

# Internet of things in the management of chronic diseases during the COVID-19 pandemic: A systematic review

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## Abstract

**Introduction:** The use of new technologies such as the Internet of Things (IoT) in the management of chronic diseases, especially in the COVID pandemics, could be a life-saving appliance for public health practice. The purpose of the current study is to identify the applications and capability of IoT and digital health in the management of the COVID-19 pandemic.

**Methods:** This systematic review was conducted by searching the online databases of PubMed, Scopus, and Web of Science using selected keywords to retrieve the relevant literature published until December 25th, 2021. The most relevant original English studies were included after initial screening based on the inclusion criteria.

**Results:** Overall, 18 studies were included. Most of the studies reported benefits and positive responses in the form of patients' and healthcare providers' satisfaction and trust in the online systems. Many services were provided to the patients, including but not limited to training the patients on their conditions; monitoring vital signs and required actions when vital signs were altered; ensuring treatment adherence; monitoring and consulting the patients regarding diet, physical activity, and lifestyle.

**Conclusion:** IoT is a new technology, which can help us improve health care services during the COVID-19 pandemic. It has a network of various sensors, obtaining data from patients. We have found several applications for this technology. Future studies can be conducted for the capability of other technologies in the management of chronic diseases.

## KEYWORDS

chronic diseases, COVID-19, IoT, Sensor, Telehealth

## 1 | INTRODUCTION

Digital technologies include the internet of things<sup>1-4</sup> with next-generation telecommunication networks (like 5G); big-data analytics; artificial intelligence (AI) that uses deep learning; and blockchain

technology.<sup>5-7</sup> The Internet of Things (IoTs)<sup>1</sup> is a collection of interconnected devices, objects, humans, and services that share data to accomplish a common goal in diverse areas and applications.<sup>1,8</sup> IoT is used in healthcare and it has rapid development.<sup>9</sup> In the health sector, IoT has drastically reformed the lives of people by providing a

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considerable enhancement in healthcare in clinical settings and out of them.<sup>10</sup> IoT allows integrating physical devices capable of connecting to the Internet and provides real-time health status of the patients to clinicians. It can also provide a platform that allows public health agencies to access the data for monitoring particularly during the coronavirus disease 2019 (COVID-19) pandemic.<sup>10,11</sup> Coronavirus disease (COVID) is a contagious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2),<sup>12</sup> which can be spread through nasal discharge and saliva droplets caused by sneeze or cough of infected people.<sup>13–15</sup> Some uses of IoT are directly related to mitigating the spread of the COVID virus (e.g., contact tracing, screening of temperature, etc.) whereas others seek to facilitate the novel normal created by the pandemic (e.g., working from home, homeschooling, home fitness, etc.).<sup>9,16</sup> Telehealth provided continuous care and minimized the risk of COVID-19 transmission by preventing direct physical contact, and reduced morbidity and mortality of patients and health providers during COVID-19 outbreak.<sup>17</sup>

There are five components of IoT that serve intelligent medical services and shape a rounded healthcare system including sensor technology, smart hospital, big-data analysis, clouding computing, and intelligence network. The system starts with the sensor gathering information.<sup>18</sup> The gathered information goes to the subsequent stage, which is a smart network to interact with the system.<sup>3,4,6</sup> The transferred information through this network is stored at the third stage of the healthcare system which is cloud computing. Following the data storage, the information must be investigated and analyzed for proper choices in the fourth stage of big data analysis.<sup>19</sup> Following an appropriate decision based on the stored data, refined information is transferred to a smart medical clinic to communicate the result to medical services experts. The smart clinic conducts activities for fitting diagnoses and treatment. Although the smart clinic is the latter part of the IoT healthcare services system, it maintains information gathering to ensure that the framework has fixed analysis and treatment. Henceforth, the system again moves to the first stage to maintain the circularity of the system.<sup>18–20</sup>

