LITERATURE REVIEW

Effectivity of Telemonitoring Toward Quality of Life in Patients with Chronic Obstructive Pulmonary Disease (COPD): A Systematic Review and Meta-Analysis

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ABSTRACT

Introduction: Chronic obstructive pulmonary disorder (COPD) is the third-leading cause of death worldwide. COPD treatment is essential to manage and attenuate the progression of symptoms. Home-based telemonitoring interventions showed several promises in increasing COPD patients' quality of life (QoL) and outcomes. However, various results were obtained in recent studies, making a secondary research presence needed to establish clear risks and benefits. This study aimed to analyze the effect of telemonitoring on QoL among COPD patients.
Methods: This study used the Preferred Reporting Items of Systematic Review and Meta-Analysis (PRISMA) reporting guidelines on several databases from February until April 2023. We performed screening and selection, followed by data extraction and quantitative analysis with Review Manager 5.4 Software. The risk of bias assessment was performed using the RoB 2.0 Cochrane tool.
Results: Ten randomized controlled trials (RCTs), mostly low-risk of bias, were included. We found a reduction in Saint George's Respiratory Questionnaire (SGRQ) score (mean difference (MD) -1.13 [95% CI -4.23, 1.97; p = 0.47]) and Hospital Anxiety and Depression Scale (HADS) for anxiety (MD-0.16 [95% Cl -0.96, 0.63; p = 0.69]). There was no significant effect of HADS on depression and EuroQol-5 Dimension (EQ-5D).
Conclusion: This study suggests that telemonitoring improves QoL in COPD patients, especially for SGRQ and HADS anxiety scores. We suggest a larger number of studies to evaluate the effect of telemonitoring on depression and anxiety. We also encourage the integration of telemedicine with the present care system to achieve the best beneficial outcome for patients.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) ranks as the fifth most frequent cause of morbidity worldwide, often inflicting distress in their daily lives upon those afflicted with the condition. Many patients experienced both physical and psychological problems during therapy.[1] The latter includes issues such as dyspnea, which diminishes patients' exercise tolerance and hampers their ability to engage in daily activities, worsening over time if left untreated. Both anxiety and depression are also associated with COPD, further contributing to a lower quality of life (QoL) for these patients. Currently, guidelines from various medical organizations worldwide recommend supportive therapy, including oxygen therapy and many pharmacological treatments, such as inhalers, mucolytics, and antibiotics, as the primary approach to managing COPD.[2] However, treatment plans can be burdensome for patients experiencing severe exacerbations of the disease, especially considering that 29-47% of patients experience at least one exacerbation annually. Prolonged hospital stays increase both the cost of hospitalization and the risk of death during care.[3]

As this issue persists, COPD remains a global public health concern. Among ongoing efforts by

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government programs to reduce exacerbations in COPD patients, telemonitoring has emerged as one of the most promising interventions available today. Telephone-based monitoring is currently being studied to allow hospital staff or healthcare providers to monitor disease progression, which might be beneficial in the context of preventing exacerbations. Previous studies have also confirmed the benefits of telemonitoring, especially in reducing re-admissions and healthcare costs that may burden COPD patients.[4,5] Furthermore, conversations with healthcare providers are seen as a therapeutic modality, where psychological symptoms may be relieved throughout the monitoring process. This contributes to the goal of telemonitoring by providing a greater QoL for patients.[6] Several previous studies have shown this result using diverse yet reliable methods, but some remain unsure about the effectiveness of the program.[7,8] Further studies and a lifetime of follow-up are required as a foundation for solid evidence of the impact of telemonitoring programs on COPD patients.

This study primarily evaluated several effects on patients' QoL who received telemonitoring programs using frequently used questionnaires such as the Saint George's Respiratory Questionnaire (SGRQ), Hospital Anxiety and Depression Scale (HADS), and EuroQol-5 Dimension (EQ-5D) QoL Questionnaire.

