The Influence of Telehealth Technology on Adult Patients with Chronic Obstructive Pulmonary Disease

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Abstract

This integrated literature review investigates the influence of telehealth technologies on adults with chronic obstructive pulmonary disease (COPD). COPD is the third leading cause of death within the United States and results in increased emergency department visits and hospital admissions. Telehealth technology has the potential to decrease emergency department visits, hospital admissions, and mortality. The inclusion criteria that guided this study were that: (a) the primary intervention was telehealth technology; (b) the comparison was routine, standard, or usual care; (c) the subjects had a diagnosis of COPD; (d) the study was published between January 1, 2009 and February 28, 2015. Participants were adult men and women over the age of 18. Data was available for a total of 2,417 participants. The analysis of the literature consistently reported a reduction in emergency department visits and hospital admissions among the telehealth intervention group. The influence of telehealth technology on mortality was inconsistent and reported no significance. Telehealth technology may be an efficient integrative approach to reducing emergency department visits and hospital admissions allowing patients to remain in their home environment. Despite advantages, further research with higher level of evidence is needed that clearly defines a technological framework and valid instrument in order to obtain consistency across studies.

Keywords: telehealth, chronic obstructive pulmonary disease, emergency services
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The Influence of Telehealth Technology on Adult Patients with Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a chronic progressive respiratory disorder that results in the obstruction of airflow within the lungs due to chronic bronchitis or emphysema (Papadakis, McPhee & Rabow, 2013). Patients typically present characteristics of both chronic bronchitis and emphysema. Chronic bronchitis is defined by excessive mucus excreted by the bronchioles that leads to inflammation or irritation of the airways. Clinical manifestations include a daily productive cough for over 3 months or at least over 2 consecutive years (Papadakis et al., 2013). Emphysema is an irreversible enlargement of the lower airways distal to the bronchioles resulting in the destruction of alveoli. The primary clinical manifestation is that patients find it difficult to breathe due to the resulting buildup of carbon dioxide that can no longer be expelled (Papadakis et al., 2013). The management of COPD is a global challenge of pandemic proportions.

Significance and Background

Over 210 million people currently live with COPD resulting in 3 million deaths globally (Dinesen et al., 2012). According to the Center of Disease Control and Prevention (CDC, 2015), COPD is the third leading cause of death in the United States behind cardiovascular disease and malignant neoplasms. With over 15 million people diagnosed with this progressive pulmonary disease, COPD accounts for greater than 140,000 deaths annually (CDC, 2015; Hoyert & Xu, 2012). Additionally, COPD accounts for more than 1.5 million emergency department visits annually, and 726,000 hospital admissions (Dinesen et al., 2012; Eui-Sik, Mandal, & Hart, 2013). The economic implications of this chronic disease exceeds $50 billion annually with an associated indirect cost of over $20.4 billion (Eui-Sik et al., 2013). Majority of these costs are
associated with frequent emergency department visits and hospitalizations (Alrajab, Smith, Owens, Arenò & Caldito, 2012).

Increased economic pressure has led to patients being discharged home from emergency departments as well as shorter hospital stays. A relationship that was once authoritative; focused on treatment of clinical manifestations, chronic illness, and regimens determined solely by the provider while confined to the clinical environment, are being expanded to the patient centered home through the use of telehealth technology (Mikkonen & Hynynen, 2012; Rutledge et al., 2014).

The United States Department of Human Health and Services has expanded the development of Health People initiatives to include the implementation and integration of technology. The Healthy People 2020 (2014) telehealth initiative insures that technology focuses on a patient driven experience and is designed to aid in the dissemination of information between the patient as the end user and the provider. Furthermore, the primary objective of the initiative is to increase the emphasis on disease prevention and health promotion. The implementation and integration of telehealth technology has the potential to decrease primary care and emergency department visits, as well as hospital admissions while decreasing the economic burden recognized by the increased cost of care (Udsen, Hejlesen, & Ehlers, 2014).