A chronic disease is a long-lasting disease, usually 3 months or more, that usually does not disappear or does not have a definite cure, usually limits activity or decreases the quality of life, and requires ongoing medical attention.<sup>21</sup> The use of new technologies in the management of chronic diseases, especially in the COVID pandemics, could be a life-saving appliance for public health practice<sup>22</sup>; even though, these potential solutions like AI and IoT may have challenges and categorized into physical, operational, resource-based, organizational, technological, and external health care issues.<sup>23</sup> An analysis, based on a unique decision support system (DSS), introduced policy implications that allocate a limited set of IoT devices to a larger number of patients, to balance the other requirements to improve the conditions of the most severe patients but to maximize the device use efficiency.<sup>24</sup>

In a systematic review, results showed that the most innovative technologies and digital solutions have been proposed for the COVID-19 diagnosis. Numerous suggestions have been identified on the use of AI-powered tools for the screening and diagnosis of

COVID-19. Digital technologies are also useful for prevention and surveillance measures, such as contact-tracing apps and monitoring of internet searches and social media usage. But fewer scientific contributions report the use of digital technologies for lifestyle empowerment or patient engagement.<sup>25</sup> Another review identified clinical and operational applications of AI, telehealth, big data analytics, and other relevant digital health solutions for public health responses in the healthcare operating environment. Although, this study's design weakness limits its generalizability and translation, highlighting the need for more pragmatic real-world investigations. There were also few descriptions of applications for digital platforms for communication (DC) (10.9%), the IoT (2.0%), digital structural screening<sup>26</sup> (8.9%), and digital solutions for data management<sup>27</sup> (1.6%); representing opportunities and gaps for digital public health. In addition, the performance of digital health technology for operational applications associated with population surveillance and points of entry has not been effectively assessed.<sup>28</sup> The purpose of the current study is to identify the features, functions, and applications of IoT and digital health in chronic diseases management during the COVID-19 pandemic.

## 2 | METHODS

This study was a systematic review conducted on June 22nd, 2021 (update on December 25th, 2021) by searching the online databases for the relevant literature using selected keywords. This systematic review is reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) checklist.<sup>29</sup>

### 2.1 | Data sources

We conducted a systematic literature search using the following online databases: PubMed, Scopus, and Web of Science. Also, we carried out hand searches from the reference lists of retrieved studies.

### 2.2 | Search strategy

The specific search strategies were carried out by the primary author and correspondence. Keywords adjoined in a highly-sensitive syntax via the Boolean operator OR. The complete search strategy is as follows:

1. COVID-19, SARS-CoV-2, 2019-nCoV, coronavirus.
2. "Internet of Things" OR IoTs OR "Internet of Medical Things" OR IoMT OR "Internet of Objects" Sensor OR "smart hospital" OR "smart home" OR "intelligence network" OR "embedded systems" OR "wireless sensor networks" OR telehealth OR telemedicine OR m-health.

3. "Heart disease" OR hypertension OR cancer OR diabetes OR "Kidney failure" OR HIV OR AIDS OR "Chronic lung disease" OR "liver disease" OR "chronic disease."
4. Design OR development OR implementation OR system OR app.
5. [A] AND [B] AND [C] AND [D].

### 2.3 | Eligibility criteria

The relevant original English studies that report the development and deployment of IoT-based systems were included applying the following exclusion criteria:

1. Nonoriginal studies, including review articles, meta-analyses, conference abstracts, and editorial.
2. Unavailability of full texts.
3. Ongoing clinical trials with unpublished results.
4. Articles that report patient experience and satisfaction.

### 2.4 | Data retrieval

The EndNote 9 software was used to organize articles identified in the literature review. Search results from reviewed databases combined in a single EndNote library and duplicate records of the same reports removed.

### 2.5 | Data screening

Two authors from the research team independently screened the retrieved articles in different steps. First, they screened the title and abstract of the records and the ineligible studies were removed. Then, the authors examined the full text of the remaining studies based on inclusion and exclusion criteria and the eligible studies were identified.

### 2.6 | Data extraction

We extracted the following data: first author, type of study, country, IoT or sensor/technology, type of chronic disease, applications, feature and function, summary of findings. Three researchers extracted and organized the findings of included studies into a table. An independent researcher reviewed the extracted data and solved any discrepancies and issues among the other researchers.

### 2.7 | Quality assessment

We used the Newcastle-Ottawa scale (NOS) to analyze the risk of bias of the studies.<sup>30</sup> NOS provide a maximum score of nine for each study in three categories of selection, comparability, and exposure. We defined a score of four or below as "poor," and above that as "acceptable."

