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Hospital-at-Home Programs for Patients With Acute Exacerbations of Chronic Obstructive Pulmonary Disease (COPD): An Evidence-Based Analysis

BR McCurdy

March 2012

Ontario Health Technology Assessment Series; Vol. 12: No. 10, pp. 1–65, March 2012

Suggested Citation

This report should be cited as follows:

McCurdy BR. Hospital-at-home programs for patients with acute exacerbations of chronic obstructive pulmonary disease (COPD): an evidence-based analysis. Ont Health Technol Assess Ser [Internet]. 2012 Mar; 12(10):1–65. Available from: www.hqontario.ca/en/mas/tech/pdfs/2012/rev_COPD_Hospital_at_Home_March.pdf

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Effective April 5, 2011, the Medical Advisory Secretariat (MAS) became a part of Health Quality Ontario (HQO), an independent body funded by the Ministry of Health and Long-Term Care. The mandate of MAS is to provide evidence-based recommendations on the coordinated uptake of health services and health technologies in Ontario to the Ministry of Health and Long-Term Care and to the health care system. This mandate helps to ensure that residents of Ontario have access to the best available and most appropriate health services and technologies to improve patient outcomes.

To fulfill its mandate, MAS conducts systematic reviews of evidence and consults with experts in the health care services community. The resulting evidence-based analyses are reviewed by the Ontario Health Technology Advisory Committee—to which MAS also provides a secretariat function—and published in the *Ontario Health Technology Assessment Series*.

About the *Ontario Health Technology Assessment Series*

To conduct its comprehensive analyses, MAS systematically reviews the available scientific literature, making every effort to consider all relevant national and international research; collaborates with partners across relevant government branches; consults with clinical and other external experts and developers of new health technologies; and solicits any necessary supplemental information.

In addition, the Secretariat collects and analyzes information about how a new technology fits within current practice and existing treatment alternatives. Details about the technology's diffusion into current health care practices add an important dimension to the review of the provision and delivery of the health technology in Ontario. Information concerning the health benefits; economic and human resources; and ethical, regulatory, social and legal issues relating to the technology assist decision-makers in making timely and relevant decisions to optimize patient outcomes.

The public consultation process is available to individuals wishing to comment on an analysis prior to publication. For more information, please visit: http://www.hqontario.ca/en/mas/ohtac_public_engage_overview.html.

Disclaimer

This evidence-based analysis was prepared by MAS for the Ontario Health Technology Advisory Committee and developed from analysis, interpretation, and comparison of scientific research and/or technology assessments conducted by other organizations. It also incorporates, when available, Ontario data and information provided by experts and applicants to MAS to inform the analysis. While every effort has been made to reflect all scientific research available, this document may not fully do so. Additionally, other relevant scientific findings may have been reported since completion of the review. This evidence-based analysis is current to the date of the literature review specified in the methods section. This analysis may be superseded by an updated publication on the same topic. Please check the MAS website for a list of all evidence-based analyses:
http://www.hqontario.ca/en/mas/mas_ohtas_mn.html.

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List of Abbreviations

COPD	Chronic obstructive pulmonary disease
CI	Confidence interval
H	Inpatient hospital group
HaH	Hospital-at-home group
HR	Hazard ratio
FEV_1	Forced expiratory volume in 1 second
FVC	Forced vital capacity
ED	Emergency department
EDHaH	Early discharge hospital-at-home program
GOLD	Global Initiative for Chronic Obstructive Lung Disease
HRQOL	Health-related quality of life
MAS	Medical Advisory Secretariat
NICE	National Institute for Health and Clinical Excellence
RCT	Randomized controlled trial
RR	Relative risk
SpO_2	Oxygen saturation level of arterial blood measured by pulse oximetry
SGRQ	St. George's Respiratory Questionnaire

Executive Summary

In July 2010, the Medical Advisory Secretariat (MAS) began work on a Chronic Obstructive Pulmonary Disease (COPD) evidentiary framework, an evidence-based review of the literature surrounding treatment strategies for patients with COPD. This project emerged from a request by the Health System Strategy Division of the Ministry of Health and Long-Term Care that MAS provide them with an evidentiary platform on the effectiveness and cost-effectiveness of COPD interventions.

