



Review

Efficacy and results of virtual nursing intervention for cancer patients: A systematic review and meta-analysis



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A B S T R A C T

Objective: Virtual nursing interventions, which use virtual reality and artificial intelligence technology to provide remote care for patients, have become increasingly common in cancer treatment, especially during the COVID-19 pandemic. This study was to evaluate the efficacy of virtual nursing interventions for cancer patients in contrast to conventional, in-person care.

Methods: Eight randomized controlled trials (RCTs) contrasted virtual nursing with conventional techniques that satisfied the inclusion criteria were found after a thorough search across databases including PubMed, Web of Science, CINAHL, EMBASE, the Cochrane Library, Scopus, and APA PsycINFO. RevMan 5.3 software was utilized for data analysis after the included literature's quality was assessed and the intended consequence indicators were extracted.

Results: Virtual nurse interventions enhanced the quality of life of cancer patients (standardized mean difference [SMD] = 0.22, 95% confidence interval [CI] 0.01 to 0.43, $P = 0.04$). Virtual nurse interventions provide cancer patients with important support, particularly when access to in-person care is limited. In light of the many demands that cancer patients have, further research is required to overcome implementation issues and provide fair access to virtual treatment.

Conclusions: All things considered, virtual nursing shows potential as an adjunctive element of all-inclusive cancer care delivery models, deserving of further investigation and thoughtful incorporation into healthcare systems.

Introduction

Approximately 19.3 million new cancer patients were diagnosed in 2020.^{1,2} Throughout their diagnosis, treatment, and recovery from the illness, many of them have significant psychological or physical side effects such as pain, stress, sadness, anxiety, and distress.^{3,4} Thirty percent of breast cancer patients have anxiety, and 70% report suffering distress while going about their regular lives.^{5,6} Fifty-nine percent of cancer survivors say they have a moderate to high level of concern about their disease returning.⁷ Additionally, distress affects a patient's ability to function daily and is regarded as the sixth vital sign in cancer treatment; nonetheless, it is frequently overlooked and not adequately addressed.⁸ Due to the weakened immunity and endocrine abnormalities brought on by these symptoms, patients frequently have lower levels of compliance with their therapy, which has a detrimental impact on their jobs, relationships with others, mood, and day-to-day activities.^{9,10} At the same time, serious complications may occur during the cancer process, such as gastrointestinal bleeding, respiratory depression, and changes in

consciousness, but drugs can usually effectively alleviate symptoms.¹¹ It significantly affects the quality of life (QoL) and therapeutic progress of cancer patients.¹²

Clinicians can assist cancer survivors in reducing the uncertainties and physical and psychological discomfort related to their condition by offering knowledge and healthy lifestyle programs.^{13,14} Significant obstacles that hinder cancer patients from accessing centralized healthcare facilities include poor health and family obligations.¹⁵ A major obstacle to many patients' access to health care is finding and keeping an appropriate staff in rural and isolated locations. This is not just confined to rural regions; many metropolitan areas also have a scarcity of workers.¹⁶ The usage of virtual nursing is one possible way to get access to specialized care.¹⁷⁻¹⁹

The "gold standard" of patient-physician contact has always been regarded as in-person treatment.²⁰ But as new communication technologies like computers and cell phones become more widely available, other methods of offering help remotely are starting to appear. These days, the words "virtual care," "virtual nursing," "telemedicine," and

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“telehealth” are often and likewise accustomed to describe distant access to health information, medical treatment, or health education via technology.²¹ Virtual nursing is part of a tested healthcare model that existed before the pandemic, with the aim of better connecting patients with their healthcare teams rather than using telemedicine as a substitute for traditional care. In the virtual integrated nursing team model, the virtual nurse is an expert-level senior practice nurse who is a member of the healthcare service team and has six core roles: patient education, employee guidance, patient safety supervision, doctor rounds, admission, and discharge. A virtual nurse is a command center that is not in the patient care ward and can access electronic health records. Because telemedicine allowed for treatment continuity while preserving social distance, preventing needless hospital trips, or cutting down on time spent in medical institutions, its usage has increased dramatically in recent years as a result of the protracted COVID-19 epidemic.^{22,23} This was especially important for cancer patients, who have a higher chance of getting COVID-19 and have poorer results if they do.^{24–26} Even though the epidemic helped make virtual care more widely used, its continued usage raises the possibility that it will always play a crucial role in the provision of cancer care.²⁷ Compared to traditional in-person treatment, telemedicine can provide many benefits, such as the ability to bypass obstacles to healthcare access, including travel expenses, time constraints, and hospital distance, all while causing less disturbance to family life.^{28,29} Furthermore, as the number of cancer patients and survivors rises, there have been several requests from the organizational perspective in oncology, expressing the unsustainable nature of the existing paradigm of conventional in-person care delivery by the specialized team.²⁷