## 3 | RESULTS

We identified 1239 records following the initial search of online databases, and after removing duplicates, 818 studies remained. Of these, 225 entered full-text screening, and finally, 18 eligible studies were included in this systematic review. Figure 1 illustrates the screening process of the present study (Tables 1 and 2).

The included were conducted in 9 countries, including Italy ( $n = 7$ ), Singapore, the United States, and Israel ( $n = 2$  each), and Iran, Tunisia, Argentina, United Kingdom, and Libya ( $n = 1$  each). All the studies performed as acceptable in the quality assessment, and the mean (SD) score of them was  $6.3 \pm 1.0$  out of 9.

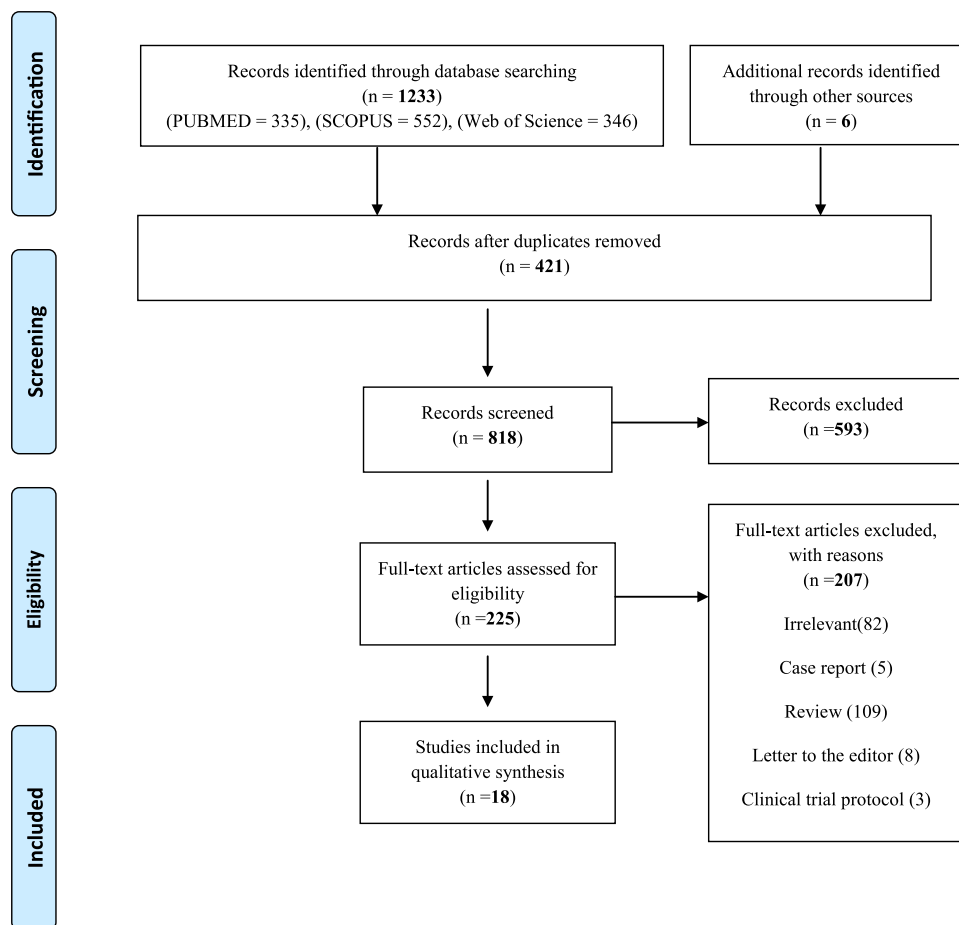
Some of the studies adopted a system that addresses various chronic conditions,<sup>26,34,38,40,41</sup> while, others designed their systems specifically for a distinct chronic conditions such as cancers,<sup>45-47</sup> celiac disease,<sup>37,42</sup> transient ischemic attack<sup>22</sup>, minor stroke,<sup>31</sup> type 2 diabetes mellitus<sup>27</sup> or prediabetes,<sup>32</sup> type 1 DM,<sup>44</sup> inflammatory bowel disease (IBD),<sup>33</sup> multiple sclerosis (MS),<sup>36</sup> connective tissue diseases,<sup>37</sup> chronic liver disease,<sup>39</sup> and chronic heart failure.<sup>43</sup>