After an initial review of health technology assessments and systematic reviews of COPD literature, and consultation with experts, MAS identified the following topics for analysis: vaccinations (influenza and pneumococcal), smoking cessation, multidisciplinary care, pulmonary rehabilitation, long-term oxygen therapy, noninvasive positive pressure ventilation for acute and chronic respiratory failure, hospital-at-home for acute exacerbations of COPD, and telehealth (including telemonitoring and telephone support). Evidence-based analyses were prepared for each of these topics. For each technology, an economic analysis was also completed where appropriate. In addition, a review of the qualitative literature on patient, caregiver, and provider perspectives on living and dying with COPD was conducted, as were reviews of the qualitative literature on each of the technologies included in these analyses.

The Chronic Obstructive Pulmonary Disease Mega-Analysis series is made up of the following reports, which can be publicly accessed at the MAS website at: http://www.hqontario.ca/en/mas/mas_ohtas_mn.html.

- Chronic Obstructive Pulmonary Disease (COPD) Evidentiary Framework
- Influenza and Pneumococcal Vaccinations for Patients With Chronic Obstructive Pulmonary Disease (COPD): An Evidence-Based Analysis
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- Cost-Effectiveness of Interventions for Chronic Obstructive Pulmonary Disease Using an Ontario Policy Model
- Experiences of Living and Dying With COPD: A Systematic Review and Synthesis of the Qualitative Empirical Literature

For more information on the qualitative review, please contact Mita Giacomini at: http://fhs.mcmaster.ca/ceb/faculty_member_giacomini.htm.

For more information on the economic analysis, please visit the PATH website: http://www.path-hta.ca/About-Us/Contact-Us.aspx.

The Toronto Health Economics and Technology Assessment (THETA) collaborative has produced an associated report on patient preference for mechanical ventilation. For more information, please visit the THETA website: http://theta.utoronto.ca/static/contact.

Objective

The objective of this analysis was to compare hospital-at-home care with inpatient hospital care for patients with acute exacerbations of chronic obstructive pulmonary disease (COPD) who present to the emergency department (ED).

Clinical Need: Condition and Target Population

Acute Exacerbations of Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease is a disease state characterized by airflow limitation that is not fully reversible. This airflow limitation is usually both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases. The natural history of COPD involves periods of acute-onset worsening of symptoms, particularly increased breathlessness, cough, and/or sputum, that go beyond normal day-to-day variations; these are known as acute exacerbations.

Two-thirds of COPD exacerbations are caused by an infection of the tracheobronchial tree or by air pollution; the cause in the remaining cases is unknown. On average, patients with moderate to severe COPD experience 2 or 3 exacerbations each year.

Exacerbations have an important impact on patients and on the health care system. For the patient, exacerbations result in decreased quality of life, potentially permanent losses of lung function, and an increased risk of mortality. For the health care system, exacerbations of COPD are a leading cause of ED visits and hospitalizations, particularly in winter.

Technology

Hospital-at-home programs offer an alternative for patients who present to the ED with an exacerbation of COPD and require hospital admission for their treatment. Hospital-at-home programs provide patients with visits in their home by medical professionals (typically specialist nurses) who monitor the patients, alter patients' treatment plans if needed, and in some programs, provide additional care such as pulmonary rehabilitation, patient and caregiver education, and smoking cessation counselling.

There are 2 types of hospital-at-home programs: admission avoidance and early discharge hospital-at-home. In the former, admission avoidance hospital-at-home, after patients are assessed in the ED, they are prescribed the necessary medications and additional care needed (e.g., oxygen therapy) and then sent home where they receive regular visits from a medical professional. In early discharge hospital-at-home, after being assessed in the ED, patients are admitted to the hospital where they receive the initial phase of their treatment. These patients are discharged into a hospital-at-home program before the exacerbation has resolved. In both cases, once the exacerbation has resolved, the patient is discharged from the hospital-at-home program and no longer receives visits in his/her home.