The comparison of the effectiveness gap between virtual nursing and traditional nursing is becoming increasingly important. To fully evaluate the efficacy and results of virtual nursing interventions for cancer patients, a systematic review and meta-analysis have been conducted. The main purpose of this systematic review is to evaluate the impact of virtual nursing on alleviating physical and psychological symptoms such as pain, anxiety, and fear of recurrence, as well as its impact on overall QoL. Further evidence is provided by comparing the effectiveness of virtual nursing with traditional face-to-face nursing in symptom management, treatment compliance, patient satisfaction, and healthcare accessibility. This can identify the obstacles and promoting factors for implementing virtual care in the cancer care environment, and provide evidence-based recommendations for its strategic integration into comprehensive cancer care. This review aims to provide an overview of the role of virtual nursing in enhancing cancer care provision and improving patient prognosis through the aforementioned approaches.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines served as the foundation for this systematic review and meta-analysis.³⁰

Database search strategy

A thorough and systematic search was carried out across many databases, such as PubMed, MEDLINE, and the Cochrane Library, to locate relevant studies that contrasted virtual nursing with conventional techniques. From the first report on virtual nursing to February 2024, the following seven databases were used by two reviewers to independently look through relevant research papers: PubMed, Web of Science, CINAHL, EMBASE, the Cochrane Library, Scopus, and APA PsycINFO. Each database was searched separately using the following phrase combinations: “virtual care” OR “virtual nursing” OR “telehealth” OR “telemedicine” AND “cancer” OR “oncology” OR “tumor.”

Criteria for selecting studies

The PICOS (Population, Intervention, Comparison, Outcome, Study) design—formed the basis of the study's inclusion criteria. This includes people with cancer of any age and includes survivors, active patients, and those diagnosed with cancer but have not started the treatment yet. For intervention, it includes all forms of virtual healthcare, such as telemedicine and virtual nursing. To conduct the meta-analysis and comparison, it includes standard therapy (such as traditional rehabilitation, health education, and psychological support) against the absence of virtual intervention (such as music, video, or iPad diversions). In the results, the study will measure life quality. The study design was randomized controlled trial (RCT). Fig. 1 is the workflow.

Reasons for excluding studies

A methodical strategy was utilized to weed out research that didn't fit the preset inclusion requirements. Studies that were observational, nonrandomized or lacked relevant outcome measures were all excluded. To maintain the caliber and dependability of the included research, studies with inadequate data, imprecise reporting, or methodological errors were also disregarded.

Assessing for bias risk

We used the Cochrane risk of bias tool for randomized trials (RoB 2)³¹ to determine the degree of bias in the included RCTs.

Assessment of reporting biases

A funnel plot was one of the tools used in the procedure to evaluate reporting biases (such as publication bias). However, since we were unable to pool more than 10 trials, this was not feasible.³²

Data synthesis

Depression was only included in one RCT; hence, we were unable to do a meta-analysis for that particular result. We used a forest plot to show the results of the other studies. We integrated continuous data from psychosocial outcome measures that were sufficiently comparable for the meta-analysis using generic inverse variance and standardized mean difference (SMD), often referred to as Cohen's *d*.³³ This allowed us to account for scale variances. Small, medium, and big are the SMD values of 0.2, 0.5, and 0.8, respectively.³⁴ To account for any differences between studies where the approach and conditions of the healthcare setting may have changed, we used a random-effects model for the meta-analysis.

Subgroup analysis and investigation of heterogeneity

Subgroup analyses were designed to examine the following research characteristics as possible causes of heterogeneity if sufficient studies were available: type of cancer, care phase, and delivery strategies for treatments. A significance criterion of $P < 0.05$ was in place.