Most of the studies gathered information using questionnaires that included questions regarding the benefits of the designed systems and observed positive results in forms of satisfaction of patients and healthcare providers, trust in the system, and so forth.<sup>31,32,35-39,43</sup> Many services were delivered to the patients, including but not limited to training the patients on their conditions; monitoring vital signs and required actions when vital signs were altered; ensuring treatment adherence; monitoring and consulting the patients regarding diet, physical activity, and lifestyle; monitoring the patients' environment; providing contact to the healthcare provider, patient, patient's relatives, and administrator; scheduling outpatient or online visits; conducting and monitoring test results (glucose, gluten contamination, etc.); online consults and phone calls for COVID-19 education, risk-stratification, screening, and diagnosis; emergency alerts; data storage for clinical profile; management of health insurance; providing social, financial, logistical, political, and other kinds of support; and so forth.

Such important measures seemed necessary during the pandemic, as they facilitated healthcare delivery to the patients and minimized their need for in-person meetings; as such meetings increase the risk of contracting the SARS-CoV-2 virus in the patients already suffering from chronic diseases.<sup>33,46,47</sup> Using up-to-date technologies could help better address the patients' needs and improve their experience of chronic disease management during the pandemic, to adequately replace the role of in-patient and physical experiences.<sup>37,45</sup>

## 4 | DISCUSSION

In late 2019, the COVID-19 pandemic has begun and yet many countries have failed to control this pandemic, which harms the health care system and could disrupt the management of chronic diseases. Several mobile- and web-based applications and technologies have been developed during this pandemic to monitor the health of individuals and prevent unnecessary hospital visits. One



**FIGURE 1** Search results from different databases

of these technologies is the Internet of things. Internet of things<sup>1</sup> offers the connectivity of physical objects with the Internet, and data can be sent or received through the Internet.<sup>11</sup> These things can interact with the internet by using various sensors, actuators, and gateways for reinforcement communication and are built with suitable procedure stacks which help them interact with each other and communicate with the end-users, who create a core part of the internet.<sup>48</sup>

IoT contains a network of sensors, gathering data both locally and remotely.<sup>11</sup> The results indicate that these data could have different applications concerning the patient's health in chronic diseases. From the included studies in this review, we found that one of the major usages of this technology is to monitor the patient's vital signs such as heart rate, blood pressure, oxygen saturation, and body temperature, which can help the health care providers to manage their patients virtually through the internet. According to Hassen et al. the patient's health monitoring in this suggested system is carried out by the nurse who periodically visits the patient according to the plan set by the supervising doctor to measure vital signs through an Android application installed on a tablet device and make a medical report that is sent to the doctor on every visit made.<sup>34</sup> Another study proposes the usage of IoT in monitoring and tracking glucose levels in patients with type 2 diabetes mellitus to improve

their treatment methods and general health. Ang et al. discovered that the mobile app and continuous glucose monitoring allowed the simultaneous tracking of diet, physical activity, and glucose, for interventions that were highly personalized and situational.<sup>32</sup>

Another important application of IoT is telemedicine such as tele-visits and tele-consulting for patients with chronic diseases who cannot go to the hospital because of the COVID-19 pandemic. According to Costantino et al., telemedicine has been often recognized as an appreciated tool with enormous potential and through advanced communication technologies, mostly computers and mobile phones, health care providers (HCPs) can interact long-distance with patients with mainly live videoconferencing, permitting for communicating consultation and instant interventions.<sup>35</sup> In addition to the previous study, Horrell LN, et al. found that as telehealth accessibility increases, health care providers (HCPs) can enhance virtual visits by focusing on patients' top concerns during the pandemic.<sup>26</sup> The present review also showed that IoT can be used for therapeutic and behavioral adjustments, training the patients about COVID-19, improving the patients' quality of life, and follow-up. On the other hand, Darcourt et al. stated that, although most of their physicians face no problem taking care of their patients using video visits, they expressed worries about the quality of care or lost important data because of a lack of physical examination.<sup>45</sup>