METHODS

This meta-analysis was conducted using the guidelines from the Cochrane Handbook for Systematic Reviews of Interventions. The results were disclosed based on the Preferred Items of Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Three independent reviewers screened articles that were eligible for analyses, assessed the risk of bias, and established the extracted data. Disagreements were resolved through discussion with a fourth reviewer.[9]

Search Strategies

The following six databases were searched for articles from inception to 15 March 2023: PubMed, EMBASE, Scopus, ProQuest, Cochrane Library, and Google Scholar. Search terms included combinations of text word terms and medical subject headings (MeSH) terms using all possible combinations using Boolean logical operators. The search keywords were 'chronic obstructive pulmonary disease', 'COPD', 'telemonitoring', 'telehealth', 'telemedicine', 'telecommunication', 'remote consultation', 'randomized controlled trial', and 'RCT'. Another layer of comprehensive screening was also performed using the previously mentioned keywords and similar terms to reduce the probability of missing any relevant articles. Obtained full texts were then managed using Google Sheets.

Eligibility Criteria

Eligibility of studies was determined with the participants, intervention, comparison, outcomes, and study design (PICOS) framework. The target population (P) included adult patients aged 18 years old or older who were diagnosed with COPD. The intervention (I) given was telemonitoring with QoL parameters included in the outcome (O). The enlisted study design (S) was randomized controlled trials (RCTs) with a control group and a comparison group. The comparison group was defined as regular or usual intervention other than telemonitoring programs. Only original research articles with full texts were included, and the non-English full texts were excluded. Time period restrictions were not made within this study.

The major inclusion criteria were, (a) studies on patients with COPD; (b) RCTs comparing telemonitoring with non-telehealth-supported usual care; and (c) studies that reported at least one outcome of interest. Non-original articles, abstracts, and pre-clinical studies were excluded. Articles not published in English were also excluded.

Data Extraction

Three reviewers independently reviewed and selected all articles from the six databases. Once duplicate studies were removed, the reviewers selected articles based on their titles, abstracts, study designs, and objectives in line with predefined criteria. Only full-text original research articles were considered. The results from the three reviewers were compared, and any disagreements were discussed to reach a consensus. If any discrepancies could not be resolved at any point in the extraction process, a fourth reviewer was consulted. The full articles were then re-evaluated by all four reviewers. The entire study extraction process was reviewed and confirmed by all reviewers.

Risk of Bias

The Cochrane risk of bias tool, RoB 2.0, was utilized to assess the risk of bias and the quality of the study methodology. Each domain within the tool was classified as low risk, high risk, or having some concerns. Three investigators independently conducted the quality assessment of all included studies and then compared their findings. In cases of discrepancies among the three, a fourth investigator was consulted to resolve the differences.

Statistical Analysis

This meta-analysis utilized Review Manager version 5.4.1 software (RevMan, Copenhagen: The

Nordic Cochrane Center, The Cochrane Collaboration, 2020). To assess statistical heterogeneity, Cochran's Q test and I statistics were employed. A fixed-effects model was used for all outcomes. For continuous variables, the results were expressed as mean difference (MD) and 95% confidence intervals (CIs), while continuous outcomes were reported as weighted MD or standardized MD with standard deviations. A two-tailed test of significance ($p < 0.05$) was conducted, and the p-value for the overall estimate's significance test was provided. Forest plots were examined visually to detect heterogeneity among studies. Treatment effect heterogeneity among the studies was measured using I^2 statistics based on the Cochrane threshold, with 0%, 25%, 50%, and 75% indicating insignificant, low, moderate, and high heterogeneity, respectively. When suitable, subgroup analyses for study follow-up were also performed. The inverse variance method, as suggested by Bender, *et al*. (2018), was applied.[10] It was acknowledged that substantial heterogeneity could be present among the studies.

RESULTS

Study Selection and Characteristics

From five database searches, 1,345 studies were identified, with specific details presented in Table 1. After the removal of duplicates and irrelevant studies, 21 records underwent scrutiny to ascertain eligibility. Ultimately, 10 studies met the criteria and underwent quantitative analysis, as depicted in Figure 1. Table 1 outlines the characteristics of these selected studies.