The amount of between-study variance linked to heterogeneity as opposed to sampling error is measured by the I^2 statistics test, which was utilized to assess the heterogeneity. The Cochrane Handbook³³ provides the following cutoff points for interpreting the I^2 : A percentage between 0 and 40% suggests that the difference may not be significant, a percentage between 30% and 60% suggests that the difference may be moderate, a percentage between 50% and 90% suggests that the difference may be substantial, and a percentage between 75% and 100% suggests that the difference may be significant.

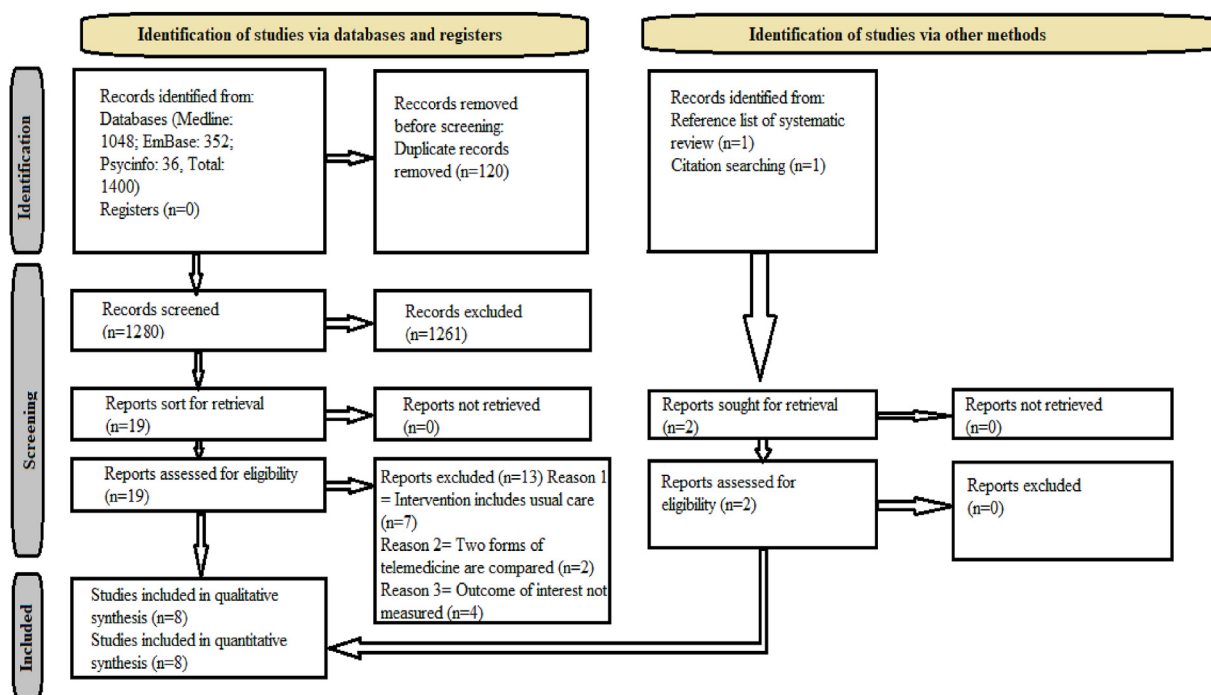


Fig. 1. Selecting the data for analysis.

Results

Study selection

12 objects in total were loaded onto the Rayyan platform after being taken out of the three databases. After duplicates were removed, screening was done on 1080 records for titles and abstracts. A comprehensive text examination of 19 publications that were thought to be potentially appropriate was done. Thirteen^{35–47} of these were removed because two forms of telemedicine were compared, telemedicine was used to enhance conventional care rather than to replace it completely, or the review's intended outcomes were not included. There were six selected papers (numbers 48–53). In the end, two additional pertinent studies were located; they were identified in the reference lists of a study⁴⁸ and a systematic review.⁴⁹ As a consequence, the evaluation had a total of eight reports.