TABLE 1 Details of the included studies

ID	First author (reference)	Type of study	Country	Technology	Chronic disease/Disorder	Applications	Feature and function	Summary of findings
1	Ajčević et al. <sup>31</sup>	Clinical trial	Italy	Telemonitoring system	TIA/minor stroke patients at risk of stroke recurrence in their early post-acute phase (<14 days after the ischemic event)	<ol style="list-style-type: none"> <li>(1) Monitoring vital signs: HR, BP, SpO<sub>2</sub>, temperature</li> <li>(2) Therapeutic and behavioral adjustments</li> </ol>	Portable devices are used to monitor the vital signs remotely. The system also has a gateway, a panic-button, and a dedicated ICT platform. Using the abovementioned pathways, the system allows emergency interventions and adjustments based on vital signs alterations.	The study on 8 patients showed prompt and remote ability to monitor patients' vital signs, leading to a better adjustment of medical and behavioral therapies. The patients had significantly improved quality of life, as well as reduced anxiety and depression. The telemonitoring system had acceptable interface quality, ease of access, and user satisfaction. The patients had complete medical adherence and no stroke/TIA recurrence or admissions to emergency departments in the 3 months follow-up period.
2	Ang et al. <sup>32</sup>	Clinical trial	Singapore	Personalized mobile health intervention program	Patients with type 2 DM or prediabetes	<ol style="list-style-type: none"> <li>(1) Monitoring glucose (continuously), physical activity, and diet. Provides</li> <li>(2) Health coaching</li> </ol>	<p>In-person features +</p> <ol style="list-style-type: none"> <li>(3) Glucose monitoring device is continuous,</li> <li>(4) Physical activity and dietary intake is monitored via mobile app and access provided by messaging the doctor and dietician,</li> <li>(5) Mobile app allowed context-sensitive digital health coaching</li> </ol>	All 21 participants found the 3-month program beneficial and scored a mean between 9.0 to 10 on the Likert scale for satisfaction questions. Mean HbA1C dropped from 7.6% to 7.0% ( $p = 0.004$ ), with no severe hypoglycemia events. Mean weight and body mass index also decreased significantly from 76.8 and 27.8 to 73.9 and 26.7, respectively. Such mHealth programs are encouraged during the COVID-19 pandemic.
3	Anushiravani et al. <sup>33</sup>	Clinical trial	Iran	Telehealth using phone calls, messaging, and mobile applications	Patients with IBD	<ol style="list-style-type: none"> <li>(1) Educating the patients about COVID-19</li> <li>(2) Fast COVID-19 screening and diagnosis</li> <li>(3) Risk-stratifying the patients based on IBD activity and COVID-19</li> <li>(4) Re-scheduling outpatient visits</li> <li>(5) Recognizing hospitalized IBD patients</li> </ol>	<p>The system uses phone calls, messages, and mobile applications for the mentioned purposes in the following style:</p> <ol style="list-style-type: none"> <li>(1) Educating the patients about COVID-19 happens via text message and WhatsApp, Telegram, or Instagram</li> <li>(2) Active phone calls for fast COVID-19 screening and diagnosis and evaluating the suspicious cases with PCR and CT</li> </ol>	Fifty-one cases of COVID-19 were diagnosed among patients with IBD using this system. Caring for IBD patients in terms of disease activity and SARS-CoV-2 infection was restored using the telehealth system.

(Continues)

TABLE 1 (Continued)

