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Effect of Mobile Health Interventions for Side Effects Management in Patients Undergoing Radiotherapy: A Systematic Review

Running Title: mHealth Interventions in Patients Undergoing Radiotherapy

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Abstract

This systematic review aimed to evaluate the role of mHealth interventions in cancer patients under radiation therapy. Studies were obtained from PubMed, Embase, Scopus, and web of science databases on Aug 01, 2022. We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Out of the 7 included studies, 4 studies had a control group as opposed to an intervention group. In two of these studies, no significant difference was observed in the quality of life, symptoms, and side effects of radiation therapy. However, in two of the other included studies, there was a significant improvement in the quality of life, improvement in the symptoms and complications caused by radiation therapy, and a significant improvement in the performance of patients in the intervention group was observed compared to the control group. In 3 other cases included studies, the feasibility of mobile health interventions in patients undergoing radiotherapy was discussed, and in all 3 studies, patients were highly satisfied with the use of these types of programs. The results of our systematic review showed that mobile health interventions are at least as safe, effective, and feasible as traditional care sessions in reducing radiation-related complications and symptoms. This study was approved by the ethical committee of MUMS (approval number IR.MUMS.REC.1398.047).

Keywords: *Mobile health, radiotherapy, side effect, mHealth.*

1. Introduction

Cancer is considered the leading cause of death throughout the world [1]. The annual incidence of cancer in the world is rapidly elevating so the affected population is expected to increase from 14.1 million individuals in 2012 to more than 20 million cases in 2030. The progress made in the field of diagnostic and therapeutic methods has increased the survival rate of cancer. Nonetheless, most cancer patients are still suffering from multiple physical, mental, and social problems [2].

Radiotherapy has a positive role in cancer treatment and is known as the most important therapeutic element for the cancer population. This method is effective in decreasing the recurrence and improvement of the disease [3]. Radiotherapy has a positive role in cancer treatment and is known as the most important therapeutic element for the cancer population. This method is effective in decreasing the recurrence and improvement of the disease. The radiotherapy technique causes short- and long-term side effects in patients. The lack of suitable control for these complications exacerbates the negative outcomes on the Quality of Life (QOL) of the patients. Therefore, these issues might neutralize the benefits of increasing the survival rate due to increasing the costs of side effects [4] patients with cancer need the management of their side effects, and technology can be of benefit in this regard [5].

Nowadays, electronic Health programs have emerged as a supportive tool for the management of advanced cancers. Electronic health is known as the usage of Information and Communications Technology (ICT), including computer, mobile phone, and satellite communications in the field of health. The term mobile health (mHealth) has been proposed and is now being used as a subset of electronic health. Currently, more than 70% of the population of some Asian countries, such as the United Arab Emirates, South Korea, Saudi Arabia, and Singapore utilize this technology. Information and Communications Technology (ICT) has emerged as a novel technique for the remote & accurate assessment of various pathological processes, including oncology [6]. These technologies are widely used in different types with distinct purposes and might lead to variable results. A valid mHealth program might influence the reduction of

costs, access to data, communication with the treatment team, and increase in knowledge level among the patients affected by cancer [7-9]. Mobile phones can be used in the field of health [10].

Although many studies have investigated the impact of mobile health [11,12]. However, there is no systematic review that examines the effect of mobile health on patients undergoing radiotherapy. Consequently, the present study aimed to evaluate the role of mHealth interventions in cancer patients under radiation therapy.

2. Methods

2.1. Search Strategies

The searched electronic databases were PubMed, Scopus, Web of Science, and Embase. A combination of MeSH terms and keywords related to mHealth and radiotherapy were used in the search process, such as mobile phone, apps, eHealth, radiotherapy, and radiation therapy. The details of search strategies are described in Appendix 1. The searches were performed in English and articles published before Aug 01, 2022, were included in the investigation. We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to report on evidence from the studies that were included in this systematic review. The PRISMA checklist is shown in Appendix 2. This study was approved by the ethical committee of MUMS (approval number IR.MUMS.REC.1398.047).

