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ORIGINAL PAPER

Telemedicine in cancer care during COVID-19 pandemic: a systematic mapping study

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Abstract

Background For monitoring, providing, and managing COVID-19 pandemic healthcare services, telemedicine holds incredible potential. During this period, there has been a change in the remote services offered to cancer patients. As a result, the purpose of this study was to conduct a mapping review to identify and classify telemedicine applications for providing cancer care to patients during the COVID-19 pandemic.

Methods Articles published in scientific databases such as Web of Science, Scopus, PubMed, and ProQuest up to 2022 were searched for in this systematic mapping study. Identifying keywords, creating a search strategy, and selecting data sources were all part of our search for relevant articles. The articles were chosen in phases based on inclusion and exclusion criteria.

Results A total of 1331 articles were found, with the majority of them (46% of them) taking place in the United States. Telemedicine systems were most commonly developed for breast cancer (11.4%), lung cancer (7.9%), head and neck cancer (6.4%), brain cancer (5.4%), gynecologic cancer (6.0%), urological cancer (5.7%), prostate cancer (5.0%), colorectal cancer (5.0%), biliary tract cancer (5.0%), and skin cancer (5.0%). Teleconsultation was the most common type of telemedicine application, with 60% of it taking place in real time.

Conclusion Because of its emphasis on providing high-quality health care while reducing costs, telemedicine has gained popularity in the majority of countries, with positive economic and social consequences. While telemedicine systems provide a variety of healthcare services, during the COVID-19 era, they do not currently provide many services to all cancer patients worldwide.

Keywords Telemedicine · Teleoncology · COVID-19 · Cancer

1 Introduction

Individuals with underlying diseases, such as chronic obstructive pulmonary disease (COPD), hypertension, diabetes mellitus, and cancer, are more susceptible to the coronavirus [1, 2]. Furthermore, cancer patients are more prone to coronavirus infection and have poorer outcomes from COVID-19 infection than non-cancerous patients because cancer-suppressing medications weaken the body's immune system [3–6]. In addition, COVID-19 causes more corona deaths in cancer patients than the overall mortality rate [5, 7, 8]. As a result, cancer patients have concerns about COVID-19 and its implications for their health, quality of life, and cancer management processes [9, 10].

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When the Corona pandemic began, patients, healthcare professionals, and caregivers had to decide whether to continue or discontinue healthcare administration until COVID-19 subsided and the crisis situation improved [11, 12]. However, cancer treatment is time-sensitive, and delays and changes in the treatment process may have unintended consequences. As a result, adopting quick and safe methods and procedures for providing medical services to cancer patients is critical [13]. In this regard, healthcare professionals must shift toward the adoption of alternative solutions that can provide medical services remotely without forcing patients to physically visit [14].

The use of Information and Communication Technology (ICT) as a practical and powerful technology for organizing and providing more effective and efficient services in many industries, particularly the healthcare industry, is increasing in today's world [15]. New health forms, such as telemedicine, telehealth, and e-health, have facilitated the exchange of information between patients and clinicians via ICT in the monitoring, delivery, and management of healthcare services [16]. Telemedicine has also improved accessibility and quality, productivity, efficacy, and effectiveness in health care, as well as reduced costs in several areas [17]. Teleoncology is a subset of telemedicine that makes use of medical telecommunications, such as pathology, radiology, and other oncology-related disciplines [18]. Since the COVID-19 pandemic has posed significant limitations and challenges in the processes of providing medical services to cancer patients, telemedicine can be used as an effective solution to facilitate communication between patients and specialists, provide medical services, and overcome existing challenges [19, 20].

In the Covid-19 era, teleoncology systems have been developed in many countries with varying purposes for cancer patients. Many scientific studies have discussed and evaluated the use of these systems. The objectives of this research were to identify and categorize cancer-related telemedicine applications during the COVID-19 period, as well as to assess the current situation and knowledge gaps in this field. Furthermore, the findings will assist stakeholders, particularly developers and graduate students, in selecting appropriate research topics for future studies. Scholars interested in conducting secondary research, such as systematic reviews, may find this work useful as a starting point.

2 Materials and methods

The method employed in this study was a systematic mapping review, which served as the foundation for researchers to conduct primary studies or systematic reviews [21]. This review used visual and statistical analytics to identify knowledge gaps in the field of telemedicine applications for cancer patients in Cavid-19. It has been developed to provide an overview of the field by systematically searching for related articles, collecting and categorizing data, and performing visual data analysis. This review, by providing an overview of the field, helps researchers in formulating research questions for primary or secondary research studies such as systematic reviews. In fact, for academics seeking for a study topic, the systematic mapping review is a good starting point [22].

This study was conducted in the following steps:

- Definition of research questions, resulting in identify scope a body of literature
- Data collection
  - Formulating search strategy and searching for articles, resulting a set of articles (Identification process)
  - Screening and selecting the relevant articles based on inclusion / exclusion criteria, resulting in a set of relevant articles. (Selection process)
- Data extraction, resulting in set of relevant data
- Classification and visual analysis, resulting in a systematic map (Mapping process)

2.1 Research questions

We provided the following seven research questions:

1. ***Keyword co-occurrence:***
   What aspects of cancer or telemedicine were covered in the articles? Keyword co-occurrence analysis focuses on the most important keywords in the articles, allowing a field of research to be conceptually structured. The number of co-occurrences of two keywords, according to van Eck and Waltman, is the number of publications in which both keywords appear together in the title, summary, or keyword list [24].
2. ***Cancer types:*** In which types of cancer are telemedicine systems being developed? What are the different types of cancer?
3. ***Telemedicine types:*** What telemedicine approaches were used in the studies? Telemedicine is classified into three types based on how it connects healthcare providers (HCPs) and patients to offer healthcare using technology [25]:

   Real time (synchronous) telemedicine: It could be as easy as a phone call or as complicated as robotic surgery. In this sort of telemedicine, both parties must be present at the same time. This comprises real-time phone or lives audio–video interaction with a patient,

generally through a smartphone or computer. This category includes real-time monitoring using peripheral medical equipment.

