
AHRQ - EPC http://www.ahrq.gov/research/findings/evidence-based-reports/search.html	1. Virtual care 2. Telemedicine 3. Telehealth
AHRQ – EHC https://effectivehealthcare.ahrq.gov/products-tools/	1. Virtual care 2. Telemedicine 3. Telehealth
Canadian Medical Association www.cma.ca	1. Virtual care 2. Telemedicine 3. Telehealth
Institute for Healthcare Improvement – White Papers www.ihc.org	N/A – no search function, reviewed ‘Publications’ and ‘White Papers’ section of site
Health Quality Council of Alberta http://hqca.ca/studies-and-reviews/completed-reviews/	1. Virtual care 2. Telemedicine 3. Telehealth
INATHA Secretariat http://www.inahta.org/publications	1. Virtual care 2. Telemedicine 3. Telehealth
WHO Health Evidence Network http://www.euro.who.int/en/what-we-do/data-and-evidence/health-evidence-network-hen/publications/by-keyword	1. Virtual care 2. Telemedicine 3. Telehealth
Targeted Database Searches	
<i>Database name & URL</i>	<i>Search strategy(s)/ terms searched</i>
Google Scholar scholar.google.com	1. “virtual care” AND quality indicators 2. Telemedicine AND quality indicators 3. eHealth AND quality indicators
MedRXiv www.medrxiv.org	1. Virtual care quality indicator 2. Telemedicine quality indicator Results screened by 1 reviewer, 23 items selected for further screening

OpenGrey http://www.opengrey.eu/	1. Virtual care Telemedicine
Targeted Journal Search	
<i>Journal Name</i>	<i>Search strategy(s)/ terms searched</i>
Journal of Medical Internet Research	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Lancet Digital Health	Hand-searched (reviewed table of contents) of all editions in previous 2 years
Nature Digital Medicine	Hand-searched (reviewed table of contents) of all editions in previous 2 years

Table: Frequency of NAM quality domain sub-codes.

<i>NAM Quality Domain</i>	Patient Experience (n=200)	Provider Experience (n=52)
<i>Effective (n=64) [n (%)]</i>	52 (81)	12 (19)
<i>Equitable (n=25) [n (%)]</i>	24 (96)	1 (4)
<i>Efficient (n=36) [n (%)]</i>	30 (83)	6 (17)
<i>Patient-centered (n=66) [n (%)]</i>	60 (91)	6 (9)
<i>Safe (n=10) [n (%)]</i>	8 (80)	2 (20)
<i>Timely (n=9) [n (%)]</i>	7 (78)	2 (22)
<i>Sustainable (n=36) [n (%)]</i>	16 (44)	20 (56)
<i>Composite (n=6) [n (%)]</i>	3 (50)	3 (50)
*Indicators that address more than one of the NAM quality domains		