ID	First author (reference)	Type of study	Country	Technology	Chronic disease/ Disorder	Applications	Feature and function	Summary of findings
4	Ben Hassen et al. <sup>34</sup>	Cohort	Tunisia	IoT, fog computing, and cloud computing	All the patients with chronic diseases at higher risk of complications	<p>(6) Weekly assessment of protocols and solving limitations</p> <p>(1) Monitoring vital signs</p> <p>(2) Detection of patients' environment</p> <p>(3) Doctors and nurses monitor the patients' environment and provide medical recommendations</p> <p>(4) Relatives get to know their patients' status online</p> <p>(5) Patients' records can be saved</p>	<p>(3) Active phone call for high-risk and regular follow-up using other methods for lower-risk groups</p> <p>(4) Online re-scheduling outpatient visits and recognizing hospitalized patients</p> <p>(1) Mobile application sense patients' vital signs and manage communications. 5 mobile applications serve as a fog server, one designed for each of the following: Patients, patients' relatives, nurses, doctors, and administrators.</p> <p>(2) Sensors in patients' environments are used for humidity and temperature, gas leakage, and smoke detection.</p> <p>(3) NoSQL database stores patients' data.</p>	<p>Home hospitalization ensures limited COVID-19 spreading and adequate care for patients with chronic conditions. This study reported a home hospitalization system based on IoT, fog computing, and cloud computing. Patients' vital signs, health conditions, and environment are monitored through this system and provided to the caregivers.</p>
5	Costantino et al. <sup>35</sup>	Clinical trial	Italy	Telemedicine using phone calls and televisits	Celiac disease	<p>(1) Televisits for patients with either mild or moderate symptoms or asymptomatic but altered blood exams</p> <p>(2) Checking dietary adherence and gluten contamination</p>	<p>(1) Phone calls were made to schedule televisits (2) Televisits assessed adherence to gluten-free diet according to CDAT and provided point-of-care gluten detection test for those suspected of gluten contamination</p>	<p>One hundred and twelve phone calls were made and 42 patients were found to be symptomatic. Researchers performed 39/42 (92.9%) televisits and gathered 34/39 (87.2%) questionnaires. CDAT score was <math>11 \pm 2</math> and they prescribed gluten detection tests to 11 participants with two positive results. A three-item questionnaire tested trust in telemedicine service with 94.1%, 88.2%, and 97.1% positive results.</p>
6	d'Arma et al. <sup>36</sup>	Cohort	Italy	Mobile application (named VIOLA)	MS	<p>(1) Reinforcing the knowledge of patients with MS</p> <p>(2) Keeping the patients' motivation to adhere to the rehabilitation program</p> <p>(3) Improving the patients' quality of life</p>	<p>VIOLA provided the interface for knowledge and motivation of rehabilitation programs in patients with MS. This application was updated during the pandemic to ensure better performance.</p>	<p>VIOLA subscriptions increased after the lockdown, reiterating the importance of telehealth. The application had a very positive rating. A current limitation of VIOLA is the required prior learnings about the disease, but the providers are planning to solve this problem.</p>

TABLE 1 (Continued)

ID	First author (reference)	Type of study	Country	Technology	Chronic disease/Disorder	Applications	Feature and function	Summary of findings
7	Debernardi et al. <sup>37</sup>	Observational study	Argentina	Teledermatology using email or WhatsApp, and phone calls or Zoom meetings	Connective tissue diseases	Virtual dermatological consult and referral to a health center if required.	<p>(1) Candidates were contacted and they sent their information using email or WhatsApp.</p> <p>(2) Email or WhatsApp response (asynchronous query), phone calls (synchronous query), or video conference using Zoom meetings (hybrid consultation) was generated after the patients sent their details.</p> <p>(3) Data of teleconsultation were recorded in an Excel spreadsheet and the hospital's database.</p>	One hundred and twenty teledermatological consultations were made, 93.3% by women. 17/120 (14.2%) needed a health-centre referral. Patients who took the survey found virtual dermatology consultations easy and helpful in resolving their medical problems. Doctors also agreed on the effectiveness of this approach and mentioned they would choose to utilize this valid approach in the near future.
8	Elhadi et al. <sup>38</sup>	Cross-sectional study	Libya	Application of the telehealth system	Have at least one chronic disease	Information on socio-demographic characteristics,	Availability and availability of health care services, the effects of COVID-19 on health care services, mental health status, and feasibility	A high level of usability and willingness to use the telemedicine system is used as an alternative to face-to-face counseling. This system has the advantage of helping to overcome health care costs, increasing access to prompt medical care and follow-up assessment, and reducing the risk of COVID-19 transmission.
9	Guarino et al. <sup>39</sup>	Prospective observational study	Italy	MHealth	Chronic liver disease	Manage chronic liver diseases, Screen patients for COVID-19 before admission	Telemedicine follow-up visits for all patients with CLD, Routine care to our patients with CLD: including promptly addressing questions, coordinating complex care, offering caregiver support, nutritional advice, and early interventions to ensure drugs compliance, and to prevent decompensation for chronic advanced liver disease while enabling patients to stay at home	Telemedicine is effective in tracking patients with CLD and reducing the impact of COVID-19.
10	Horrell et al. <sup>26</sup>	Cross-sectional study	USA	MHealth	Asthma, cystic fibrosis, chronic disease, migraines, hypertension,	Telehealth use	Support needs and information sources and information and support needs	N/A