In the models that exist to date, hospital-at-home programs differ from other home care programs because they deal with higher acuity patients who require higher acuity care, and because hospitals retain the medical and legal responsibility for patients. Furthermore, patients requiring home care services may require such services for long periods of time or indefinitely, whereas patients in hospital-at-home programs require and receive the services for a short period of time only.

Hospital-at-home care is not appropriate for all patients with acute exacerbations of COPD. Ineligible patients include: those with mild exacerbations that can be managed without admission to hospital; those

who require admission to hospital; and those who cannot be safely treated in a hospital-at-home program either for medical reasons and/or because of a lack of, or poor, social support at home.

The proposed possible benefits of hospital-at-home for treatment of exacerbations of COPD include: decreased utilization of health care resources by avoiding hospital admission and/or reducing length of stay in hospital; decreased costs; increased health-related quality of life for patients and caregivers when treated at home; and reduced risk of hospital-acquired infections in this susceptible patient population.

Ontario Context

No hospital-at-home programs for the treatment of acute exacerbations of COPD were identified in Ontario. Patients requiring acute care for their exacerbations are treated in hospitals.

Research Question

What is the effectiveness, cost-effectiveness, and safety of hospital-at-home care compared with inpatient hospital care of acute exacerbations of COPD?

Research Methods

Literature Search

Search Strategy

A literature search was performed on August 5, 2010, using OVID MEDLINE, OVID MEDLINE In-Process and Other Non-Indexed Citations, OVID EMBASE, EBSCO Cumulative Index to Nursing & Allied Health Literature (CINAHL), the Wiley Cochrane Library, and the Centre for Reviews and Dissemination database for studies published from January 1, 1990, to August 5, 2010. Abstracts were reviewed by a single reviewer and, for those studies meeting the eligibility criteria, full-text articles were obtained. Reference lists and health technology assessment websites were also examined for any additional relevant studies not identified through the systematic search.

Inclusion Criteria

- English language full-text reports;
- health technology assessments, systematic reviews, meta-analyses, and randomized controlled trials (RCTs);
- studies performed exclusively in patients with a diagnosis of COPD or studies including patients with COPD as well as patients with other conditions, if results are reported for COPD patients separately;
- studies performed in patients with acute exacerbations of COPD who present to the ED;
- studies published between January 1, 1990, and August 5, 2010;
- studies comparing hospital-at-home and inpatient hospital care for patients with acute exacerbations of COPD;
- studies that include at least 1 of the outcomes of interest (listed below).

Cochrane Collaboration reviews have defined hospital-at-home programs as those that provide patients with active treatment for their acute exacerbation in their home by medical professionals for a limited period of time (in this case, until the resolution of the exacerbation). If a hospital-at-home program had not been available, these patients would have been admitted to hospital for their treatment.

Exclusion Criteria

- < 18 years of age
- animal studies
- duplicate publications
- grey literature

Outcomes of Interest

Patient/clinical outcomes

- mortality
- lung function (forced expiratory volume in 1 second)
- health-related quality of life
- patient or caregiver preference
- patient or caregiver satisfaction with care
- complications

Health system outcomes

- hospital readmissions
- length of stay in hospital and hospital-at-home
- ED visits
- transfer to long-term care
- days to readmission
- eligibility for hospital-at-home

Statistical Methods

When possible, results were pooled using Review Manager 5 Version 5.1; otherwise, results were summarized descriptively. Data from RCTs were analyzed using intention-to-treat protocols. In addition, a sensitivity analysis was done assigning all missing data/withdrawals to the event. *P* values less than 0.05 were considered significant. A priori subgroup analyses were planned for the acuity of hospital-at-home program, type of hospital-at-home program (early discharge or admission avoidance), and severity of the patients' COPD. Additional subgroup analyses were conducted as needed based on the identified literature. Post hoc sample size calculations were performed using STATA 10.1.

Quality of Evidence

The quality of each included study was assessed, taking into consideration allocation concealment, randomization, blinding, power/sample size, withdrawals/dropouts, and intention-to-treat analyses.