2.2. Eligibility criteria

The inclusion criteria entailed studies on cancer patients, investigations on the feasibility assessment, pilot studies, and evaluations of mHealth application interventions using a smartphone or a tablet computer, and being in the English language. The exclusion criteria encompassed being conducted on patients with other diseases, focusing on the methods of radiation therapy, reviews, conference proceedings, letters to the editor, protocols, and theses.

2.3. Data Extraction and Synthesis

The following data were extracted from the selected articles: [1] General study characteristics, including the year of publication, authors, country, study design, language, the number of participants, and cancer type, [2] The type of intervention, and [3] Goal of study and outcome measures. Disagreements were rare and were easily resolved by consensus. The four authors reviewed and extracted the information from the articles.

2.4. Quality Assessment of Studies

The methodological quality of the studies was critically appraised using the Downs and Black checklist [13]. This checklist was developed to assess the quality of randomized and nonrandomized studies. The checklist includes 27 items under five subscales. Downs and Black checklists were scored as one point for each item so that the modified total score was 27. The subscales of this checklist included reporting, external validity, internal validity bias, internal validity confounding, and power with 10, 3, 7, 6, and 1 item, respectively. The authors individually reviewed each included article in terms of quality using a quality scoring sheet. Quality scores of above 20, 11–20, and below 11 were considered as good, moderate, and poor, respectively [14]. The higher score represented a better methodology. The four authors independently rated all the studies, recorded final scores for each article, and resolved any differences by discussion.

3. Results

3.1. Study Selection

The search strategy for this review has been consolidated into a Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) diagram [15] shown in Figure 1. For database screening, two authors (ASM & SFMB) searched the databases on 01 Aug 2022, with a yield of 1525 articles. After the removal of duplicates and articles with other languages, 1049 remained and were evaluated based on title and abstract. Of these, 1008 were discarded as not meeting the inclusion criteria, and 41 records were selected for full-text screening. Finally, 7 eligible articles were found through this review.