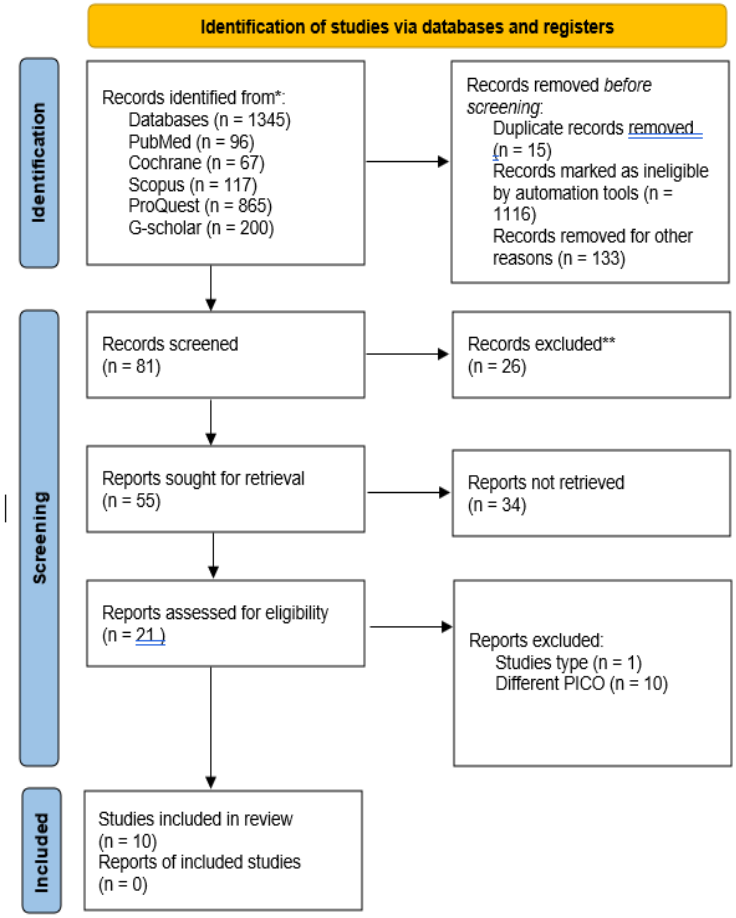

Figure 1. PRISMA flow diagram

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Table 1. Characteristics of study used

Author, Year	Study Location	Study Interval	Sample size (n)	Mean age (Mean (SD))	Type of telemonitoring	Gender (F/M)	Outcome (Mean (SD))							
							SGRQ		HADS Anxiety		HADS Depression		EQ-5D	
							Telemonitoring	Control	Telemonitoring	Control	Telemonitoring	Control	Telemonitoring	Control
Kopfli, 2023	Denmark	6 months	T = 101 C = 97	T = 69 (8.3) C = 70 (7.8)	Smart device (Tunstall HealthCare's telemonitoring equipment)	T = 66/35 C = 55/42	Baseline: 52.0 (18.6) After: 51.1 (18.7)	Baseline: 52.4 (21.2) After: 53.1 (19.0)	Baseline: 12.1 (4.4) After: 11.2 (4.8)	Baseline: 12.0 (4.3) After:11.5 (5.2)	Baseline: 10.1 (3.6) After: 9.3 (3.7)	Baseline: 9.7 (3.4) After: 9.1 (3.3)	N/A	N/A
Boer, 2019	Netherlands	12 months	T = 43 C = 44	T = 69.3 (8.8) C = 65.9 (8.9)	Smartphone app	T = 18/25 C = 15/29	N/A	N/A	N/A	N/A	N/A	N/A	Baseline:0.81 (0.15) After: 0.79 (0.16)	Baseline: 0.74 (0.20) After: 0.77 (0.21)
Landeskrankenanstalten-Betriebsgesellschaft, 2018	Austria	12 Months	T = 37 C = 28	T = 63.83 (7.69) C = 73.62 (10.28)	Mobile device with caretaker	N/A	Baseline: 54.6 (18.1) After: 50.8 (24.0	Baseline: 64.8 (15.3) After: 64.2 (17.7)	N/A	N/A	N/A	N/A	N/A	N/A
Farmer, 2017	England	6 and 12 Months	T = 110 C = 56	T = 69.8 (9.1) C = 69.8 (10.6)	Fully automated internet-linked, tablet computer-based system of monitoring and self-management support	T = 42/68 C = 22/34	Baseline: 56.4 (19.7) After 6 months: 55.7 (20.2) After 12 months: 56.9 (19.5)	Baseline: 55.5 (16.2) After 6 months: 54.3 (21.8) After 12 months: 56.8 (20.9)	N/A	N/A	N/A	N/A	N/A	N/A
Walker, 2017	Europe	9 months	T = 154 C = 158	T = 71 (66.0-75.8) C = 71 (65.3-76.0)	A device which measured within-breath respiratory mechanical impedance	T = 101/53 C = 105/53	N/A	N/A	N/A	N/A	N/A	N/A	Baseline: 0.641 (0.224) After: 0.637 (0.225)	Baseline: 0.663 (0.225) After: 0.640 (0.248)
Chatwin, 2016	England	6 months	T = 38 C = 34	N/A	Telephone line	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Baseline: 0.57 (0.16) After: 0.511 (0.187)	Baseline: 0.57 (0.16) After: 0.531 (0.19)