**Research Question**

The purpose of this integrated literature review is to explore and examine the evidence available to answer the question: In adults treated for chronic obstructive pulmonary disease who are discharged from the emergency department, how does telehealth technology compared to routine follow-up influence return visits within 1 year?
Method

A comprehensive search of the literature was initiated to ascertain published articles comparing the utilization of telehealth technologies compared to routine follow up of care of recently discharged patients diagnosed with COPD. The search strategy included multiple electronic data sets that included CINAHL, MEDLINE, PsycINFO, Academic Search Premier, Health Technology Assessments and Cochrane Database of Systematic Reviews.

Search Strategy

The investigative strategy key terms included: Telehealth*, COPD*, Chronic Obstructive Pulmonary Disease, routine*, return visits and 1 year. An advanced search limited articles to publication between January 2009 and February 2015, available in English and in full text, adults of all genders and any ethnic origin, and research articles. The searches of CINAHL, MEDLINE, Academic Search Premier, PsycINFO, Health Technology and Cochrane Database of Systemic Reviews identified 145 articles. A total of 32 articles were reviewed. There were 27 articles excluded due to not fully meeting inclusion criteria. The remaining 5 articles completely met the inclusion criteria.

Definitions

Telehealth technology was defined as an instrument to deliver healthcare services in patients. Instruments included telephone service, mobile applications, electronics, internet, and video consultation. Routine care was defined as standard or usual care provided in the office setting by primary care providers or specialist.

Inclusion and Exclusion Criteria

Inclusion criteria established that each article was required to implement telehealth technology as the primary intervention compared to routine, standard, or usual care while
patients resided at home or in assisted living facilities. Technologies utilized were either asynchronous or synchronous. While COPD was the primary diagnosis for review, articles that included additional chronic illness were included as long as COPD measures were extracted independently. Additionally, articles must have measured outcomes that considered number of emergency department visits, and office visits or hospital readmissions. Only articles that included adults of all genders were reviewed.

Exclusion criteria for studies inappropriate to this review were patients who were currently hospitalized or participants without access to telecommunications or computers. Telehealth interventions that focused solely on education were excluded. Additionally, patients who were required to return to health care facilities for downloading data, or who had follow-up studies fewer than six months were not included in the review.

**Validity of Findings**

The level of evidence and quality of studies were determined using the criteria published by Melnyk and Fineout-Overholt (2011). Further supporting the level of evidence and quality of studies, a rapid critical appraisal was utilized to evaluate whether the articles demonstrated validity, reliability, and applicability (Melnyk & Fineout-Overholt, 2011). Each article reviewed supported randomization of the intervention and control group as set forth by the inclusion criteria to ensure results of the study were valid. The reliability of the studies was determined by if the telehealth technology intervention worked, how large of an effect was attained, and whether similar results were anticipated in clinical practice. Additionally, each article was considered for applicability by determining if each subject was similar to patients who are being treated for COPD, if the benefits are greater than the risk, the practicality of implementing telehealth technology, and if the patient desires the intervention.
An analysis resulted in 5 primary articles to be utilized in the review. The primary studies included 1 article that was a level I systematic review (McClean et al., 2012), 1 article that was a level I systematic review and meta-analysis (Polisena et al., 2010), 2 articles that were level II randomized control trials (De, Smith & Lewin, 2013; Gellis et al., 2012), and the final article was a level IV retrospective cohort study (Alrajab et al., 2012).

Coding and Themes

Five primary articles utilized telehealth technologies as the primary intervention and the control group as usual care or standard care. While the measurable outcomes varied across studies, commonalities did exist. For the purpose of this review the primary results are provided as they pertain to service utilization of emergency department visits and hospital admissions. Mortality and quality of life (QOL) were secondary outcomes measured across studies. However, QOL was excluded from the results due to the subjective nature of the results and risk of bias.