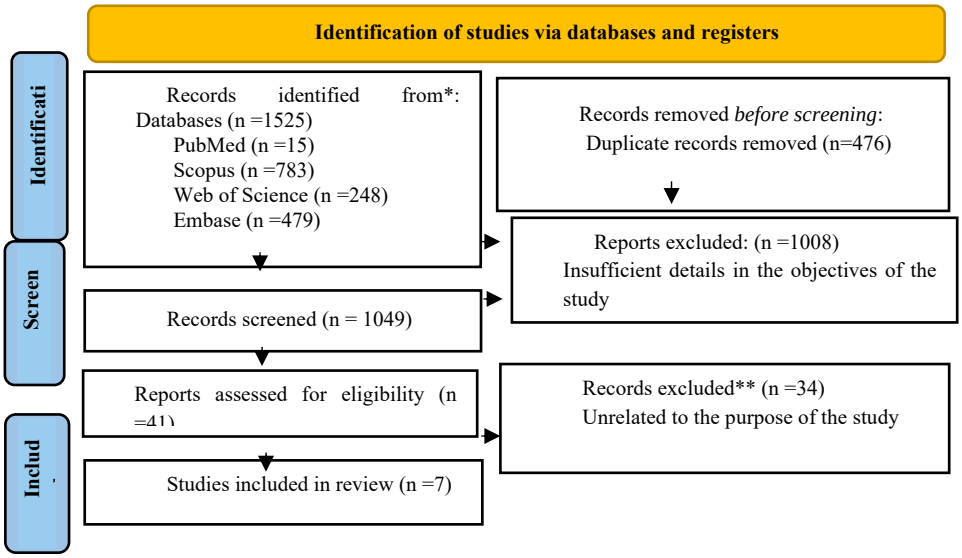

Figure 1. Flow diagram of the literature search and study selection

3.2. General Characteristics

The characteristics of all included studies are reported in Table 1. Of the 7 included studies, 3 (43%) studies were conducted in Sweden [16,17,18], 2 (30%) studies were conducted in China [19,20] and other studies in France [21], and North Carolina [22]. The studies' sample sizes ranged from 9 participants [17] to 132 participants [20]. Studies designs were classified into four categories randomized controlled trials (2/7, 30%) [19,20], there feasibility studies (3/7, 43%)[17,21,22], a quasi-experimental [16] and a non-randomized controlled trial [18]. Follow-up periods ranged from 2 weeks [17] to 6 months [20]. Mobile health interventions included studies were categorized into four categories of the 7 studies, 4 (57%) used mobile applications [16,18,20,22], and other studies used remote monitoring via a connected platform [21], Exercise intervention based on the internet and social media software (CEIBISMS) [19] and Interactive Information and Communication Technology (ICT) platform [17]. The target populations in the assessed studies included the patients with prostate cancer [16-18], bladder cancer [21], lung cancer [21], nasopharynx cancer [20], breast cancer [19,21], and head and neck cancer [22].

3.3. Quality Assessment

The mean methodologic score using the Downs and Black Checklist of the studies was between 12 of 20. The quality assessment of all articles was reported in moderation.

3.4. Clinical and Technological Characteristics

Of the 7 included studies, 4 studies had a control group as opposed to an intervention group (intervention with mobile health) [16,18-20]. In two of these studies, no significant difference was observed in the QOL, symptoms, and side effects of radiation therapy [16,20]. However, in one of these studies, the patients of the intervention group reported a better improvement in their information regarding the selection of a reliable source of health information and the ability to plan for their care management [16]. However, in two of the other included studies, there was a significant improvement in the QOL and improvement in the symptoms and complications caused by radiation therapy, including (reducing fatigue, nausea, barometer, and emotional factors and improving mental health, insomnia, and urination), as well as a significant improvement in the performance of patients in the intervention group was observed compared to the control group [18,19].

In 3 other cases of included studies, the feasibility of mobile health interventions in patients undergoing radiotherapy was discussed, and in all 3 studies, patients were highly satisfied with the use of these types of programs; So that they stated that mobile health programs had increased the partnership between themselves and their providers. They also stated that mobile health programs for managing radiotherapy symptoms and complications were user-friendly, safe, and feasible [17,21,22].

Table1. The characteristics of included studies

Author Year Country	Participants number	Study Type	Cancer type	Duration	Intervention Type	Goal of study	Results of study
Yasmine Meghiref 2021 France [21]	39	A prospective feasibility study	Prostate Lung Breast Bladder	No mentioned	Remote monitoring via a connected platform	Assessing the Feasibility of Remote Monitoring and Collecting Patient-Reported Outcomes in Clinical Trials	Out of the 35 participants who answered a satisfaction questionnaire, 95 % (n = 33) were satisfied or very satisfied with the Remote monitoring, and 85 % (n = 30) were satisfied with their relationship with the healthcare team.
Kay Sundberg 2021 Sweden [16]	130	Quasi-experimental	Prostate cancer	3 – months	Application	Comparison of health literacy and self-care ability in men with prostate cancer who underwent radiotherapy and used a symptom management program versus a control group.	The application group had improved regarding the " ability to select information needed from a variety of information sources " (p = .020), " ability to determine the information credible " (p = .041), and " being able to plan and decide what to do to improve health " (p = .004). No, the inter-group difference was found for the Appraisal of Self-Care Agency.
Dong et al. 2019 China [19]	60	RCT	Breast cancer	12- weeks	Exercise intervention based on internet and social media software (CEIBISMS)	Investigating the effect of CEIBISMS on breast cancer patients after surgery by evaluating their QOL, muscle strength, and cardiorespiratory capacity.	The CEIBISMS yielded significantly better results than traditional methods, in vitality (p = 0.009), mental health (p = 0.001) and reported health transition (p = 0.048) by week 12. The CEIBISMS resulted in significant improvement in the stand-up and sit-down