The quality of the body of evidence was assessed as high, moderate, low, or very low according to the GRADE Working Group criteria. The following definitions of quality were used in grading the quality of the evidence:

High	Further research is very unlikely to change confidence in the estimate of effect.
Moderate	Further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate.
Low	Further research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate.
Very Low	Any estimate of effect is very uncertain.

Summary of Findings

Fourteen studies met the inclusion criteria and were included in this review: 1 health technology assessment, 5 systematic reviews, and 7 RCTs.

The following conclusions are based on low to very low quality of evidence. The reviewed evidence was based on RCTs that were inadequately powered to observe differences between hospital-at-home and inpatient hospital care for most outcomes, so there is a strong possibility of type II error. Given the low to very low quality of evidence, these conclusions must be considered with caution.

- Approximately 21% to 37% of patients with acute exacerbations of COPD who present to the ED may be eligible for hospital-at-home care.
- Of the patients who are eligible for care, some may refuse to participate in hospital-at-home care.
- Eligibility for hospital-at-home care may be increased depending on the design of the hospital-at-home program, such as the size of the geographical service area for hospital-at-home and the hours of operation for patient assessment and entry into hospital-at-home.
- Hospital-at-home care for acute exacerbations of COPD was associated with a nonsignificant reduction in the risk of mortality and hospital readmissions compared with inpatient hospital care during 2- to 6-month follow-up.
- Limited, very low quality evidence suggests that hospital readmissions are delayed in patients who received hospital-at-home care compared with those who received inpatient hospital care (mean additional days before readmission comparing hospital-at-home to inpatient hospital care ranged from 4 to 38 days).
- There is insufficient evidence to determine whether hospital-at-home care, compared with inpatient hospital care, is associated with improved lung function.
- The majority of studies did not find significant differences between hospital-at-home and inpatient hospital care for a variety of health-related quality of life measures at follow-up. However, follow-up may have been too late to observe an impact of hospital-at-home care on quality of life.
- A conclusion about the impact of hospital-at-home care on length of stay for the initial exacerbation (defined as days in hospital or days in hospital plus hospital-at-home care for inpatient hospital and hospital-at-home, respectively) could not be determined because of limited and inconsistent evidence.
- Patient and caregiver satisfaction with care is high for both hospital-at-home and inpatient hospital care.

Background

In July 2010, the Medical Advisory Secretariat (MAS) began work on a Chronic Obstructive Pulmonary Disease (COPD) evidentiary framework, an evidence-based review of the literature surrounding treatment strategies for patients with COPD. This project emerged from a request by the Health System Strategy Division of the Ministry of Health and Long-Term Care that MAS provide them with an evidentiary platform on the effectiveness and cost-effectiveness of COPD interventions.

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Clinical Need and Target Population

Acute Exacerbations of Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease is a disease state that is characterized by a limitation in airflow that is not fully reversible. This airflow limitation is usually both progressive and associated with abnormal inflammatory response of the lungs to noxious particles or gases. (1) The natural history of COPD involves periods of worsening symptoms known as acute exacerbations. There is debate about the best definition for exacerbations; a consensus definition developed by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) defines an acute exacerbation as "an event in the natural course of the disease characterized by a change in the patient's baseline dyspnea, cough, and/or sputum that is beyond normal day-to-day variations, is acute in onset, and may warrant a change in regular medication." (2) Patients may also experience a variety of other symptoms such as worsening exercise tolerance, fatigue, malaise, and decreased oxygen saturation. (3)

Two-thirds of COPD exacerbations are caused by an infection of the tracheobronchial tree or by air pollution; the cause is unknown in the remaining cases. (2;4) Risk factors for exacerbations include disease severity, winter months, and a previous exacerbation in the previous 8 weeks. (3;5) The frequency of exacerbations seems to vary with disease severity. Using data from the Inhaled Steroids in Obstructive Lung Disease Study (ISOLDE Study), the European Respiratory Society Study on COPD, and the Copenhagen City Lung Study, Donaldson et al (3) found that patients with severe disease (GOLD category III) experienced an average of 3.43 exacerbations per year, whereas patients with moderate disease (GOLD category II) experienced an average of 2.68 exacerbations per year. (3)