Findings

Study Characteristics

A total of 5 articles were reviewed reporting on 23 studies. Three articles were published in telehealth journals and 2 were in medical related journals (gerontology and general practice). Ten studies were included in 1 article that was a level I systematic review (McClean et al., 2012), and 9 studies were reported in a level I systematic review and meta-analysis (Polisena et al., 2010). Two level II articles were randomized control trials (De et al., 2013; Gellis et al., 2012), and the final article was a level IV retrospective cohort study (Alrajab et al., 2012).

Sample Characteristics

The total sample size was 2,417 with studies ranging from 71 to 1,004 participants. All studies included adult men and women. However, a single study conducted by the Veteran
Affairs hospital enrolled 95% men (Alrajab et al., 2012). The mean age across studies was 72 and did not vary based on gender. One study reported 84% Caucasian participants (Alrajab et al., 2012), and a single study identified socio-economic and education (Gellis et al., 2012). All studies included COPD as a diagnosis with 2 studies including comorbidities.

Themes

Service Utilization

Service Utilization refers to the areas of healthcare delivery in which patients frequent during acute illness, exacerbations of chronic disease, and annual wellness visits. Five studies involved telehealth services to monitor and transmit data regarding management of patients with COPD. Each study comprised of telehealth specialists and consisted of telehealth technologies that could be remotely monitored via web based services over wireless and telephone lines (Alrajab et al., 2012; De et al., 2013; Gellis et al., 2012; McLean et al., 2012; Polisena et al., 2010). Four of 5 studies concluded that telehealth services positively influenced patient care by reducing emergency department visits and hospital admissions. De et al. (2013) randomized control trial and Polisena et al., (2010) systematic review and meta-analysis were unique in that they measured emergency department visits, hospital admissions, general practice, and specialist visits as they pertained to COPD and non-COPD related issues. De et al. (2013) concluded that while the telehealth service group had less visits to the emergency department and fewer hospitalization they had 25% more visits to the general practitioner. Contrary to the De et al. trial, the Polisena et al. (2010) review found 4 randomized control trials and 2 observational studies with lower mean number of patient visits to primary care and specialist offices when comparing telehealth services and usual care (0.48, 1.18; 0.25, 0.27). While there was no significant difference in the results of the primary care and specialist visits, patients with
telehealth services did recognize a significant difference in emergency department visits and hospital admissions.

**Clinical Manifestations**

Three studies investigated the influence of telehealth technology as it pertains to monitoring patients who exhibited clinical manifestations that resulted in emergency department visits and hospital admissions. Two studies showed significant decrease in exacerbations resulting in fewer emergency department visits and hospital admissions (Alrajab et al., 2012; McLean et al., 2012). One study reported a 71% decrease in exacerbations compared to the year prior to the telehealth intervention (Alrajab et al., 2012). As a result patients had a 43% decrease in emergency department visits and a 58% decrease in hospital admissions. The McLean et al. (2012) review reported a single study with a 30% reduction of COPD exacerbations over 12 months in the telehealth group compared to a 5% reduction in the usual care group. While the purpose of this review is to focus on the influence of telehealth on patients with COPD, it’s important to note that patients with comorbidities experienced 80.3% fewer COPD exacerbations compared to 67.5% (p = .011) with COPD alone suggesting that telehealth technology may positively affect the management of additional chronic diseases (Alrajab et al., 2012).

One study considered the importance of measuring the effect of telehealth technology on patient’s mental health. Utilizing the Patient Health Questionnaire and the Center for Epidemiological Studies- Depression diagnostic instrument, Gellis et al., (2012) reported that over the first 3 months patients experienced a clinically significant improvement in depression scores: PHQ-9 ($F = 6.47, p < .008$), CES-D (7.81, $p < .004$). When compared to the usual care group, the telehealth group showed more interest in activities of daily living, less sadness, and an increase in energy leading to decreased emergency department visits and hospital admissions.
Mortality

Two level I reviews weighed the effects of telehealth technology on patient mortality (McClean et al., 2012; Polisena et al., 2010). Reports of the reviews were inconsistent across studies (McClean et al., 2012; Polisena et al., 2010). McClean et al., (2012) suggests that the implementation and integration of technologies such as video conferencing, remote pulse oximetry, electronic blood pressure monitoring, and virtual visits has no significant difference when compared to the usual care group. However, Polisena et al., (2010) reported that patients who utilized telehealth technology were at a higher risk of mortality though the results were not significantly different (RR = 1.21, 95% CI [0.84, 1.75]). The validity of the Polisena et al. report on mortality has been questioned by McClean et al., (2012) due to the results being obtained from non-randomized trials.