Vianello, 2016	Italy	12 months	T = 230 C =104	T = 75.96 (6.54) C = 76.48 (6.16)	Telephone line	T = 66/164 C = 28/76	N/A	N/A	Baseline: 4.68 (3.45) After: 5.53 (3.47)	Baseline: 5.4 (3.35) After: 6.02 (3.5)	Baseline: 5.1 (4.42) After: 5.6 (4.42)	Baseline: 5.48 (4.49) After: 6.2 (4.24)	N/A	N/A
McDowell, 2015	Ireland	6 months	T = 55 C =55	T = 69.8 (7.1) C = 70.2 (7.4)	Telephone line	T = 32/23 C = 30/25	Baseline: 63.6 (15.9) After: 61.1 (17)	Baseline: 64.2 (14.5) After: 66.8 (15)	N/A	N/A	N/A	N/A	Baseline: 0.49 (0.35) After: 0.57 (0.32)	Baseline: 0.52 (0.30) After: 0.49 (0.33)
Jódar-Sánchez,2013	Spain	6 months	T = 24 C = 21	T = 74 (8) C = 71 (10)	Telephone line	T = 1/23 C = 1/20	Difference: -10.9 (21.9)	Difference: -4.5 (19.7)	N/A	N/A	N/A	N/A	Difference: 0.0359 (0.28)	Difference: 0.0034 (0.24)
Pinnock, 2013	Scotland		T = 128 C = 128	T = 69.4 (8.8) C = 68.4 (8.4)	Telephone line	T = 75/53 C = 65/63	Baseline: 67.2 (16.6) After: 68.2 (16.3)	Baseline: 68.0 (16.0) After: 67.3 (17.3)	Baseline: 9.8 (5.3) After: 9.6 (5.0)	Baseline: 9.4 (4.7) After: 9.1 (5.1)	Baseline: 8.8 (4.3) After: 9.1 (4.6)	Baseline: 8.3 (4.3) After: 8.4 (4.2)	N/A	N/A
M: Male; F: Female; SD: Standard deviation; T: Telemonitoring; C: Control; N/A: Not available														

In this systematic review and meta-analysis, 1,677 patients were engaged across the studies. Nearly all of the studies included were conducted within European settings. The analysis centered on treatments that involved telemonitoring patients' QoL. Scoring measures such as SGRQ, HADS for anxiety and depression, and EQ-5D were used. Six studies could be compared for SGRQ. Moreover, four studies were available for HADS assessment, while five were accessible for EQ-5D evaluation.

Quality Assessment

The majority of RCTs examined in this study demonstrated a low risk of bias according to the Cochrane Risk of Bias 2.0 tool (Figure 2).