(Continues)

TABLE 1 (Continued)

ID	First author (reference)	Type of study	Country	Technology	Chronic disease/Disorder	Applications	Feature and function	Summary of findings
11	Lee et al. <sup>40</sup>	Exploratory Qualitative Study	Singapore	Video Consultations	At least three chronic conditions	To explore patients' and physicians' acceptance, Communication issues, and logistical demands, Thereby elucidating the features of an optimal video consultation	To understand and explore the social, technical, financial, and logistical support or lack thereof from the organization, Thereby elucidating the requirements for introducing, sustaining, and scaling up of video consultations, To understand the current regulatory, legal, professional, sociocultural, political, or policy context, To alert key stakeholders to the potential barriers and challenges of video consultation as a regular health care service model in the post-COVID-19 phase.	The digital divide is a reality in Singapore, despite its wealth and high levels of public literacy and technology literacy. The next steps that seek full-scale implementation should certainly make the practicality and desirability of video consulting available to all sections of the demographic community, by providing additional IT support, given the lower level of access to technology and literacy. Older people have less in the economy.
12	Mercuri et al. <sup>41</sup>	Clinical trial	Italy	Video consultations	Patients with chronic disabilities	A set of incremental services, creating every step, from identifying patients to providing the most accurate and sophisticated level of care	Eligibility of this service by examining all pediatric patients who need regular follow-up, eligibility of services due to several influential factors Prioritize patients who need long-term follow-up.	The multi-disciplinary, multi-disciplinary "Contactless" model has made it possible for all units of our children's ward and families with children with disabilities or chronic conditions to enter. The strengths of this project depend on its reproducibility outside of children and the limited resources needed to influence patients, caregivers, and professionals involved in the care process. Implementing it in the future can help reduce hospital admissions, money, and parental absence from work.
13	Muhammad et al. <sup>42</sup>	Cohort	United Kingdom	Online video consultations, Telephone consultations	Celiac disease	Communication with health professionals	Tele-medicine and follow-up of celiac patients, routine care, and giving information about the disease, diet, and consults about necessary additional treatment	Appointments with health professionals have major problems that can be partially resolved with telephone and online counselling.



TABLE 1 (Continued)

ID	First author (reference)	Type of study	Country	Technology	Chronic disease/Disorder	Applications	Feature and function	Summary of findings
14	Orso et al. <sup>43</sup>	Clinical trial	Italy	MHealth	Chronic heart failure	Follow up patients during 4 weeks after discharge from hospital	Outpatient visit to the clinics and follow-up of the patients	Patients were comfortable with telephone communication, especially in which they were isolated. The patients who were not adherent to nonpharmacological recommendations were identified and reinforced to follow them. In some cases, by prescribing diuretic symptoms improved. Also, time and type of patient admission (elective/urgent) were determined in critical patients.
15	Rachmiel et al. <sup>44</sup>	Observational study	Israel	Application (Dexcom Clarity, CareLink, and Tidepool-softwares)	Type 1 diabetes mellitus	Assess the change of time-in-range (TIR) (time-in-range is the amount of time you spend in the target blood glucose range) and find the associated parameters in changing TIR.	Sending data of continuous glucose monitoring system (CGM), and continuous subcutaneous insulin infusion sets (pumps).	After the telehealth visit, glycaemic ranges improved significantly. The increase from $59.0 \pm 17.2\%$ to $62.9 \pm 16.0\%$ was shown in percent of TIR. The percent time of being in severe hypoglycaemic range significantly decreased. Associated parameters with relative-TIR improvement were living with a single-parent, higher mean glucose level, and the number of other initial glycaemic parameters. In multi regression logistic two factors including initial lower TIR and living with a single-parent were significantly associated with improvement in relative-TIR.
16	Darcourt et al. <sup>45</sup>	Observational study	USA	Telehealth video visits	Cancer	Methodist MyChart platform	As an alternative to in-person visits	Used Vido integration for the video component
17	Hasson et al. <sup>46</sup>	Cross-sectional study	Israel	Telemedicine meeting using a mobile phone video application	Cancer	N/A	During the pandemic, all patient encounters were converted to virtual telemedicine meetings	N/A