							chair test ($p < 0.0001$), and arm lifting test ($p=0.017$). The CEIBISMS offered rehabilitative effects in QOL and muscle strength of postoperative patients with breast cancer.
Di et al. 2018 China [20]	132	RCT	Nasopharyngeal carcinoma	3 months and 6 months after discharge.	Smartphone medical app	Investigating the effect of the intervention of a smart-phone medical program on the complications and QOL of patients with nasopharyngeal cancer who underwent radiotherapy and chemotherapy	The smartphone app can effectively decrease radiotherapy and chemotherapy complications. It can improve fatigue, pain, sleep loss, appetite loss, constipation, and other symptoms. The use of the app improves QOL and satisfaction among patients after discharge. However, there was no difference between the complications of radiotherapy and chemotherapy and QOL between the 2 groups at discharge ($P>0.05$).
Falchook et al. 2016 North Carolina [22]	22	A prospective feasibility study	Head and neck cancer	Approximately 5 to 7 weeks	Mobile application	Evaluating the feasibility of monitoring patient-reported symptoms via mobile devices	Most patients use mobile device technology to report symptoms. Patient satisfaction with using mobile devices to report symptoms was that mobile devices can be a useful method to collect patient-reported outcomes.
Sundberg et al. 2015 Sweden [17]	9	Feasibility study	Prostate cancer	2 weeks	Interactive ICT-platform	The feasibility and acceptability of an information and communicatio	Patients felt safe and well cared for with the use of the platform with an alert system. Both patients and nurses responded positively to the

						n technology platform were evaluated for the evaluation and management of patient-reported symptoms during prostate cancer radiation therapy.	platform and saw that it could enhance symptom management and self-care during cancer treatment.
Sundberg et al. 2017 Sweden [18]	130	A non-randomized controlled	Prostate cancer	During treatment and 3 weeks after	Smartphone application (Interaktor)	Evaluation of the effect of using a program for immediate symptom assessment and management during radiation therapy for localized prostate cancer on symptom burden and QOL.	The application group rated significantly lower levels of fatigue and nausea at the end of radiotherapy. Additionally, they had significantly less burden in emotional functioning, insomnia, and urinary-related symptoms at the end of treatment compared with the control group. Use of application decreases levels of fatigue and nausea and less burden in emotional functioning, insomnia, and urinary-related symptoms at the end of radiotherapy.

4. Discussion

4.1. Principal Findings

The results of this study showed that using ICT, such as mHealth results in decreased side effects due to radiation therapy and has a critical role in the improvement of QOL and the satisfaction of patients.

Out of 7 included studies, 4 studies had a control group as opposed to an intervention group (intervention with mobile health) [16,18-20]. In two of these studies, no significant difference was observed in the QOL, symptoms, and side effects of radiation therapy [16,20]. However, in two of the other included studies, there was a significant improvement in the QOL, improvement in the symptoms and complications caused by radiation therapy, and a significant improvement in the performance of patients in the intervention group was observed compared to the control group [19,18].

In 3 other cases of included studies, the feasibility of mobile health interventions in patients undergoing radiotherapy was discussed, and in all 3 studies, patients were highly satisfied with the use of these types of programs; Additionally, they stated that mobile health programs for managing radiotherapy symptoms and complications were user-friendly, safe and feasible [17,21,22]. The QOL of patients with cancer are correlated with their positive attitudes [23].

The application of these technologies is an opportunity for empowering the patients through self-care recommendations

that elevate the knowledge and active cooperation of the patients in the care process resulting in enhanced health. Cancer treatment is a highly stressful experience in life, which is accompanied by a wide range of psychological, social, physical, and functional issues. Therefore, the patients affected by cancer require information that helps them to understand the disease better and make more suitable decisions for the treatment course [24].

In cancer patients, self-care means improving QOL, managing the symptoms, and increasing satisfaction with life [25]. Zhu et al. reported that the enhancement of self-care strategies for women with breast cancer is considerably important for improving QOL and mental well-being [26]. In addition, the cooperation of the patient in taking care of himself/herself results in the promotion of care quality [27]. Various factors, including age, socioeconomic status, marital status, familial history of cancer, and smoking history are among the suitable predictors of self-care behaviors [28].