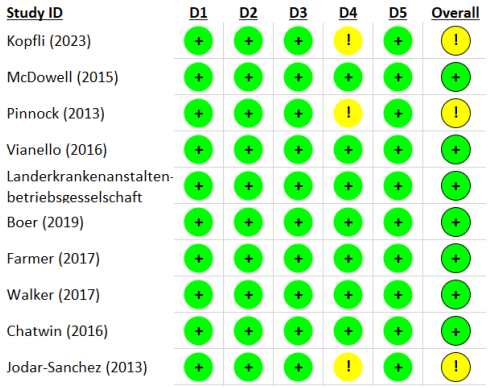

Figure 2. Bias assessment

SGRQ

SGRQ was observed in six studies.[6,11–15] The qualitative analysis found an MD of -1.13 [95% CI -4.23, 1.97; p = 0.47]. The findings also indicated that a 6-month intervention had a more significant effect than a 12-month intervention, despite the p-value being above 0.05. These six studies showed low heterogeneity (Figure 3).

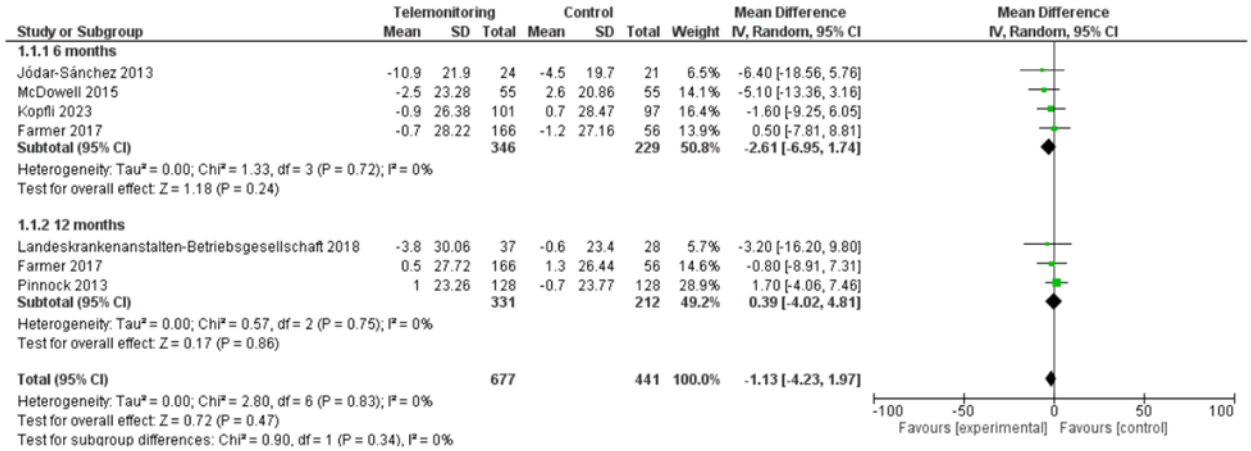

Figure 3. Forest plot for SGRQ

HADS

Four studies were observed to analyze HADS for anxiety and depression.[6,11,15,16] There was an MD of -0.16 [95% CI -0.96, 0.63; p = 0.69]. Low heterogeneity was found in this qualitative analysis (Figure 4A). Conversely, HADS for depression demonstrated a less significant effect with an MD of 0.04 [95% CI -0.64, 0.72; p = 0.69] and a low heterogeneity (Figure 4B).