(Continues)

TABLE 1 (Continued)

First author (reference)	Type of study	Country	Technology	Chronic disease/Disorder	Applications	Feature and function	Summary of findings
18 Pardolesi et al. <sup>47</sup>	Cross-sectional study	Italy	The video-consulting clinical visit	Lung cancer	First clinical evaluation or second opinion consultation for pulmonary malignancies.	To replace in-office practice for patients who had recently undergone surgical procedures	The workstation included a Surface Pro device (Microsoft, Redmond, WA) and a dedicated Microsoft Teams account to perform video meetings also the Microsoft Teams platform for "e-visits."

Abbreviations: BP, blood pressure; CDAT, Celiac Dietary Adherence Test; CGM, continuous glucose monitoring system; COVID-19, coronavirus disease-2019; CT, computed tomography; DM, diabetes mellitus; GP, general practitioner; HR, heart rate; IBD, inflammatory bowel disease; ICT, information and communications technology; MIoT, Medical internet of things; MS, multiple sclerosis; PCR, polymerase chain reaction; SpO<sub>2</sub>, oxygen saturation; TIA, transient ischemic attack; TIR, time-in-range; PA, physical activity.

TABLE 2 Newcastle-Ottawa scale (NOS) quality assessment for the included studies

First author	Selection (out of 4)	Comparability (out of 2)	Outcome (out of 3)	Total (out of 9)
Ajčević, M.	**	-	***	5
Ang, L.Y.H.	****	*	***	8
Anushiravani, A.	***	*	***	7
Ben Hassen, H.	***	-	**	5
Costantino, T.	***	-	***	6
d'Arma, A.	***	-	**	5
Debernardi, M.E.	***	-	***	6
Elhadi, M.	****	-	***	7
Guarino, M.	***	-	***	6
Horrell, L.N.	****	*	***	8
Lee, E.S.	***	-	***	6
Mercuri, E.	***	-	***	6
Muhammad, H.	***	-	***	6
Orso, F.	***	-	**	5
Rachmiel, M.	****	**	*	7
Darcourt, J.G.	****	*	***	8
Hasson, S.P.	***	-	***	6
Pardolesi, A.	***	-	***	6

To use the medical internet of things (MIOT) necessitates exploiting some sensors and technologies. MIOT tools are rapidly transforming healthcare delivery due to their ability to capture, interpret, and distribute health information. Our data suggest that video consultation is one of the most common technologies used in telemedicine and IoT. In line with our findings, Lee et al. found that video consultations could support patients with chronic diseases and prevent unnecessary hospital visits.<sup>40</sup> They also believe that video consultations have a better bond to help understanding through nonverbal communication in comparison with telephone consultations.<sup>40</sup> Several other technologies were also found to benefit the patients' care such as mobile health (M-health), personalized mobile health intervention programs, and other mobile applications like WhatsApp, zoom, and so forth. The present study only represents the initial step to discover new technology and its application in the health care system and management of chronic diseases and further studies are recommended to extend the usage of IoT in health care and develop new appliances for better patient care and service delivery.

## 5 | CONCLUSION

One of the major applications of the "Internet of things" is to manage patients with chronic diseases during the COVID-19 pandemic. It has a network of various sensors, obtaining data from patients and

communicating them with health care providers. Another usage of this technology is telemedicine such as tele-visits, which can be extremely helpful for both patients and HCPs. Video consultation is another practical way that IoT can benefit healthcare providers deliver the necessary services during the current pandemic. IoT has extreme potential to help and improve the health care system, nevertheless, it is a new technology and further studies are needed.

### TRANSPARENCY STATEMENT

Esmail Mehraeen affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

### ETHICS STATEMENT

This study received an ethics code IR.ESFARAYENUMS.REC.1400.011 from Esfarayen University of Medical Sciences.

### AUTHOR CONTRIBUTIONS

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### DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

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