Store and forward (asynchronous) telemedicine: It involves gathering patient medical data such as a biography, medical imaging, and vital signs and transmitting them offline to an HCP for examination; hence, both parties are not need to be present at the same moment. Data is saved in the appropriate media before being sent to the HCPs and is sent to them at the appropriate time. Patient portals can facilitate this type of communication between them via secure messaging.

Hybrid telemedicine: hybrid telemedicine refers to the combination of synchronous and asynchronous telemedicine.

4. **Telemedicine system evaluation:** What features of telemedicine systems have been studied? How are system evaluations carried out? What data collection instrument (tools or data sources) was used to evaluate the system?
5. **User interactions:** In telemedicine, how do people connect with one another? Telemedicine services can make advantage of two-way interaction between individuals (patients, caregivers, and HCPs) and HCPs via telecommunications technologies [25].
6. **Teleoncology over time:** What role did telemedicine systems play in the field of cancer research in 2020 and 2021? Which aspect of cancer garnered the most attention in each of the years 2020 and 2021?
7. **Teleoncology in countries:** Which countries have developed telemedicine systems for which types of cancer? Which aspects of cancer have been prioritized by which countries? Which countries have helped to advance cancer telemedicine applications?

2.2 Search strategy

Identifying keywords, formulating a search strategy, and selecting data sources were all part of our search for relevant articles. Using the content of the major research questions, we discovered the keywords and constructed the necessary search strategy. Following a preliminary search, the keywords were refined. In multiple iterations, we merged various search phrases until we found an acceptable set of keywords, which included "cancer," "telemedicine," and "COVID-19." The synonyms of these keywords were grouped into three sets as shown in Table 1 and the search strategy was formulated as follows [(Set1) AND (Set2) AND (Set3)]:

Because of the coronavirus's emergence in late 2019, major online academic databases such as PubMed, Scopus, ISI Web of Sciences, and ProQuest were searched for articles published between 2020 and 2021

2.3 Studies selection

A total of 1331 articles were searched and entered into Endnote software as a reference management software to handle the searched articles. Duplicate articles were detected and removed, and the 559 articles remained.

The articles were selected in two steps based on the exclusion criteria. First, the study's two authors independently reviewed the titles and abstracts of articles to find more relevant articles based on our inclusion/exclusion criteria. After this step, there were 138 articles left, which we reviewed through full-text reading and included 39 of them in our study. This study's study selection process is depicted in Fig. 1.

2.4 Inclusion and exclusion criteria

We excluded letters, short communications, reports, conference articles, and books. All articles about using telemedicine in other diseases except cancer were excluded. We excluded studies that were on using other types of information technologies to provide healthcare to cancer patients during COVID-19.

2.5 Data extraction

The data extraction technique provided pertinent information to answer each study question. The data were gathered by the authors, with cases of disagreement referred to the third author, who was the project administrator. The data were

Table 1 Keywords and synonyms

Time limitation	**2020–2021**
Language limitation	English
Set 1	“telemedicine” OR “tele-medicine” OR "Mobile Health" OR “telehealth” OR “tele-health” OR “mhealth” OR “ehealth” OR “m-health” OR “telemonitor*” OR “telecommunication” OR “telemanagement” OR “telecare” OR “telepathology” OR “telerehabilitation” OR “telescreening” OR “telediagnos*” OR “teletreatment” OR “teleoncology”
Set 2	"Neoplasm*" OR " Cancer*" OR "Carcinoma*" OR "tumor*" OR “oncology” OR “chemotherapy” OR “radiotherapy”
Set 3	“COVID-19” OR “SARS-COV-2” OR “ corona virus” OR “COVID”