Exacerbations have an important impact on patients and on the health care system. For patients, exacerbations result in decreased quality of life, potential permanent loss in lung function, and increased risk of mortality. For patients with severe exacerbations that require hospitalization, estimates of inpatient mortality range from 4% to 30%. Higher hospital mortality rates are observed for patients admitted with respiratory failure. Mortality following discharge is also high: data from the United Kingdom shows a 14% mortality rate within 3 months of readmission, and data from the United States shows a 43% mortality rate after 12 months. (3) Furthermore, exacerbations of COPD are a leading cause of ED visits and hospitalizations, particularly in winter. The health care burden associated with exacerbations is high; inpatient costs for exacerbations have been estimated to account for 70% of total health care costs for COPD treatment. (6;7)

Technology

Hospital-at-home programs offer an alternative to inpatient hospital programs for patients who present to the ED with an exacerbation of COPD that requires hospital admission for treatment. In general, when patients are enrolled in hospital-at-home for COPD exacerbations programs, medical professionals (typically specialist nurses) visit the patients in their home to monitor them, alter their treatment plans if needed, and in some programs, provide additional care such as pulmonary rehabilitation, patient and caregiver education, smoking cessation counselling, etc., and support services. In the programs discussed in the literature, patients remain under the legal and medical responsibility of the hospital while being treated at home.

There are 2 types of hospital-at-home programs: admission avoidance and early discharge hospital-at-home. In admission avoidance hospital-at-home, after being assessed in the ED, patients are prescribed any necessary medications and additional care (e.g., oxygen therapy) and then sent home where they receive visits from medical professionals. Alternatively, patients may be referred directly to admission avoidance hospital-at-home care by their general practitioner, bypassing the ED visit. In contrast, in early discharge hospital-at-home, after being assessed in the ED, patients are admitted to the hospital where they receive the initial phase of their treatment. Following this, they are discharged into hospital-at-home before the exacerbation has resolved. In both cases, once the exacerbation has resolved, the patient is discharged from the hospital-at-home program and no longer receives visits at his/her home.

Cochrane reviews have defined hospital-at-home programs as services that provide patients with active treatment by health care professionals in the patient's home for a condition that otherwise would require acute inpatient hospital care for a limited time period. In other words, if hospital-at-home is not available, the patient would be admitted to an acute hospital ward. (8;9)

Figure 1 shows a comparison of inpatient hospital care and hospital-at-home care (including admission avoidance and early discharge) pathways for acute exacerbations of COPD, as well as admission avoidance and early discharge hospital-at-home options.