The results indicate that ASyMS usage by patients may lead to self-efficacy. In addition, other studies confirm that the enhancement of self-efficacy has a remarkable role in reducing anxiety [29]. The perceived needs of patients with cancer for supportive practices are highly different due to the diversities in culture, diagnosis, prognosis, and treatment-related signs and these mentioned factors might influence the acceptance of technologies by the patients [30-32].

In designing technologies; Content, information, and the characteristics of the developed technology are among the important factors of user satisfaction and the contents should reflect the needs of the users [33]. The results of previous studies in the current study showed that the simplicity and proportional contents of technologies affect the acceptance of mHealth.

The studies show that the relationship between the treatment team and cancer patients in gaining the information regarding treatment process is weak [18, 34]. In addition, the patients do not receive sufficient information from the healthcare team in terms of the side effects of treatment [24]. Consequently, mHealth technologies have been useful in meeting the health needs of patients. Moreover, communication with the care team through these technologies led to the feeling of safety in patients and timely management of the symptoms caused by treatment.

Mobile phone applications can facilitate the relationship between physicians and patients. Therefore, physicians have the opportunity for the fast and simple presentation of the required information to the patients resulting in reduced anxiety in the patients. Furthermore, physicians can regularly monitor the patients and obtain information concerning their conditions [35-37].

It should be mentioned that family members are usually the main source of support for cancer patients who regularly participate in counseling sessions and have a role in important medical decisions. Therefore, reporting the symptoms by charts using this technology can show the recovery process of the disease to the patients and their families [38].

Patient satisfaction is a method for evaluating the counseling process and relation patterns, such as presenting information and patient participation in decisions. Patient satisfaction is one of the main outcome indices for the provision of health care and is one of the considerable features in assessing health care quality [67]. Various studies demonstrate that one of the important factors for the successful implementation of mHealth is patient satisfaction [39]. The present study indicated that the subjects were sufficiently satisfied with mHealth technology in terms of managing the side effects due to radiation therapy.

Physicians believed that using this technology has a relationship with the age of the patient. El Shafie et al. found in their study that the age of the patient is among the remarkable factors in using mHealth technology and young people have more tendency for applying such technologies [40]. On the other hand, some studies indicate that old individuals have the needed confidence and ability for using a cell phone [41, 42].

This study was in line with previous studies in examining the impact of mHealth on improving clinical conditions and QOL of patients [11,12,43-61].

4.2. Strengths and Limitations

This was the first systematic review of the impact of mHealth on cancer patients under radiation therapy. One of the limitations of the present review was included only peer-reviewed studies published in scientific journals and conferences; therefore, articles published in the gray literature are not included in the present study. Also, the included studies had very heterogeneous designs and used different methods for measuring the outcomes of mHealth; therefore, performing meta-analysis and investigating the effect of these studies was not possible as a group.

5. Conclusion

The results of our systematic review showed that mobile health interventions are at least as safe, effective, and feasible as traditional care sessions in reducing radiation-related complications and symptoms. The benefits of this technology include facilitating communication with healthcare providers, enhancing the knowledge of the patient through presenting self-care recommendations, and activating the role of the patient regarding self-care, self-management, as well as self-efficacy. Overall, this technology improves QOL, highly

influences the satisfaction of the patients, and has a supportive role for cancer patients.