Recommendations

Practice

The integration and implementation of telehealth technologies should be implemented as it may allow patients to remain in their home environment potentially decreasing their need for emergency department visits and hospitalization. Despite this notable advantage, limited research and inconsistencies of specific technologies that influence the care of chronic diseases such as COPD, should encourage investigators to conduct additional randomized control trials that consider the integration of telehealth services upon initial diagnosis (Alrajab et al., 2012; De et al., 2013; Gellis et al., 2012; McLean et al., 2012; Polisena et al., 2010). Telehealth technologies such as remote monitors and spirometry, tablets, smart phones, integrated messaging devices, and asynchronous and synchronous video should be implemented as it may permit early detection of abnormalities, proactive clinical interventions, and pharmacological modifications
further reducing emergency department visits and hospital admissions (Alrajab et al., 2012; Gellis et al., 2012; McLean et al., 2012).

According to Ebell et al. (2004) strength of recommendation taxonomy (SORT), consistent findings of patient oriented-evidence within a systematic review/meta-analysis or 2 good quality cohorts or RCT’s qualifies the strength of recommendation as level I evidence and qualifies for an A strength recommendation. A review of the literature shows a single retrospective cohort study, a single randomized control study, and 2 systematic reviews consistently reported a decrease in emergency department visits and hospital admissions. It is important to note that a single RCT showed no significant reduction. However, due to the studies small sample size and limitations, this study did not influence the strength of recommendation.

**Future Research**

Further research with higher level of evidence should be considered to determine the effects of telehealth technologies on the rate of mortality and morbidity as present studies have shown inconsistencies. While data provided by studies clearly showed clinical significance in emergency department visits and hospital admission, the studies reported inconsistencies in mortality rates (McLean et al., 2012; Polisena et al., 2010). The systematic review by McLean et al. (2012) did not show clinical significance in mortality and morbidity rates. However, the Polisena et al. (2010) systematic review and meta-analysis showed a higher risk of mortality but the concluding results were not clinically significant. The inconsistency may be due to 3 of the Polisena et al. studies being observational and 6 being randomized control trials. The development of a valid instrument based off of a telehealth theoretical framework could provide researchers means for obtaining quality and consistent results (McLean et al., 2012; Polisena et
al., 2010). Additionally, instrument development should consider separate classifications for different technology modalities so that comparisons can be made between interventions.

Finally, future research should consider artificial intelligence combined with telehealth technologies as it pertains to the influence of patients who are at risk for increased emergency department visits and hospital readmissions. Considering the implementation of electronic health records, and the increasing amount of patient data, the utilization of artificial intelligence algorithms can potentially identify patients at risk for increased service utilization (Shams, Ajorlou & Yang, 2015). Combined with telehealth technology, healthcare providers may be in a position to proactively initiate interventions avoiding exacerbations and allowing patients to remain at home (McLean et al., 2012; Shams et al., 2015).