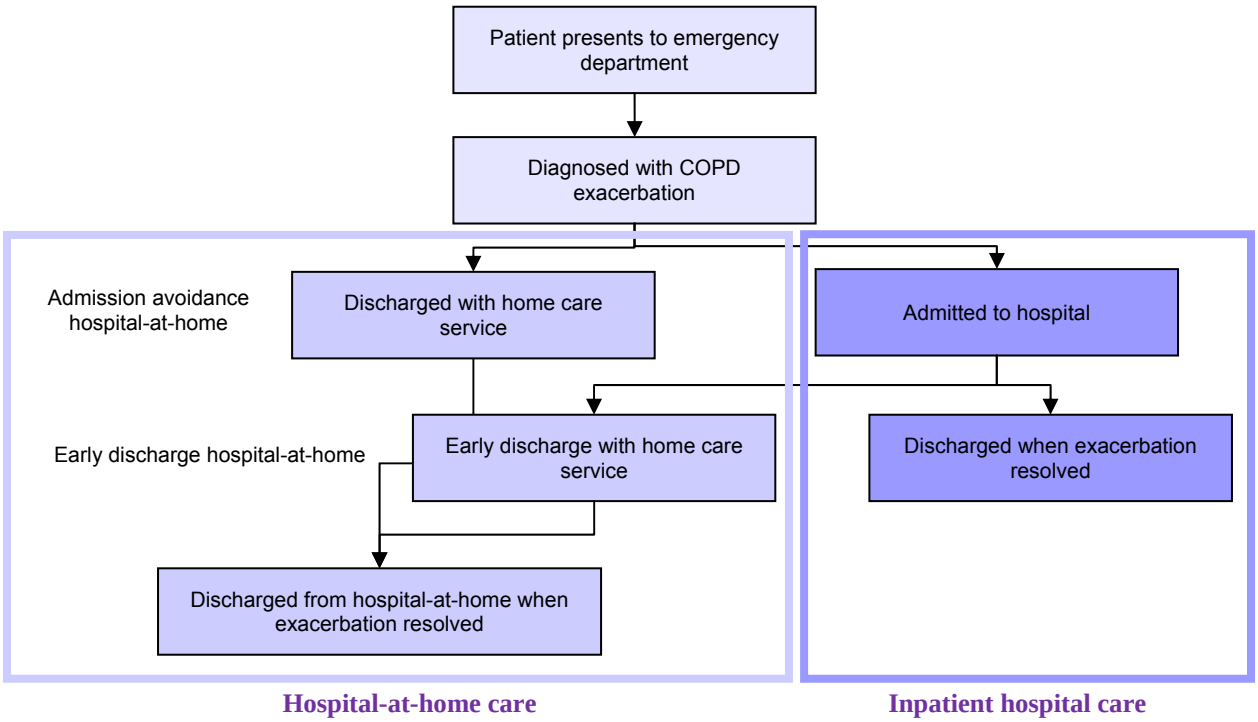

Figure 1: Hospital-at-Home Program Versus Inpatient Hospital Care

Hospital-at-home programs differ from other home care programs partly because they deal with higher acuity patients who require higher acuity care—in this case, patients with severe acute exacerbations of COPD who would otherwise require hospitalization to treat their condition—and partly because hospitals retain the medical and legal responsibility for patients (at least in the COPD models that have existed to date). Furthermore, patients requiring home care services may need these services for long periods of time or perhaps indefinitely; patients in hospital-at-home programs require and receive services for a limited period of time (e.g., until the acute exacerbation has resolved).

Hospital-at-home care is not appropriate for all patients with acute exacerbations of COPD. First, patients with less severe exacerbations that can be managed without admission to hospital are not eligible for hospital-at-home care; this includes those patients who do not present to the ED for their exacerbation or those that can be discharged with some changes in medication only. Second, some patients require admission to the hospital and cannot be safely treated in a hospital-at-home program whether for medical reasons (e.g., diminished consciousness) or lack of adequate social support at home. The issue of appropriate eligibility for hospital-at-home programs is addressed in both the results and in the summary of current hospital-at-home guidelines sections of the evidence-based review section.

The proposed possible benefits of hospital-at-home for exacerbations of COPD include: decreased health care resource utilization through avoided hospital admissions and/or reduced length of stay in the hospital; lower costs; increased health-related quality of life (HRQOL) for both patients and caregivers when patients are treated at home; and reduced risk of hospital-acquired infections in this susceptible patient population.

Ontario Context

No hospital-at-home programs for the treatment of acute exacerbations of COPD were identified in Ontario based on conversations with experts.

Evidence-Based Analysis

Research Question

What is the effectiveness, cost-effectiveness, and safety of hospital-at-home care compared with inpatient hospital care of acute exacerbations of COPD?

Research Methods

Literature Search

Search Strategy

A literature search was performed on August 5, 2010, using OVID MEDLINE, OVID MEDLINE In-Process and Other Non-Indexed Citations, OVID EMBASE, EBSCO Cumulative Index to Nursing & Allied Health Literature (CINAHL), the Wiley Cochrane Library, and the Centre for Reviews Dissemination database for studies published from January 1, 1990, to August 5, 2010. The search strategy is shown in Appendix 1.

Abstracts were reviewed by a single reviewer and, for those studies meeting the eligibility criteria, full-text articles were obtained. Reference lists and health technology assessment websites were also examined for any additional relevant studies not identified through the search.