Appendix 1

Search strategy for each database

#	Search Strategy in Embase Database	Results
1	'telemedicine':ti,ab,kw OR 'mobile health':ti,ab,kw OR 'mhealth':ti,ab,kw OR 'telehealth':ti,ab,kw OR 'ehealth':ti,ab,kw OR 'mobile application*':ti,ab,kw OR 'mobile app*':ti,ab,kw OR 'portable electronic app*':ti,ab,kw OR 'portable electronic application*':ti,ab,kw OR 'portable software app*':ti,ab,kw OR 'portable software application*':ti,ab,kw OR 'cell phone*':ti,ab,kw OR 'cellular phone*':ti,ab,kw OR 'cellular telephone*':ti,ab,kw OR 'portable cellular phone*':ti,ab,kw OR 'transportable cellular phone*':ti,ab,kw OR 'mobile phone*':ti,ab,kw OR 'mobile telephone*':ti,ab,kw OR 'car phone*':ti,ab,kw OR 'smartphone':ti,ab,kw OR 'cell phone use*':ti,ab,kw OR 'mobile phone use*':ti,ab,kw OR 'handheld computer*':ti,ab,kw OR 'palmtop computer*':ti,ab,kw OR 'palm-top computer*':ti,ab,kw OR 'personal digital assistant':ti,ab,kw OR 'pda computer':ti,ab,kw OR 'pocket pc':ti,ab,kw OR 'tablet computer*':ti,ab,kw OR 'palm pilot*':ti,ab,kw OR 'iphone*':ti,ab,kw OR 'ipad*':ti,ab,kw OR 'ipod*':ti,ab,kw OR 'ios':ti,ab,kw OR 'android':ti,ab,kw OR 'texting*':ti,ab,kw OR 'short message service':ti,ab,kw OR 'text message*':ti,ab,kw	**N=125319**
2	'radiotherapy*':ti,ab,kw OR 'radiation therapy*':ti,ab,kw OR 'radiation treatment*':ti,ab,kw OR 'targeted radiation therapy*':ti,ab,kw OR 'targeted radiotherapy*':ti,ab,kw OR 'adjuvant radiotherapy*':ti,ab,kw OR 'chemoradiotherapy*':ti,ab,kw OR 'radiochemotherapy*':ti,ab,kw OR 'concurrent chemoradiotherapy*':ti,ab,kw OR 'synchronous chemoradiotherapy*':ti,ab,kw OR 'concurrent radiochemotherapy*':ti,ab,kw OR 'concomitant chemoradiotherapy*':ti,ab,kw OR 'concomitant radiochemotherapy*':ti,ab,kw	**N=433962**
3	1 AND 2	**N= 487**
4	#1 AND #2 AND [english]/lim	**N=479**

#	Search Strategy in Pubmed Database	Results
1	Search ((((("telemedicine"[MeSH Terms]) OR "mobile applications"[MeSH Terms]) OR "cell phone"[MeSH Terms]) OR "smartphone"[MeSH Terms]) OR "cell phone use"[MeSH Terms]) OR "computers, handheld"[MeSH Terms]) OR "text messaging"[MeSH Terms]	**N= 7589**
2	Search ((((((((((((((((((((((((((((((("telemedicine"[Title/Abstract]) OR "mobile health"[Title/Abstract]) OR "mhealth"[Title/Abstract]) OR "telehealth"[Title/Abstract]) OR "ehealth"[Title/Abstract]) OR "Mobile Application*"[Title/Abstract]) OR "Mobile App*"[Title/Abstract]) OR "Portable Electronic App*"[Title/Abstract]) OR "Portable Electronic Application*"[Title/Abstract]) OR "Portable Software App*"[Title/Abstract]) OR "Portable Software Application*"[Title/Abstract]) OR "Cell Phone*"[Title/Abstract]) OR "Cellular Phone*"[Title/Abstract]) OR "Cellular Telephone*"[Title/Abstract]) OR "Portable Cellular Phone*"[Title/Abstract]) OR "Transportable Cellular Phone*"[Title/Abstract]) OR "Mobile Phone*"[Title/Abstract]) OR "Mobile Telephone*"[Title/Abstract]) OR "Car Phone*"[Title/Abstract]) OR "smartphone"[Title/Abstract]) OR "Cell Phone Use*"[Title/Abstract]) OR "Mobile Phone Use*"[Title/Abstract]) OR "Handheld Computer*"[Title/Abstract]) OR "Palmtop Computer*"[Title/Abstract]) OR "Palm-Top Computer*"[Title/Abstract]) OR "personal digital assistant"[Title/Abstract]) OR "pda computer"[Title/Abstract]) OR "pocket pc"[Title/Abstract]) OR "Tablet Computer*"[Title/Abstract]) OR "Palm Pilot*"[Title/Abstract]) OR Iphone*[Title/Abstract]) OR ipad*[Title/Abstract]) OR	**N= 9599**