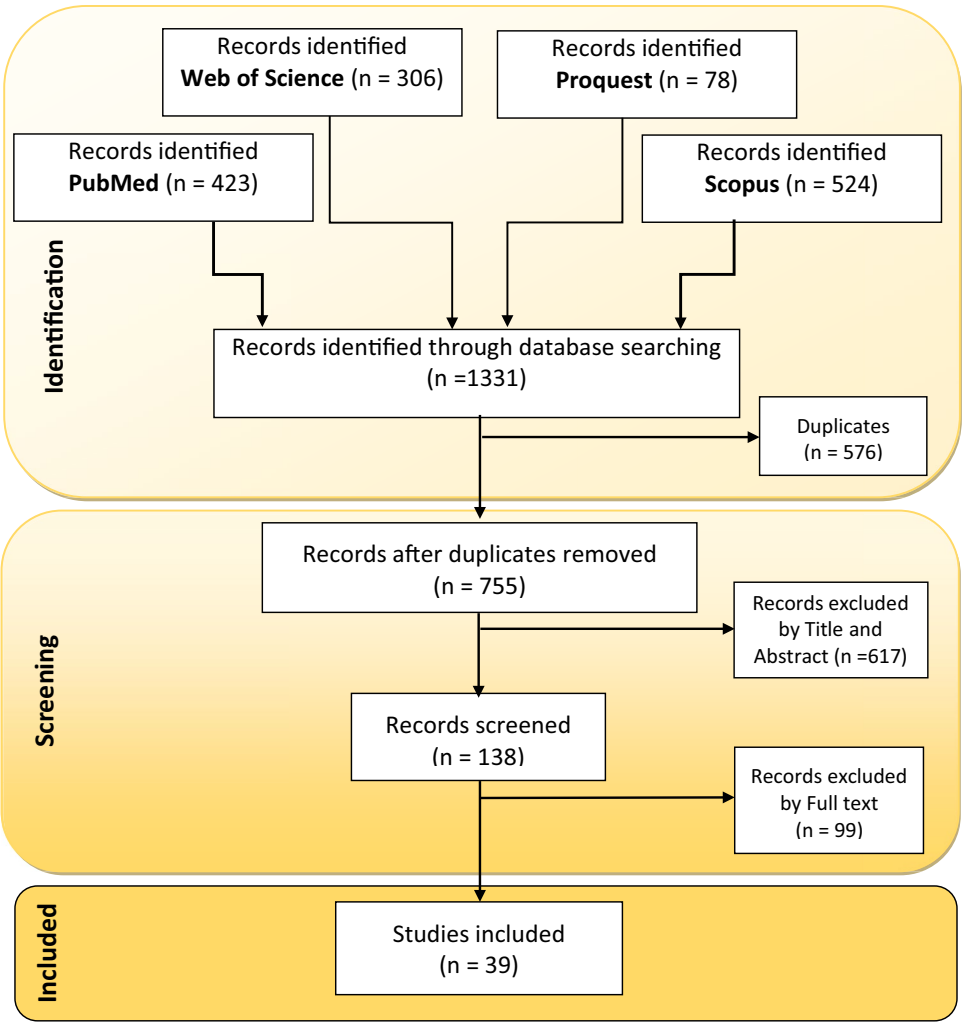

Fig. 1 The flow diagram of study selection processes

extracted using a data extraction form designed in Microsoft Excel based on the study questions (see Table A in the supplementary material section).

3 Results

The findings were classified into categories based on each study question and then presented as tabular or graphic representations such as bubble plots and sunburst hierarchical graphs. In Microsoft Excel, bubble plots and sunburst hierarchical graphs were created.

3.1 Keyword co-occurrence networks

The keyword co-occurrence was analyzed to provide an overview of the study disciplines relevant to our search strategy keywords. VOSviewer (1.6.17) software was used to visualize a network of keywords (VOSviewer software is a free and open-source bibliometric mapping tool that can be downloaded from the website http://www.vosviewer.com). In this network (Fig. 2), the number of occurrences of keywords is shown by the circle size (minimum one), and the number of co-occurrences of two words in articles is shown by the thickness of the link (minimum one). Clusters identify a group of linked elements and are represented on the map with various colors. According to the analyses, there were 84 items organized into 5 clusters and 423 total link strength.

The terms "COVID-19" and "telemedicine" were the most frequently used (18 and 13, respectively), and they had the strongest links (link strength = 10). Table 2 also shows the 10 words with the most occurrences and total linkage strength. The link strength values for "COVID-19" and "cancer", "COVID-19" and "palliative care", "telemedicine" and "palliative care", "COVID-19" and "breast cancer", and "COVID-19" and "telehealth" were 4, 4, 3, 3, and 3.

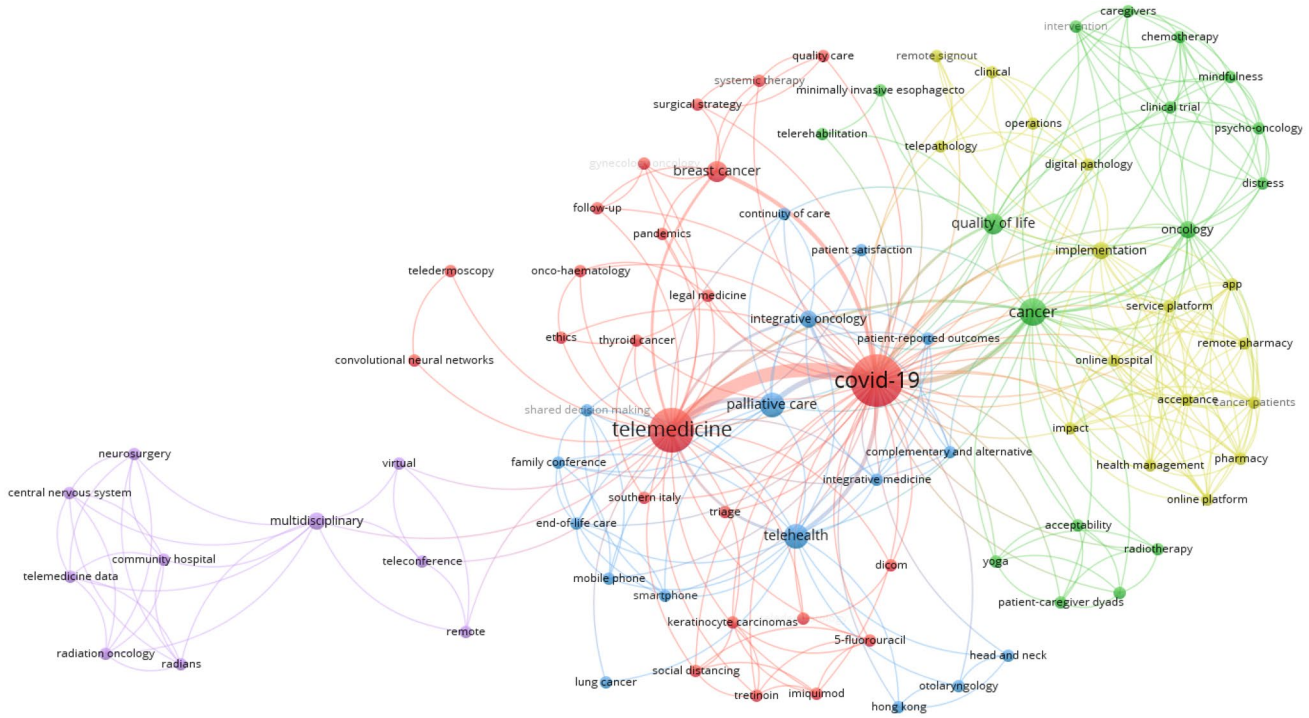

Fig. 2 The keyword occurrence network using VOSviewer: minimum occurrence threshold of 1 and 100 links

3.2 Cancer types

Cancers mentioned in studies are classified according to cancer type, organ, and medical field. Figure 3 depicts this classification in a hierarchical format based on the MESH (MEdical Subject Headings). Because seven articles did not specify the type of cancer, we labeled them as "cancers" in the diagram. The most common cancers for which telemedicine systems are available are breast (n = 16), lung (n = 11), gynecologic (n = 8), skin (n = 7), brain (n = 7), colorectal (n = 7), and prostate (n = 7). The majority of these cancers are related to the urogenital system (20%), the gastrointestinal system (19%), and skin and connective tissue (18%).