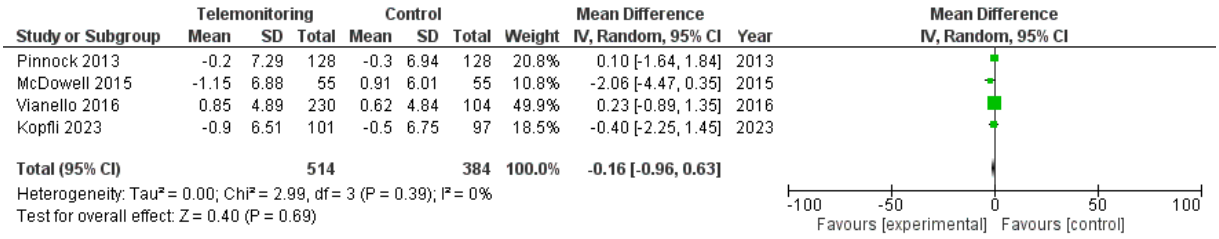

Figure 4A. Forest plot for HADS anxiety

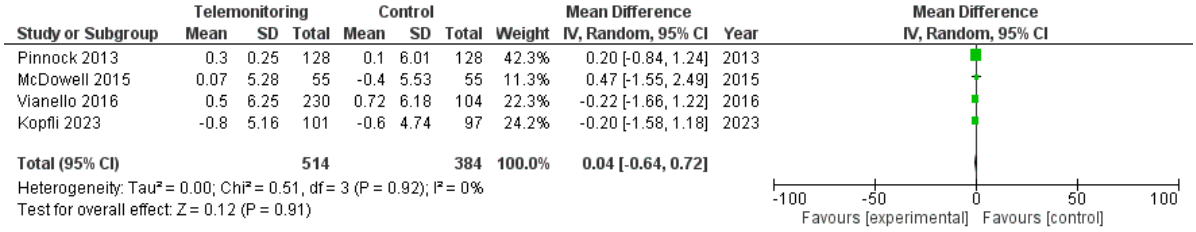

Figure 4B. Forest plot for HADS depression

EQ-5D

EQ-5D was analyzed with five pieces of literature, and we found an insignificant result with an MD of 0.01 [95% CI -0.04, 0.06; p = 0.63] although there was low heterogeneity in the result (Figure 5).[11,12,17–19]

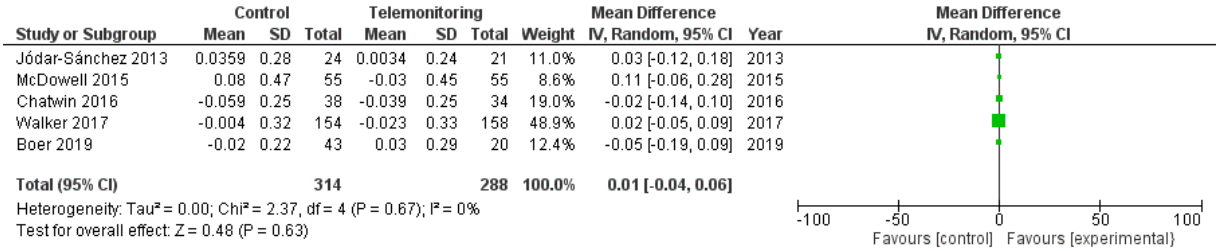

Figure 5. Forest plot for EQ-5D

DISCUSSION

Home-Based Telemonitoring in Improving QoL of COPD Patients

The study observed a decrease in the SGRQ score, with an MD of -1.13 [95% CI -4.23, 1.97; p = 0.47]. Similarly, there was a reduction in the HADS score for anxiety, with an MD of -0.16 [95% CI -0.96, 0.63; p = 0.69]. These findings align with the study by Køpfli, *et al*. (2023), which also reported a decrease in SGRQ scores.[6] However, the HADS scores showed no significant difference and, in some instances, even worsened. In terms of QoL for patients, Hofer, *et al*. (2022) demonstrated that individuals receiving telemonitoring exhibited enhanced emotional functioning, which improved over time compared to the control group. Furthermore, telemonitoring resulted in reduced exacerbation rates and shorter hospital stays.[6,20]

Analysis of collected data revealed a chronological progression in telemonitoring modalities. Historically, until 2016, telemonitoring primarily relied on telephone lines, integrating vital sign detection and standard telephone communication. However, a paradigm shift occurred following an investigation by Walker, *et al*. (2018), marking the emergence of advanced technologies.[18] Subsequent studies, exemplified by Køpfli, *et al*. (2023), showcased personalized telemonitoring solutions leveraging modern smartphone applications and internet connectivity.[6] Consequently, these technological advancements have demonstrated efficacy in enhancing the QoL for patients afflicted with COPD.[6,11–19]

The Reported QoL Score for COPD Patients

Studies reporting the intervention of home-based telemonitoring vs control for improving COPD patients' QoL were evaluated in terms of SGRQ score and HADS.