	ipod*[Title/Abstract]) OR ios[Title/Abstract]) OR "android"[Title/Abstract]) OR Texting*[Title/Abstract]) OR "short message service"[Title/Abstract]) OR "Text Message*"[Title/Abstract]	
3	Search (("radiotherapy"[MeSH Terms]) OR "radiotherapy, adjuvant"[MeSH Terms]) OR "chemoradiotherapy"[MeSH Terms]	**N= 21777**
4	Search ((((((((((Radiotherapy*[Title/Abstract]) OR "Radiation Therapy*"[Title/Abstract]) OR "Radiation Treatment*"[Title/Abstract]) OR "Targeted Radiation Therapy*"[Title/Abstract]) OR "Targeted Radiotherapy*"[Title/Abstract]) OR "Adjuvant Radiotherapy*"[Title/Abstract]) OR Chemoradiotherapy*[Title/Abstract]) OR Radiochemotherapy*[Title/Abstract]) OR "Concurrent Chemoradiotherapy*"[Title/Abstract]) OR "Synchronous Chemoradiotherapy*"[Title/Abstract]) OR "Concurrent Radiochemotherapy*"[Title/Abstract]) OR "Concomitant Chemoradiotherapy*"[Title/Abstract]) OR "Concomitant Radiochemotherapy*"[Title/Abstract]	**N= 7787**
5	1 OR 2	**N= 12524**
6	3 OR 4	**N= 29934**
7	5 AND 6	**N= 15**
8	Search (LIMIT-TO (LANGUAGE, "English"))	**N= 15**

#	Search Strategy in Scopus Database	Results
1	(TITLE-ABS-KEY (telemedicine) OR TITLE-ABS-KEY ("Mobile Health") OR TITLE-ABS-KEY (mhealth) OR TITLE-ABS-KEY (telehealth) OR TITLE-ABS-KEY (ehealth) OR TITLE-ABS-KEY ("Mobile Application*") OR TITLE-ABS-KEY ("Mobile App*") OR TITLE-ABS-KEY ("Portable Electronic App*") OR TITLE-ABS-KEY ("Portable Electronic Application*") OR TITLE-ABS-KEY ("Portable Software App*") OR TITLE-ABS-KEY ("Portable Software Application*") OR TITLE-ABS-KEY ("Cell Phone*") OR TITLE-ABS-KEY ("Cellular Phone*") OR TITLE-ABS-KEY ("Cellular Telephone*") OR TITLE-ABS-KEY ("Portable Cellular Phone*") OR TITLE-ABS-KEY ("Transportable Cellular Phone*") OR TITLE-ABS-KEY ("Mobile Phone*") OR TITLE-ABS-KEY ("Mobile Telephone*") OR TITLE-ABS-KEY ("Car Phone*") OR TITLE-ABS-KEY (smartphone) OR TITLE-ABS-KEY ("Cell Phone Use*") OR TITLE-ABS-KEY (" Mobile Phone Use*") OR TITLE-ABS-KEY ("Handheld Computer*") OR TITLE-ABS-KEY ("Palmtop Computer*") OR TITLE-ABS-KEY ("Palm-Top Computer*") OR TITLE-ABS-KEY ("Personal Digital Assistant") OR TITLE-ABS-KEY ("PDA Computer") OR TITLE-ABS-KEY ("Pocket PC") OR TITLE-ABS-KEY ("Tablet Computer*") OR TITLE-ABS-KEY ("Palm Pilot*") OR TITLE-ABS-KEY (iphone*) OR TITLE-ABS-KEY (ipad*) OR TITLE-ABS-KEY (ipod*) OR TITLE-ABS-KEY (ios) OR TITLE-ABS-KEY (android) OR TITLE-ABS-KEY (texting*) OR TITLE-ABS-KEY ("Short Message Service") OR TITLE-ABS-KEY ("Text Message*"))	**N= 381,695**
2	(TITLE-ABS-KEY (radiotherapy*) OR TITLE-ABS-KEY ("Radiation Therapy*") OR TITLE-ABS-KEY ("Radiation Treatment*") OR TITLE-ABS-KEY ("Targeted Radiation Therapy*") OR TITLE-ABS-KEY ("Targeted Radiotherapy*") OR TITLE-ABS-KEY ("Adjuvant Radiotherapy*") OR TITLE-ABS-KEY (chemoradiotherapy*) OR TITLE-ABS-KEY (radiochemotherapy*) OR TITLE-ABS-KEY ("Concurrent Chemoradiotherapy*") OR TITLE-ABS-KEY ("Synchronous Chemoradiotherapy*") OR TITLE-ABS-KEY ("Concurrent Radiochemotherapy*") OR TITLE-ABS-KEY ("Concomitant Chemoradiotherapy*") OR TITLE-ABS-KEY ("Concomitant Radiochemotherapy*"))	**N= 524,403**
3	1 AND 2	**N=800**