Table 2 Top 10 high occurrence keywords: minimum occurrence threshold of 1 and 100 links

Ranking	Keyword	Occurrences	Total link strength
1	COVID-19	18	85
2	Telemedicine	13	49
3	Cancer	5	39
4	Telehealth	4	20
5	Palliative care	4	18
6	Quality of life	3	17
7	Breast cancer	3	11
8	Oncology	2	22
9	Integrative oncology	2	12
10	Multidiciplinary	2	10

3.3 Telemedicine types

Various telemedicine systems, modalities, and healthcare domains are depicted in Fig. 4. Teleconsultations account for 99% of telemedicine-based visits, with the vast majority (more than 60%) taking place in real time. There was only one store and forward telemediine developed for telepathology. Mobile-based teleconsultation systems accounted for 29% of all teleconsultation systems, half of which were real-time.

Support for real-time or store and forward communication is one of the features of smartphone Apps. As a result, in mobile-based teleconsultations, all three telemedicine modalities are used: real-time (n = 5), store and forward (n = 1), and hybrid (n = 5).

3.4 Telemedicine system evaluation

Hierarchy diagram (Fig. 5) depicts the evaluation methods for the telemedicine system, as well as the evaluation instruments and data sources used in the articles. Two internal levels are shown for the evaluation methods and evaluation

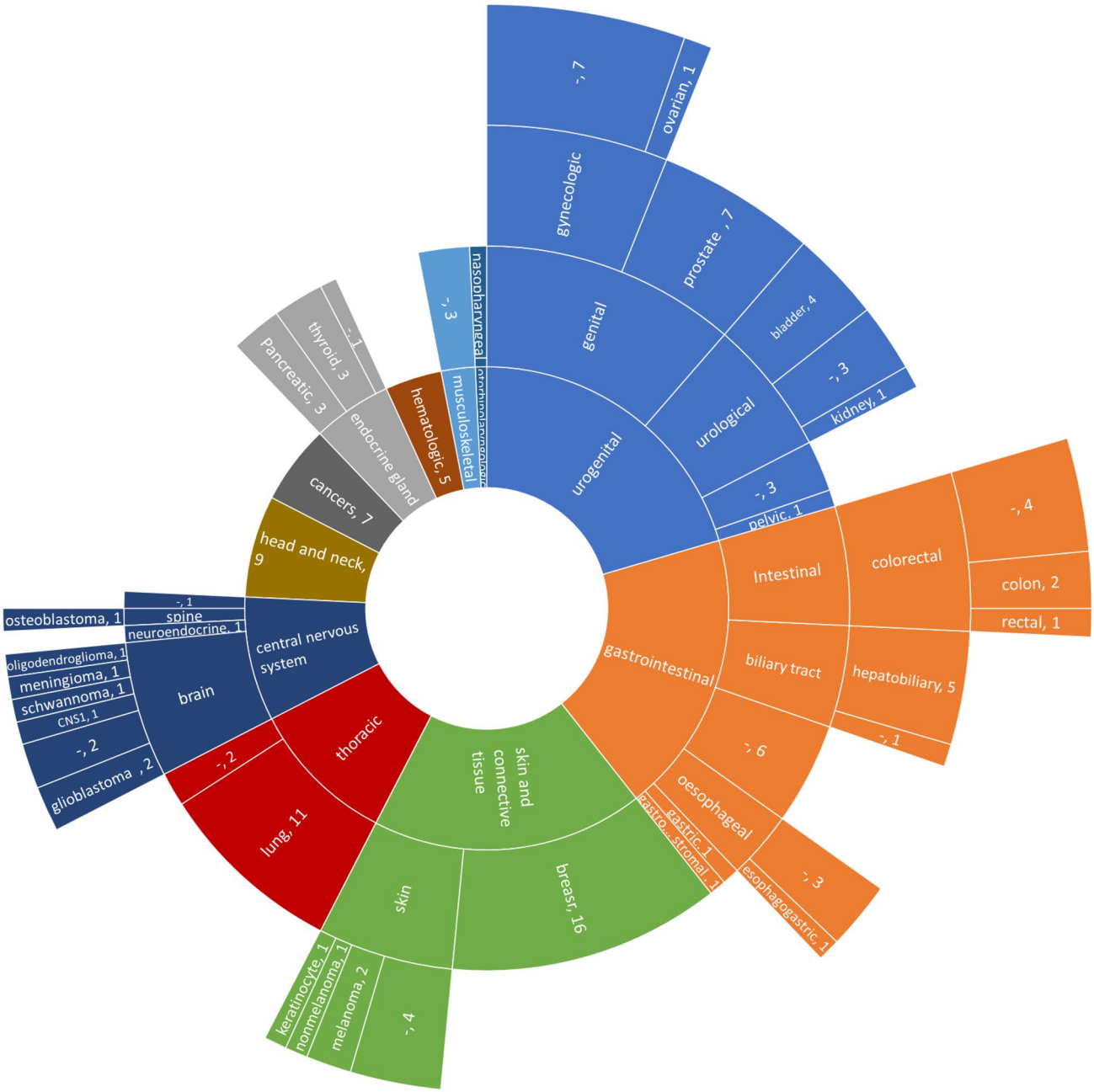

Fig. 3 sunburst graph of the types of cancers, organ systems and medical fields ("-" symbol indicates undefined items in articles)

instruments / data. The external level indicates whether the evaluation was based on a comparison of two in-person and telemedicine visits. The most commonly used evaluation methods in this study were satisfaction, feasibility, efficiency, perception, quality, adoption, and impact.

User satisfaction assessment is the most important method of telemedicine system evaluation: patient satisfaction (24%), physician satisfaction (12%), and patients' relatives (2%). In this type of evaluation, questionnaires were used as an evaluation instrument to gather user feedback.

Assessing the feasibility and efficiency of telemedicine systems were used frequently in 12% and 10% of the articles, respectively. Five of the 39 articles reported on their experiences using the telemedicine system at medical centers without assessing the technology in any way.