Study characteristics

A total of 3414 patients (1952 intervention vs. 1462 control) were assessed in the RCTs. Out of the studies that were chosen, five had their headquarters in Europe, one each in the USA, Canada, and China. In terms of cancer types, the Maguire study⁵⁰ included 829 patients getting chemotherapy for non-metastatic breast cancer, non-lymphoma, or colorectal cancer and 32 patients had colon cancer, 76 patients had head and neck cancer, 1287 women had breast cancer, 236 had endometrial cancer, and 89 had ovarian cancer. For the measure of influence on QoL, we examined data from five studies, including 1213 patients, seven studies involving anxiety, two studies involving global distress, and one research involving depression. The QoL was assessed using the following instruments: the EuroQol EQ-5 Dimensions-3 Level (EQ-5D-3L),⁵¹ the EORTC Core Quality of Life Questionnaire (EORTC QLQ-C30),^{48,49,52} the Functional Assessment of Cancer Therapy—Head & Neck Scale (FACT-HN),⁵³ the Functional Assessment of Cancer Therapy—General (FACT-G),⁵⁰ and a specific endometrial cancer module (QLQ-EN24).⁵³ The Memorial Symptom Assessment Scale (MSAS) Global Distress Index (GDI) was used to measure global distress.^{50,53} The cancer center contrasted control groups, who got standard treatment, with intervention

groups that received technologically based interventions (consultation, clinical examination, etc.). In five treatments (48–50, 54–55), patients were followed up via phone consultations facilitated by specialized nurses. The delivery methods used in these experiments varied (telephone,⁵⁴ website,⁵⁰ and telehealth device⁵³). Although a range of impact indicators were used in all the research, none looked at how telemedicine affected the four outcomes that may be reviewed. To be exact, seven studies looked at global distress Beaver studies,^{49,51,55} as a secondary outcome in Kimman et al.,⁵² Krzyzanowska et al.,⁵⁴ QoL was a primary endpoint in two studies,^{52,53} a secondary endpoint in four studies,^{48–50,54} and a secondary outcome in Maguire et al.,⁵⁰ as well as a secondary outcome in Ngu et al.,⁴⁸ one study mainly assessed depression as a secondary result.⁵⁴ Table 1 presents a synopsis of the features of the studies that were part of the review.

Risk of bias in studies

The assessments of each “risk of bias” item are shown as percentages across all included RCTs in our “risk of bias” graph (Fig. 2).

Fig. 3 provides an overview of the “risk of bias” and includes the assessments of each “risk of bias” item for each included study.

Randomization process

An “unclear” risk of selection bias was only associated with one study⁴⁹ since not enough information was provided. This is a result of the trial's sequence generation being unknown. The remaining seven studies were assigned a risk of bias rating of “low” since no obvious baseline imbalances were found between groups, indicating that the randomization process was flawed. Sequence generation was also explained explicitly in these articles.

Blinding of participants and personnel

Systematic disparities in the care that is requested, received, or given between groups are referred to as performance bias.³³ Information on participants' awareness of the intervention allocated during the trial was available in only one study.⁵⁰

Table 1

Presents a synopsis of the features of the studies that were part of the review.

Author, year	Number of patients	Cancer type	Virtual nursing method	Outcome
Ashing and Miller, 2016	39	Breast	Telephone	In the intervention group, overall quality of life rose considerably between baseline and follow-up ($P = 0.049$). Between the baseline and follow-up, the control group's overall quality of life did not change.
Beaver, 2009 ⁵⁵	374	Breast	Telephone	Intervention arm: hospital policy-compliant appointments made by specialized nurses at intervals in line. The control group receives standard hospital follow-up, which includes a clinical examination, consultation, and mammography under hospital practice. For two years, participants underwent reviews every three months; after that, they underwent reviews every year for an additional year.
Beaver, 2012 ⁵¹	65	Colorectal	Telephone	Planned intervention by a colorectal nurse practitioner during follow-up visits that occurred at the same regular intervals as the control. Control hospital appointments after six weeks of therapy, then six-monthly visits for two years, and finally, annual visits for three more years.
Beaver, 2016 ⁴⁹	259	Endometrial	Telephone	The intervention arm involves the examination of patients by gynecology oncology nurses at study locations at intervals that align with hospital protocol. The examination frequency needs to be comparable to the control group's scheduled hospital appointments. Hospital-based follow-up, conducted at the study locations in compliance with hospital protocol, which serves as the control.
Kimman, 2011 ⁵²	320	Breast	Telephone	In addition to the interviews done at 3, 6, 9, and 18 months by a breast care nurse or nurse practitioner, there is also a mammogram and an outpatient clinic visit at 12 months. The control will get a normal hospital follow-up at the same intervals as the intervention, which will include outpatient clinic visits and a mammogram at 12 months.
Krzyzanowska, 2021 ⁵⁴	2158	Breast	Telephone	Intervention arm: two scheduled follow-up calls with a nurse-led evaluation of common toxicities using a standardized questionnaire at the end of each chemotherapy cycle. Control arm: the institution's recommended standard of care. Standard care often included initial patient education regarding chemotherapy and its frequent side effects, as well as the recommendation to call the cancer center between clinic visits with any symptoms or questions about the course of therapy.