**Conclusion**

Telehealth technology can be an integral part of integrative medicine. The integration and implementation of telehealth technology is a much anticipated approach to healthcare delivery. This study has shown that patients with COPD who utilize telehealth technologies experience fewer emergency department visits and hospital readmissions. Telehealth technology has shown to enhance the management of chronic illness through remote monitoring, videoconferencing, and web based applications resulting in an improvement of physical and mental health. Further study is needed to examine the role of telehealth technology and the influence on patient mortality and morbidity. Additionally, valid instrument development based off of a telehealth theoretical framework must be considered to fully identify the benefits of telehealth technology.
References


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doi:10.1515/ijnes-2013-0061

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pneumonia, or COPD. *Health Care Management Science, 18*(1), 19-34.
doi:10.1007/s10729-014-9278-y

Udsen, F. W., Hejlesen, O., & Ehlers, L. H. (2014). A systematic review of the cost and cost-
effectiveness of telehealth for patients suffering from chronic obstructive pulmonary
### Appendix

<table>
<thead>
<tr>
<th>Citation</th>
<th>Patient Group and Sample Size</th>
<th>Study Design and Level of Evidence</th>
<th>Outcome Variables</th>
<th>Key Results DATA</th>
<th>Study Weaknesses</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alrajab et al. (2012)</td>
<td>Adults 1,333 enrolled 369 analyzed n=369</td>
<td>Retrospective Cohort Study (Level 3)</td>
<td>ED Visits</td>
<td>Subjects utilizing telehealth services had a significant decrease in ED visits (70%, Mean 0.15±1.65, Median 0, Range -8.47,7.43, p&lt;0.01)</td>
<td>Design was not Randomized</td>
<td>Five studies considered telehealth services and the influence on Service Utilization</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>Mean Age: 69 Male: 95% Caucasian: 84% Comorbidities: 32%</td>
<td>Hospital admissions</td>
<td>Subjects utilizing telehealth services had a significant decrease in hospital admission (58%, Mean 0.41±1.68, Median 0.73, Range -11.70,5.62, p&lt;0.01)</td>
<td>Sample method excluded patients not documented in EMR</td>
<td>Three studies evaluated the management of Clinical Manifestations</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Exacerbations</td>
<td></td>
<td>Participants who went outside of the VA may have been excluded from ED visits.</td>
<td>Predominately male population</td>
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<td>Study Weaknesses</td>
<td>Themes</td>
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<tr>
<td>De et al. (2013)</td>
<td>n=71</td>
<td>Randomized Control Trial (Level 2)</td>
<td>ED Visits</td>
<td>There was no significant difference in ED visits vs usual care (6; 0.17,0.51 vs 11; 0.31, 0.63)</td>
<td>Small Sample Size</td>
<td>Five studies considered telehealth services and the influence on Service Utilization</td>
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<td></td>
<td>Australia</td>
<td></td>
<td>Hospital Admissions</td>
<td>There was no significant difference in hospital admissions vs usual care (8; 0.22, 0.48 vs 17; 0.49, 0.85)</td>
<td></td>
<td>Three studies evaluated the management of Clinical Manifestations</td>
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<td>General Practice Visits</td>
<td>There was no significant difference in hospital admissions vs usual care (8; 0.22, 0.48 vs 17; 0.49, 0.85)</td>
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<td></td>
<td>Specialist Visits</td>
<td>There was no significant difference in specialist</td>
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<td>Hospital Length of Stay (LOS)</td>
<td>There was no significant difference in GP visits vs usual care (35; 0.97, 1.3 vs 33; 0.94, 1.3)</td>
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<td></td>
<td>There was no significant difference in specialist</td>
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<td>Study was not blinded</td>
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<tr>
<td>Study Details</td>
<td>Randomized Control Trial (Level 2)</td>
<td>ED Visits</td>
<td>Patients receiving telehealth (TH) monitoring compared with usual care (UC)</td>
<td>Small sample size</td>
<td>Five studies considered telehealth services and the influence on Service Utilization</td>
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<tr>
<td>Gellis et al. (2012) United States</td>
<td>n=115 Telehealth (n=57) COPD: 19% Usual Care (n=58) COPD: 26% TH Age: 80 Male: 38% Female: 62% UC Age: 78 Male: 32% Female: 68%</td>
<td>ED Visits Hospital Admission Depression</td>
<td>A significantly higher proportion of the UC group visited the ED (0.6, 1.6 vs 1.4, 1.2; p= 0.03) A significantly higher proportion of the UC group were readmitted to the hospital (7.5, 4.3 vs 10.5, 6.5; p= 0.06)</td>
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</table>