Figure 6 depicts two main data gathering instruments, questionnaires and interviews, as well as medical records utilized as data sources in system evaluation. Medical records, whether electronic or paper, include valuable information that can be utilized to assess the efficacy of

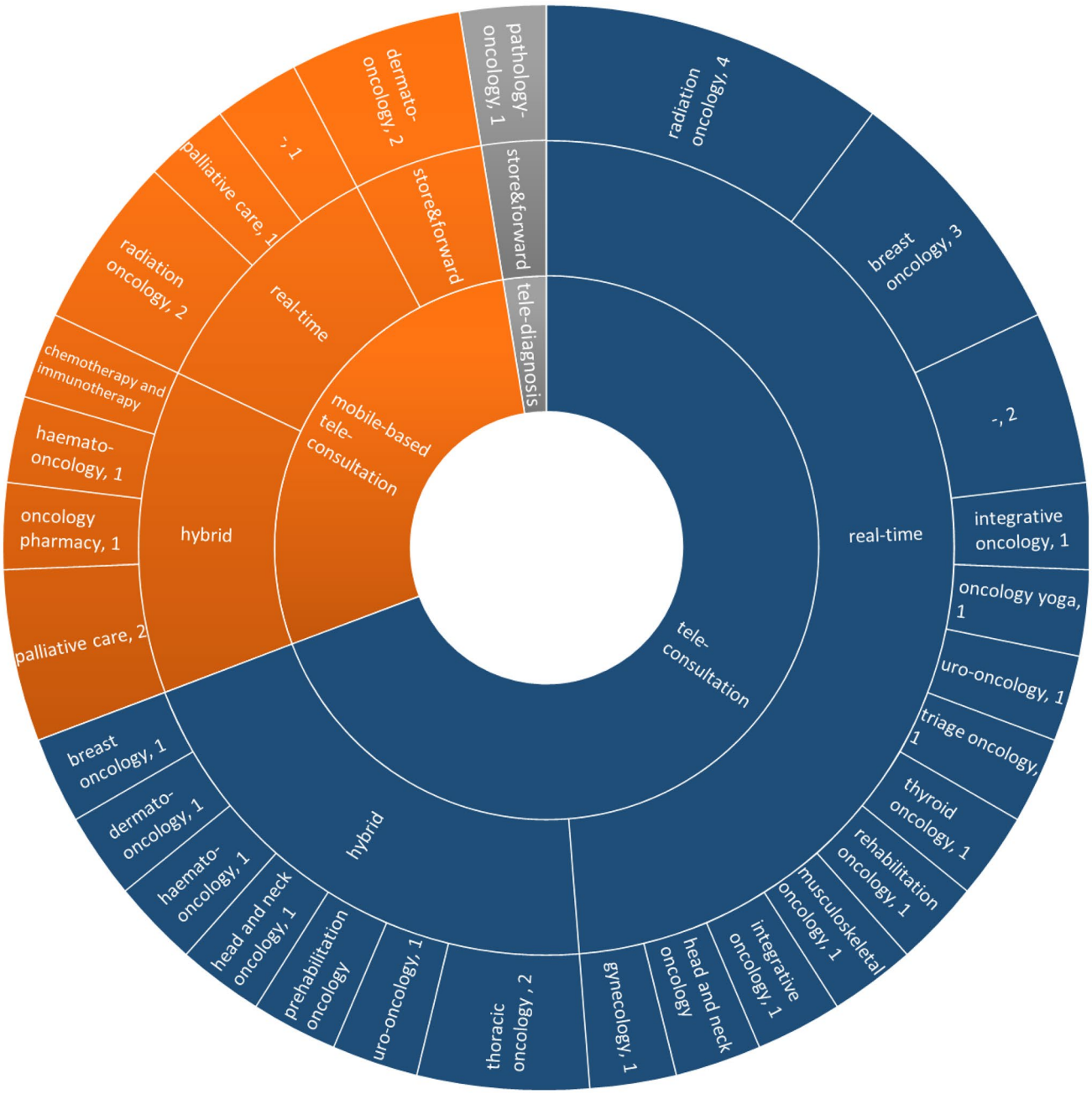

Fig. 4 types of telemedicine, modalities of telemedicine, and healthcare domains ("-" symbol indicates undefined items in articles)

telemedicine systems. In some research, these data collection instruments and medical records may be utilized in combination.

3.5 User interactions

Figure 7 depicts the various types of interactions that telemedicine systems provide between various users (HCPs, cancer patients, patient's family or caregivers). HCPs are the main user of all telemedicine systems and play an important role as service providers. The vast majority of interactions occur between HCPs and patients. HCPs are depicted in blue circles in this diagram, while other users are depicted in orange circles.

3.6 Teleoncology over time

Figure 8 depicts 14 and 25 teleoncolgy articles published in 2020 and 2021, respectively. The emphasis during these two years was on radiation oncology and breast cancer. In

Fig. 5 A sunburst graph of evaluation aspects, data gathering instruments and sources for evaluation, as well as a comparison of face-to-face or telemedicine visits ("-" symbol indicates undefined items in articles)

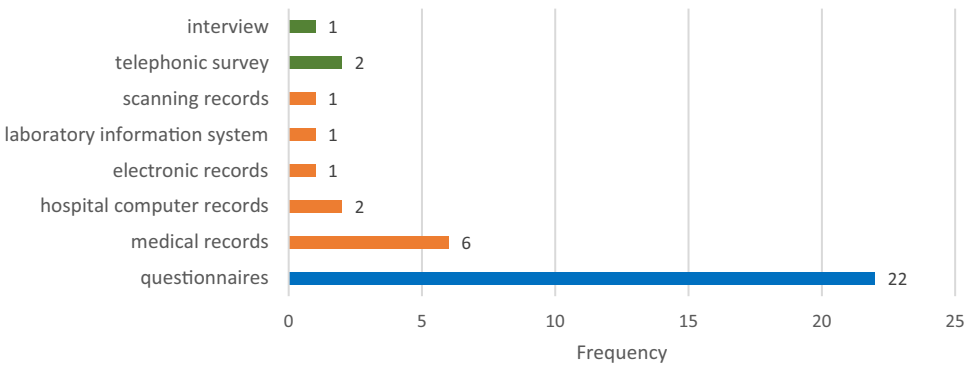

Fig. 6 Data gathering instruments and medical records used in articles for system eveluation