(continued on next page)

Table 1 (continued)

Author, year	Number of patients	Cancer type	Virtual nursing method	Outcome
Maguire, 2021 ⁵⁰	829	Colorectal, Hodgkin's disease, breast, non-Hodgkin's lymphoma	Web site	Time, round-the-clock toxicity control, and monitoring of treatment. A toxicity self-assessment questionnaire was completed by patients daily, or whenever they felt unwell, for up to six rounds of chemotherapy. When required, alerts were produced for clinicians. Control: Standard cancer center care. It was suggested to the participants to get in touch with doctors via common channels.
Ngu, 2020 ⁴⁸	385	Endometrial or ovarian cancer	Telephone	After therapy, research nurses will conduct interviews every three months for the first two years, then every six months for the next three, and eventually every year. Furthermore, a yearly clinic follow-up with gynecologists will be conducted. Follow-up following the regular schedule of the local gynecological clinic, with appointments for a clinical evaluation and symptom review occurring at the same intervals as the telephone consultation.
Pfeifer, 2015 ⁵³	80	Head and neck	Telehealth messaging device	The participants received daily algorithm question response training. They would receive customized information and recommendations on when to contact doctors based on their responses. The coordinator called the patient directly and/or contacted doctors in order to ensure an effective and prompt response in cases of unrelieved symptoms or those identified as needing immediate attention. Control arm: routine care, which is characterized as assessment-only or standard care

Regardless of the nature of the intervention, it is quite likely that the participants knew what it was that was assigned to them during the process. Because blinding was either not disclosed or was impractical, all the studies were considered to have an “unclear” risk of bias.

Blinding the evaluation of the outcome

Detection bias is the term used to describe systematic disparities in the way outcomes are determined between groups.³³ Since the results were self-reported, study participants, who served as the outcome assessors, were likely aware of the status of the intervention. There isn't much evidence to suggest that the awareness of the intervention received had an impact on the result evaluation, but it may have. Every study had an “unclear” risk of detection bias, according to our rating.

Incomplete outcome data

Systematic variations in study withdrawal rates between groups are referred to as attrition bias.³³ We deemed three studies^{52,53,56} to have a “low” risk of bias since the response rates were balanced and the missing data in both groups had comparable causes. The risk of bias was deemed “unclear” due to the inadequate reporting of follow-up reasons and information on the distribution of attrition between the groups in two

studies.^{50,54} The substantial attrition, the disparity in numbers, or the different reasons for attrition between the two groups placed three studies^{48,51,55} at a “high” risk of bias.

Selective reporting

With all predetermined outcomes reported and research procedures available, three studies^{50,52,54} were deemed to have a “low” risk of reporting bias. There was clear reporting bias in one research⁴⁸ as it only included data on statistically significant QoL domains, which prevented findings from being included in the meta-analysis. Since no research protocol was provided, the remaining studies were rated as having an “unclear” risk; however, all of the objectives stated results were disclosed.

Other possible bias sources

The only study that satisfied our standards for having a “high” risk of bias due to potential contamination was.⁵¹ Due to possible carry-over effects and the timing of the outcome questionnaire administration, three studies were evaluated as having an “unclear” risk,⁵⁵ while four studies were rated as having a “low” risk of additional potential sources of bias.^{50,52–54}

	B1	B2	B3	B4	B5	B6
Ashing 2016	+	-	-	×	-	-
Beaver 2009	+	-	-	×	-	-
Beaver 2012	+	-	-	×	-	×
Beaver 2017	+	-	-	+	-	-
Kimman	+	-	-	+	+	+
Ngu	+	-	-	-	+	+
Pfeifer	-	-	-	+	+	-
Krzyzanowska	+	-	-	-	-	+

+

-

×

B1: Random generation

B2: Blinding participants and personnel

B3: Blind outcome assessment

B4: incomplete outcome data

B5: Selective reporting

B6: Other Bias

Fig. 2. The risk of bias graph displays the percentages representing the assessments of each risk of bias item for all the included research.