4	Search ((#1) AND #2) (LIMIT-TO (LANGUAGE , "English"))	**N=783**

#	Search Strategy in Web of Science Database	Results
1	TOPIC: (Telemedicine OR "Mobile Health" OR health OR telehealth OR health OR "Mobile Application*" OR "Mobile App*" OR "Portable Electronic App*" OR "Portable Electronic Application*" OR "Portable Software App*" OR "Portable Software Application*" OR "Cell Phone*" OR "Cellular Phone*" OR "Cellular Telephone*" OR "Portable Cellular Phone*" OR "Transportable Cellular Phone*" OR "Mobile Phone*" OR "Mobile Telephone*" OR "Car Phone*" OR "Smartphone" OR "Cell Phone Use*" OR "Mobile Phone Use*" OR "Handheld Computer*" OR "Palmtop Computer*" OR "Palm-Top Computer*" OR "Personal Digital Assistant" OR "PDA Computer" OR "Pocket PC" OR "Tablet Computer*" OR "Palm Pilot*" OR "iPhone*" OR iPad* OR iPod* OR ios OR android OR Texting* OR "Short Message Service" OR "Text Message*")	**N= 135588**
2	TOPIC: (Radiotherapy* OR "Radiation Therapy*" OR "Radiation Treatment*" OR "Targeted Radiation Therapy*" OR "Targeted Radiotherapy*" OR "Adjuvant Radiotherapy*" OR "Chemoradiotherapy*" OR "Radiochemotherapy*" OR "Concurrent Chemoradiotherapy*" OR "Synchronous Chemoradiotherapy*" OR "Concurrent Radiochemotherapy*" OR "Concomitant Chemoradiotherapy*" OR "Concomitant Radiochemotherapy*")	**N= 343221**
3	1 AND 2	**N= 254**
4	Search ((#1) AND #2) (LIMIT-TO (LANGUAGE, "English"))	**N=248**

Appendix 2

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed concerning participants, interventions, comparisons, outcomes, and study design (PICOS).	2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present a full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	7,8
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in a systematic review, and, if applicable, included in the meta-analysis).	3
Data collection process	10	Describe the method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing the risk of bias in individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, the difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of the risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give the number of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	3
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	4-5
Risk of bias within studies	19	Present data on the risk of bias of each study and, if available, any outcome level assessment (see item 12).	5
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	4-5
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of the risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policymakers).	6-7
Limitations	25	Discuss limitations at the study and outcome level (e.g., risk of bias), and at the review level (e.g., incomplete retrieval of identified research, reporting bias).	7
Conclusions	26	Provide a general interpretation of the results in the context of other evidence and implications for future research.	7
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); the role of funders for the systematic review.	2

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