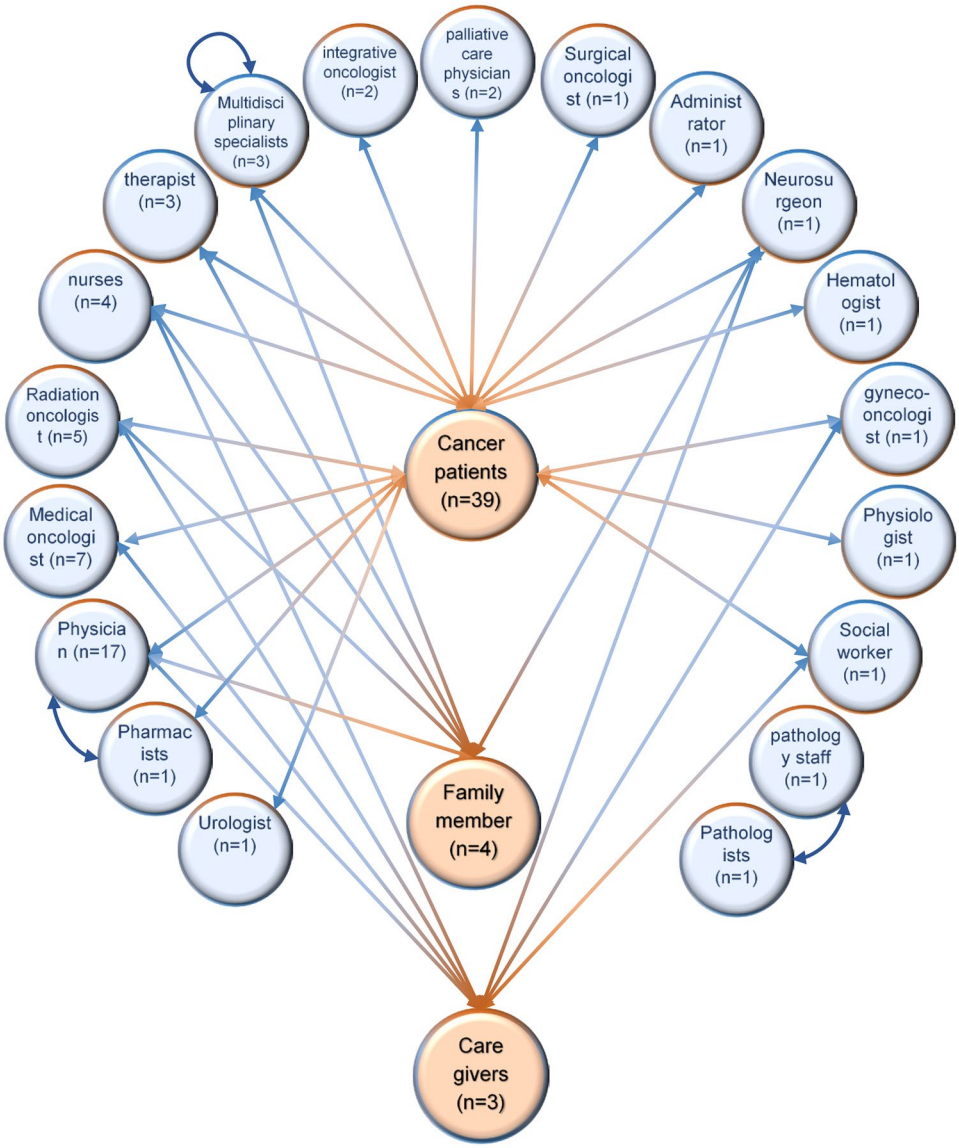

Fig. 7 Interactions between different individuals in telemedicine

2021, teleoncolgy systems were available for more types of cancer, but no new systems in the following five areas were developed: hematology, head and neck, thyroid, triage, and urology.

3.6.1 Teleoncology in countries

During the COVID-19 period, thirteen countries were active in the field of teleoncology. With 18 articles, the United States leads the way in the development of teleoncology systems, followed by Italy, the United Kingdom, India, and China with 6, 3, 2, and 2 articles, respectively (Fig. 9). The United States has prioritized teleoncology systems in radiation oncology and made them available for a wide range of cancers.

4 Discussion

The purpose of this research was to identify and map current cancer telemedicine developments during the COVID-19 pandemic.

Prior to the appearance of COVID-19, the World Health Organization reported cancer as the second leading cause of death worldwide, accounting for an estimated 9.6 million deaths, or one in every six deaths, in 2018. Men were more likely to develop cancers of the lung, prostate, colorectal, stomach, and liver, whereas women were more likely to develop cancers of the breast, colorectal, lung, cervical, and thyroid [26]. Cancer patients are more likely to experience serious complications, such as frequent pneumonias, a higher rate of hospitalization, respiratory