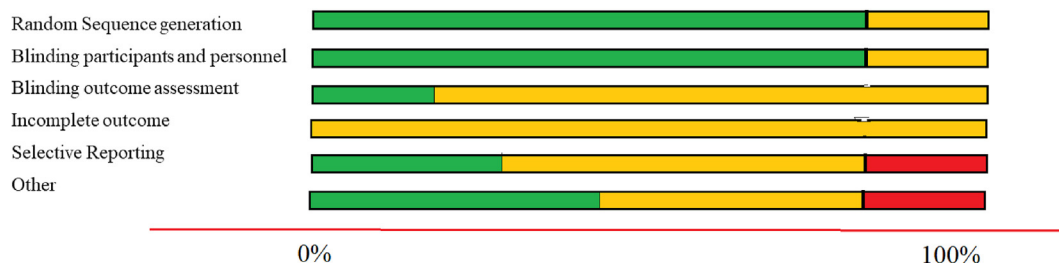


Fig. 3. Risk of bias summary: judgments about each risk of bias item for each included study.

Effects of interventions

There was at least one of the relevant outcomes reported in each paper that was chosen for the systematic review that was part of the meta-analysis. In Fig. 4, the meta-findings are displayed analysis's.

Quality of life

In the meta-analysis on this outcome, five studies^{48,50,52-54} involving 1493/2085 (72%) cancer patients were included. Although QoL was considered in the Ngu et al. study,⁴⁸ underreporting kept it out of the meta-analysis. With a statistically significant overall estimate (SMD = 0.22, [0.01-0.43] CI 95%, P = 0.04), the QoL of the intervention arm was demonstrated to be improved in all included trials, ranging from mild to moderate (SMD = 0.33 in Maguire et al.⁵⁰) to (SMD = 0.04 in Kimman et al.⁵²). Furthermore, no indication of heterogeneity was seen.

Discussion

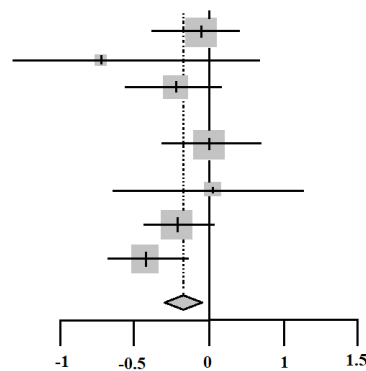
To the best of our knowledge, this is the first meta-analysis of RCTs looking at how telemedicine, as opposed to conventional in-person therapy, might help cancer patients' mental health. Numerous meta-analyses on this subject were available at the time the report was prepared.^{17,57,58} However, none of them was limited to assessing the effectiveness of virtual care provided in place of standard, in-person care at hospitals; instead, they included psychosocial treatments based on telehealth, which we did not include since they would have altered the methodology used to determine the impact of the treatment modality.

This meta-findings analyses demonstrates that there is no negative impact on patient's psychological wellness when technology-based, distant cancer therapy is substituted for conventional clinician-led, in-person cancer care. Conversely, all of the conclusions of the investigation showed improvements. These advancements are therapeutically significant, as cancer diagnosis and therapy can have detrimental psychological effects. Furthermore, the modest heterogeneity we found adds to the validity of our findings. These results might be the result of several factors. In comparison to traditional healthcare, telehealth treatments may give cancer patients quicker access to information about their condition, easing their anxiety and lowering their level of uncertainty.⁵⁸

Technology may help people and healthcare providers communicate by offering a platform for interaction. This allows us to better attend to patients' needs,⁵⁸ promote self-management, and assist patients in resolving various cancer-related concerns.⁵⁹ Furthermore, telemedicine has the potential to bridge the gap in care between physicians and patients by providing essential medical care to distant or rural communities.⁵⁹ Lastly, getting care outside of a hospital may allow patients to feel more at ease by giving them more room to focus on their issues and lessen their emotional anxiety.²⁸

The results of the three subgroup analyses produced some interesting ideas, but they can only be used to generate hypotheses that require confirmation in larger-scale research because of the well-known research constraints (false negatives from inadequate power, false positives from numerous comparisons, and limited ability to influence individual