| Study Details | Systematic Review (Level 1) | Primary: ED Visits (Six RCT) Hospital Admission (Five RCT) Exacerbations (Two RCT) Morbidity (Four RCT) Secondary: FEV1 | Three trials had significant reduction in ED visits (80%, OR 0.27, 95% CI, 0.11 0.66) Six trials had significantly reduced hospital admissions (55%, OR 0.46, 95% CI, 0.33, 0.65) There was no significant difference in mortality for the TH group compared to the UC group (OR 1.05, 95% CI, 0.63, 1.75) | One study was noted to have risk of selection bias Eight studies were not blinded Three RCT provided incomplete outcome data Instrument validity and reliability was inconsistent | |
| McLean et al. (2012) United Kingdom | 10 RCT n=1004 3 ED trials n= 449 6 Hospital Admission trials n=604 2 QOL trials n= 253 3 Morbidity trials n= 503 | | | | |

**Service Utilization**

- 3 ED trials
- 6 Hospital Admission trials
- 2 QOL trials
- 3 Morbidity trials

**Clinical Manifestations**

- FEV1
### The Influence of Telehealth on Adults with COPD

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Type of Study</th>
<th>Measures</th>
<th>Results</th>
<th>Quality Ratings</th>
<th>Qualitative Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polisena et al. (2010)</td>
<td>9 Studies</td>
<td>Systematic Review/Meta-analysis (Level 1)</td>
<td>ED Visits, Hospital Admissions, General Practice Visits, Specialist Visits</td>
<td>A significantly higher proportion of UC compared to TH visited the emergency department (60/95 vs 39/96, p = 0.002)</td>
<td>Three studies rated A (high quality)</td>
<td>Three studies rated B (good quality)</td>
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<td></td>
<td>n= 858</td>
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<td>One study rated C</td>
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<td></td>
<td>6 RCT</td>
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<td></td>
<td>TH (n=351)</td>
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<td></td>
<td>UC (n=367)</td>
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<td>Canada</td>
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</table>

There was no significant difference of FEV1 in TH and UC:
- Telehealth (0.01 ± 0.14)
- Usual Care (0.06 ± 0.35) (p = 0.6)

There was no significant difference in FVC in TH and UC:
- Telehealth (2.27 ± 0.74 vs 2.31 ± 0.77)
- Usual Care (2.24 ± 0.69 vs 2.3 ± 0.68)

There was no significant cost difference between TH, TH monitored and UC:
- USD 22.11 vs USD 33.11 vs USD 48.27

There was no significant difference per patient cost associated with assigned case management (USD 3778 vs 3338)

One study considered the Economic Impact for consumers and health care facilities.
<table>
<thead>
<tr>
<th>Study Type</th>
<th>Sample Size</th>
<th>Male</th>
<th>Female</th>
<th>Mean Age</th>
<th>Quality of Life (QoL)</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 quasi-experimental</td>
<td>n=30</td>
<td>n=13.5</td>
<td>n=7.5</td>
<td>70.5</td>
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<tr>
<td>1 prospective study</td>
<td>n=115</td>
<td>n=27.34</td>
<td>n=32.22</td>
<td>69.5</td>
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<tr>
<td>1 Cohort study</td>
<td>n=18</td>
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<tr>
<td>A significantly higher proportion of UC compared to TH had hospital admissions (66% vs 46%, p= 0.03) (51% vs 32%, p= 0.01)</td>
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<td>Two studies measured Morbidity and Mortality.</td>
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<td>There was no significant difference in mortality in the TH group compared to UC (RR= 1.21, 95% CI, 0.84, 1.75). No heterogeneity (I² = 0%)</td>
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<td>(fair to good quality)</td>
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<td>Meta-regression was not initiated due to limited number of subgroups (n &lt; 10)</td>
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<td>Instrument validity and reliability was inconsistent</td>
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