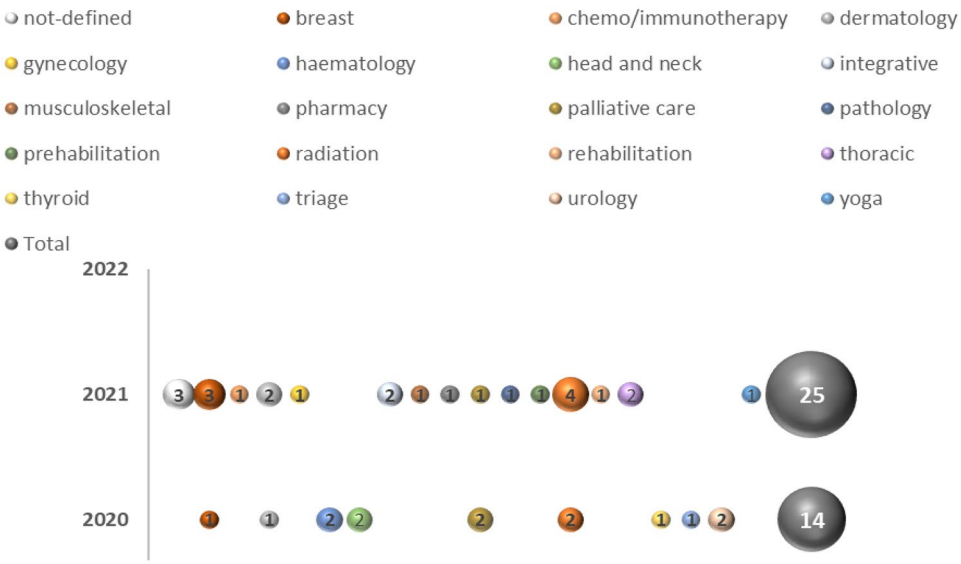

Fig. 8 Publication year vs. cancer type

failure or multiple organ failure, and even death [27]. On the other hand, the COVID-19 pandemic hampered cancer diagnosis and treatment; the figure may have been higher in the last two years due to reduced access care, which resulted in delays in diagnosis and treatment, which may have resulted in a short-term drop in cancer incidence followed by an increase in advanced stage disease and ultimately increased mortality [28].

Our findings show that the most common types of cancer for which telemedicine systems have been developed are breast, lung, head and neck, brain, gynecologic, urological, prostate, colorectal, biliary tract, and skin cancers. According to an update on the global cancer burden using the GLOBOCAN 2020 [29], female breast cancer has surpassed lung cancer as the most commonly diagnosed cancer, followed by lung, colorectal, prostate, and stomach cancers. Lung cancer continued to be the leading cause of cancer death, followed by colorectal, liver, stomach, and female breast. As a result, breast and lung cancers have a greater prevalence and mortality rate than other cancers, and our study's findings show that more telemedicine systems for these cancers have been proposed in the included articles.

Despite the fact that stomach and liver cancers are common and deadly, little research has been conducted on them as well. As a result, research in this area should be pursued with the goal of developing a telemedicine system for

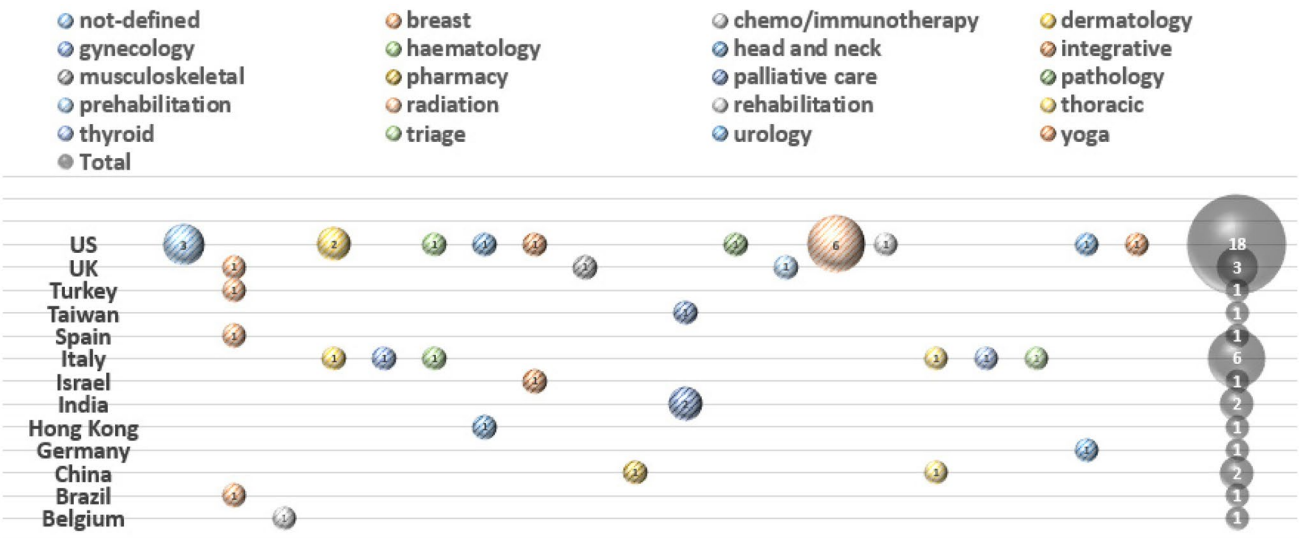

Fig. 9 Country vs. cancer type

managing and serving cancer patients. Furthermore, other areas of cancer that have not been addressed in the publications could be appealing for underutilized but high-potential telemedicine services.

The most prevalent countries for COVID-19 occurrences were the United States, India, Brazil, France, the United Kingdom, Russia, Germany, Turkey, Italy, and Spain, in that order [30]. In contrast, our findings show that the majority of teleoncology systems are established in developed countries with the highest proportion of COVID-19 infections or deaths. Lack of or poor utilization of telemedicine in other countries may be due to infrastructural and access constraints, operational and system issues, and legislative and regulatory barriers. The lack of internet connection in many low-income countries, owing to a lack of infrastructure, is a significant barrier to appropriate telemedicine utilization. Although the purpose of telemedicine is to minimize costs, these technologies may incur costs for cancer patients. Furthermore, healthcare institutions may lack an operational or patient support plan in place to make the best use of telemedicine systems. During the COVID-19 pandemic healthcare emergency, several telemedicine regulatory barriers were removed, and many countries implemented legislation and regulations governing the use of telemedicine services. The European Society of Medical Oncology issued guidelines for patient care [31]. The US Centers for Medicare & Medicaid Services (CMS) issued an interim final rule on March 30, 2020, allowing health care providers to use telehealth services to treat COVID-19 from offices, hospitals, and places of residence [32].