SGRQ is a validated and widely used scoring system for assessing the QoL in patients, particularly

those with COPD. It evaluates various aspects of the disease's impact on general health, daily life, and well-being. The questionnaire includes 50 items divided into three main domains, with scores ranging from 0 to 100. Higher scores reflect greater limitations in daily activities. This study yielded significant results that surpassed previous meta-analyses, which included smaller populations, indicating more reliable outcomes from this study.[21,22]

HADS is a 14-item tool, with seven items dedicated to measuring anxiety and another seven for measuring depression. Each aspect is evaluated separately, with each item offering four response options scored from 0 to 3, resulting in a total score ranging from 0 to 21. Scores are categorized as follows: 0–7 indicates no cases, 8–10 suggests borderline or mild cases, and 11 or above signifies moderate or severe cases.[5] This meta-analysis demonstrates that home-based telemonitoring enhances the QoL for COPD patients. Given its significance and low subgroup heterogeneity, this analysis is statistically sufficient.

Another scale used to evaluate QoL was EQ-5D, a straightforward two-page questionnaire comprising five descriptive questions. Each question offers three response levels and includes a visual analog scale (VAS). The five dimensions assessed are mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Patients respond to each question by indicating one of three levels of functioning: no problems, some problems, or extreme problems/unable to perform. This meta-analysis reviewed five studies and found that telemonitoring did not significantly improve the QoL for COPD patients. This result is likely due to the few studies included and the different methodologies used in each study, which may have influenced the outcomes.[23]

The Benefit in Future Usage

As previously explained, telemonitoring improves QoL for patients with COPD. Differences and similarities in home telemonitoring models can support evaluating their clinical outcomes, patient self-management, and resource uses. Thus, the ability to evaluate more frequently accessible data helps healthcare clinicians assess patients' clinical conditions along with cost and time-effective monitoring that would be beneficial for long-term follow-ups in terms of finding less costly interventions that result in less damage reduction with improved clinical outcomes. However, regarding cost-effectiveness, it still remains unclear, and the outcome was varied.[7] Cruz, *et al*. (2014) discovered that there was a tendency toward lower healthcare expenses in the telemonitoring group.[7] A study also indicated a total cost savings of 112,439 United States dollars (USD) in the home telemonitoring group and reduced healthcare-related expenses compared to standard care. However, the difference was not statistically significant.[7] Furthermore, according to a study by van der Burg, *et al*. (2020), healthcare expenditures were much reduced, about 54% lower in COPD patients after the telemonitoring intervention began.[4] However, it contrasted with the findings of McDowell, *et al*. (2015), Pedone, *et al*. (2015), and Hofer, *et al*. (2022), who found considerably greater expenses associated with telemonitoring in COPD patients over a one-to-two-year period.[12,20,24] Hofer, *et al*. (2022) discovered that telemonitoring improved patient survival rates.[20] As a result, more extensive research is required to understand the links properly.

Strength and Limitation

The strength of this study is that we have a higher population in assessing the QoL, hence it can represent the general population. Likewise, new studies also supported to give the best result. Several studies, including those by Cruz, *et al*. (2014) and Li, *et al*. (2020), explored the impact of telemonitoring on COPD patients.[25,26] While Cruz, *et al.* (2014) focused on patient satisfaction and feedback, Li, *et al*. (2020) conducted a comprehensive assessment, including QoL measured only through the SGRQ assessment.[25,26] On the other hand, this study examined QoL using SGRQ and HADS scores for anxiety and depression, supplemented by the EQ-5D scale assessment for enhanced reliability. We also included the most recent studies up to 2023 to provide the latest insights into telemonitoring effectiveness for COPD patients.[25,26] However, each study's modalities and types of telemonitoring were different. These studies also did not compile a large-scale population, thereby definitive results could not be concluded.

SUMMARY

Telemonitoring has demonstrated notable benefits in enhancing the QoL among COPD patients. This comprehensive meta-analysis underscores a significant improvement in QoL, particularly evident through enhancements in SGRQ scores. Nonetheless, the impacts on HADS and EQ-5D scores appeared to be negligible. To furnish a more thorough comprehension of the ramifications of telemonitoring on depression and anxiety in COPD patients, we suggest the initiation of expansive research endeavors.

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Conflict of Interest
The authors declared there is no conflict of interest.

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Authors' Contributions
Analyzing and manuscript writing: APV, JJ, KEU, KR, AW, NTN. Finalizing the paper: AW and NTN.

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