Study	SMD	SE	Control	Virtual Nursing	Std	95% CI
Beaver 2016	0.0953	2.0918	106	111	0.10	-4.00; 4.20
Kimman	0.0432	0.1157	149	150	0.04	-0.18; 0.27
Kryzanowska	0.0477	1.3776	283	278	0.05	-2.65; 2.75
Maguire	0.3326	0.0839	157	179	0.33	0.17; 0.50
Pfeifer	0.2975	0.2279	35	45	0.30	-0.15; 0.74



Heterogeneity: $I^2 = 5\%$ $t^2=0.0175$, $p=0.38$

Test for overall effect: $z = 2.05$ ($p = 0.04$)

Fig. 4. The result of the comparison forest plot between the telehealth intervention and the control group is SMD for the change in QoL from baseline. SMD, standardized mean difference; QoL, quality of life.

treatment decisions = 58). Among these theories is the idea that, in contrast to the follow-up period, telemedicine is more advantageous during active therapy. One possible explanation for this might be that patients undergoing active therapy requires more guidance on how to manage their symptoms and having easier access to physicians during an especially trying phase of the disease trajectory could lower anxiety and enhance QoL. It has been noted that the QoL trend peaks negatively three months after the start of cancer therapy and then steadily improves.⁶⁰ A second finding from the research is that, in contrast to other cancer types, technology-based virtual care does not seem to enhance the QoL or reduce anxiety in patients with breast cancer. We were unable to identify any explanation for this result; given that the sample covered by this meta-analysis is predominately female, neither heterogeneity nor a gender effect can explain it (94%). The finding that telemedicine seems to improve anxiety and QoL when provided through channels other than the phone leads to a third theory. This finding may be explained by the fact that, rather than focusing on the type of technology utilized, all studies on telephone interventions were conducted on follow-up patients, who may not require clinical advice and contact as much as those having active treatment, as previously claimed. Additionally, participants in trials evaluating more advanced, cutting-edge technology could not be

the same as those using the telephone, a device that is easily utilized by anyone.

Limitations

There are several restrictions on this study. First off, our results are not as strong since psychosocial consequences were often examined as secondary endpoints in most research. Second, only half of the included studies have a low risk of bias, and three have a high risk. Overall, the quality of the included research is moderate. Numerous methodological problems, primarily related to reporting biases and attrition, have been identified. Thirdly, the results of this meta-analysis may not apply to other types of cancer or individuals of either gender, as the majority of the included papers concentrate on cancers in women. Finally, summary statistics were used for the meta-analysis because patient-level data were not available for all included trials.

Conclusions

One of the key worries is the potential harm that the growing decentralization of health care through the use of communication technology

may do to patients' mental well-being. This paper addresses this pertinent topic by demonstrating that, although many details have to be worked out, telehealth does not worsen but rather improves QoL. First off, even though research on telehealth acceptability and satisfaction is typically positive, people who consent to participate in telemedicine trials may already be amenable to this type of therapy.⁶¹ The literature highlights many implementation challenges that need to be taken into consideration in this respect. The most common obstacle to telemedicine, according to a summary of systematic studies,⁶² is the dearth of data that informs telemedicine design, making it challenging to modify interventions for a wide range of cancer kinds, ages, languages, and environments. Furthermore, many obstacles might keep telemedicine from being viable, including the dearth of cancer-specific apps, the high cost of employing staff with the necessary training, and the difficulty of incorporating patient-centered care into the design.⁶² Lastly, while considering the implementation of virtual care systems, patients should keep in mind the possible issues of digital illiteracy and unequal access to technology.^{61,62} Therefore, the present focus on virtual care mustn't result in health disparities. Therefore, future research should focus on determining which patient populations stand to gain the most from telemedicine and which ones still benefit from in-person consultations, taking into account psychosocial outcomes while making their assessments. Interventions also need to be well recorded to ensure repeatability, allow researchers to build on study findings, and make it easier for evidence to be used in practice.

Ethics statement

Not required.

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CRediT authorship contribution statement

Dongfeng Yu: Conceptualization, Methodology, Software. **Dongfeng Yu:** Data curation, Writing – Original draft preparation. **Yajun Sun:** Visualization, Investigation. **Yuhong Xu:** Supervision. **Yajun Sun:** Software, Validation. **Hui Fang:** Writing – Reviewing and Editing. All authors had full access to all the data in the study, and the corresponding author had final responsibility for the decision to submit for publication. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data could be obtained by contacting the corresponding author.

Declaration of generative AI and AI-assisted technologies in the writing process

No AI tools or services were used during the preparation of this work.

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