Our findings demonstrated the importance of cancer diagnosis, treatment, and follow-up in order to improve service quality and reduce costs in the Covid-19 era. Most countries with good economic and social outcomes have made telemedicine available for this reason. The gap mentioned in this section is the poor participation of various countries in cancer telemedicine, particularly in developing countries, which may reflect a lack of resources, ICT infrastructure, regulation and strategy related to the development of telemedicine systems. A comprehensive study on the status of telemedicine use for cancer patients in both developed and developing countries is suggested to determine the reasons for telemedicine use and non-use.

According to the occurrence analysis, terms like "palliative care" and "breast cancer" were the most frequently encountered, along with terms such as "telemedicine" and "COVID-19," which are relevant to the study's objectives. Palliative care was a subject that received a lot of attention throughout the COVID-19 period [33]. Palliative care for cancer patients via telemedicine has been considered as an appropriate approach during the COVID-19 period [34]. It also appears that co-occurrence analysis has resulted from the worldwide high prevalence of breast cancer.

We found that teleconsultation were the most common form of teleoncology system during the COVID-19 timeframe. Technologies are becoming smaller, faster, less expensive, and more portable (mobile), which has an impact on telemedicine advancement. The findings revealed that mobile phones were used in real-time, stored and forward, or hybrid interactions via various mobile Apps. End-to-end video calling, text messaging, VoIP, and file sharing are all advantages of using mobile-based teleconsultation. While similar functions are accessible on desktop or laptop computers, mobile devices' ubiquity and ease of use made them appropriate for telemedicine. Dermatology [35, 36] and pathology [37] are two medical fields that can be employed in a backward and forward way. because some consultations include the sharing of data such as images of samples or skin, and this necessitates the doctor examining the documents and doing the consultation at the appropriate time.

During the COVID-19 period, patients can receive real-time radiation oncology services via telemedicine on a range of platforms, including mobile-base [38, 39] and system-base [40–43]. However, several studies have used a hybrid modality to provide telemedicine services, which appears to be a more reasonable option for providing extensive telemedicine services depending on diverse needs and technical infrastructures. On the other hand, the number of radiation oncology studies has increased significantly over time. Telemedicine-based radiation oncology provides cancer patients with services such as new patient counseling, interdisciplinary discussions, simulation, treatment plans, quality assurance, and follow-up care [44–46]. Some services, such as radiation oncology, cannot be offered to patients via telemedicine due to their nature; however, some radiation oncology services require the patient to present in person, while some consulting services can be performed remotely. Radiation oncology systems based on teleconsultation reduced in-person visits while enhancing patient satisfaction [46].

Because of the importance of telemedicine systems in the delivery of health services and their direct impact on patient health, it is critical to ensure the quality and proper operation of these systems; thus, evaluation of these systems to identify problems and attempts to minimize them is required. Given that patients and physicians are the primary users of telemedicine systems, it is preferable to assess patient and physician satisfaction in appropriate ways. Pilot and feasibility studies are methods for analyzing aspects of telemedicine systems in order to determine the chances of successfully completing the systems.

Data pertaining to system users is required for system evaluation. Some of these data are kept in the patients' medical records, while others are acquired through questionnaire or interview. Given that most studies focus on certain

characteristics of telemedicine systems, questionnaires or interviews are commonly used as a data gathering method to evaluate the system. Our finding in line with the findings of the Whitten et al. study [47], showed that the most widely utilized data collection methods were interviews, questionnaires, and archival data.

HCPs are the primary main clients of telemedicine systems [25]. The relationship between physician and patient is the most important relationship in providing telemedicine-based services. Identifying and determining the various users of telemedicine systems is an important step in the system's successful design and development. Patients and HCPs, as recipients and providers, have always been taken into account [23, 48]. One study proposed a telemedicine system in which a connection was established between the pathologist and the pathology staff and no interaction occurred between the patients and the HCPs; In fact, in this system, services are provided to patients indirectly [37].

Telemedicine research in the COVID-19 era includes medical, technological, and social/organizational studies. Depending on the nature of the topics studied, research norms, and what they and their stakeholders deem essential outcomes, each of these studies may be conducted in a variety of methods.

4.1 Limitations

The findings of this article are based solely on articles selected depending on the study's inclusion and exclusion criteria. As a result, telemedicine-related research or projects for cancer patients during the COVID-19 pandemic may have been conducted but not published as an article. therefore levels reported in this review may not be reflective of the whole picture of application of telemedicine for cancer patients during the COVID-19 pandemic. Furthermore, this mapping review has some limitations. The quality assessment of the included articles was not conducted in the present study for two reasons: a) Unlike the systematic reviews, in systematic mapping study, the quality assessment of the included articles is optional [49], and b) we did not want to miss any works having studied in the field.

The following articles may have been missed in this study:

- Other relevant articles written in other languages were excluded.
- Aside from the four main databases (Scopus, Web of Knowledge, PubMed, and ProQuest), no other databases were considered.
- No manual searches were conducted in the reference lists of the selected articles.

5 Conclusion

Despite the fact that telemedicine can overcome geographical borders via information and communication technologies, it has not benefited low-income countries. Infrastructure, budget level, rules and regulations, and political strategy all have an impact on the development of telemedicine in each country. Telemedicine for cancer patients is gaining popularity in countries with good economic and social outcomes. Patient counseling is one of the most important services given to cancer patients. During the Covid-19 era, these services were provided to patients through teleconsultation systems, which are a type of telemedicine. The recording of vital signs in cancer patients supports physicians in diagnosis and treatment, and can be monitored and managed using telemonitoring devices. Telemonitoring of cancer patients is one area that necessitates more attention. Given the high prevalence and mortality rate of lung, breast, stomach, and liver cancers, there have been numerous studies on telemedicine systems for lung and breast cancers, but few studies on stomach and liver cancers have been conducted. Due to the current situation resulting from the COVID-19 pandemic and the advancement of information and communication technology, the demand for telemedicine has greatly increased.

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Availability of data and material Not applicable.

Code availability Not applicable.

Declarations

Conflicts of interest The authors declare no conflicts of interest.

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