Inclusion Criteria

- English language full-text reports;
- health technology assessments, systematic reviews, meta-analyses, and randomized controlled trials (RCTs);
- studies performed exclusively in patients diagnosed with COPD or studies that included patients with COPD as well as patients with other conditions, if results are reported for COPD patients separately;
- studies performed in patients with acute exacerbations of COPD who present to the ED;
- studies published between January 1, 1990, and August 5, 2010;
- studies comparing hospital-at-home and inpatient hospital care for patients with acute exacerbations of COPD;
- studies that report at least 1 of the outcomes of interest (listed below).

This review adopted the Cochrane definition of hospital-at-home used by Shepperd et al (8;9). As such, studies were only included if the hospital-at-home programs provided patients with active treatment for their acute exacerbation in their home by medical professionals for a limited period of time (in this case, until the resolution of the exacerbation). If a hospital-at-home program had not been available, these patients would have been admitted to hospital for their treatment.

Exclusion Criteria

- < 18 years of age
- animal studies
- duplicate publications
- grey literature

Outcomes of Interest

Patient/clinical outcomes

- mortality
- lung function
- HRQOL
- patient or caregiver preference
- patient or caregiver satisfaction with care
- complications

Health system outcomes

- hospital readmissions
- length of stay in hospital and hospital-at-home
- ED visits
- transfer to long-term care
- days to readmission
- eligibility for hospital-at-home

Statistical Analysis

When possible, results were pooled using Review Manager 5 Version 5.1 (10) to calculate relative risks (RRs) using the Mantel–Haenszel method and a random effects model. If the data could not be pooled, the results were summarized descriptively. Data from RCTs were analyzed using intention-to-treat protocols. *P* values less than 0.05 were considered significant. Post hoc sample size calculations were performed using STATA 10.1.

To account for clinical heterogeneity between the studies, it was decided a priori to conduct subgroup analyses to reflect important differences between studies. These included acuity of hospital-at-home program, type of hospital-at-home program (early discharge or admission avoidance), and the severity of COPD of the patients included in the study. Additional subgroup analyses were completed as needed based on the identified literature.

Quality of Evidence

The quality of each included study was assessed, taking into consideration the following 7 study design characteristics:

- adequate allocation concealment;
- randomization (study must include a description of the randomization procedure used and must be a proper method);
- power/sample size (adequate sample size based on a priori calculations; underpowered studies were identified, when possible, using post hoc sample size power calculations);
- blinding (if double blinding is not possible, a single blind study with unbiased assessment of outcome was considered adequate for this criterion);
- < 20% withdrawals/dropouts;
- intention-to-treat (ITT) analysis conducted and done properly (withdrawals/dropouts considered in analysis); and

- other criteria as appropriate for the particular research question and study design.

The quality of the body of evidence was assessed as high, moderate, low, or very low according to the GRADE Working Group criteria (11) as presented below.

- Quality indicates the criteria such as the adequacy of allocation concealment, blinding and follow-up.
- Consistency indicates the similarity of estimates of effect across studies. If there are important and unexplained inconsistencies in the results, our confidence in the estimate of effect for that outcome decreases. Differences in the direction of effect, the magnitude of the difference in effect, and the significance of the differences guide the decision about whether important inconsistency exists.
- Directness indicates the extent to which the interventions and outcome measures are similar to those of interest.

As stated by the GRADE Working Group, the following definitions of quality were used in grading the quality of the evidence:

High	Further research is very unlikely to change confidence in the estimate of effect.
Moderate	Further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate.
Low	Further research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate.
Very Low	Any estimate of effect is very uncertain.

Results of Evidence-Based Analysis

The database search yielded 3,142 citations published between January 1, 1990, and August 5, 2010 (with duplicates removed). Articles were excluded based on information in the title and abstract. The full texts of potentially relevant articles were obtained for further assessment. Figure 2 shows the breakdown of when and for what reason citations were excluded in the analysis.

Ten studies (3 systematic reviews and 7 RCTs) met the inclusion criteria. The reference lists of included studies and health technology assessment websites were hand-searched to identify any additional potentially relevant studies. In these, 3 additional citations (1 health technology assessment and 2 systematic reviews) were found, making a total of 13 included citations.

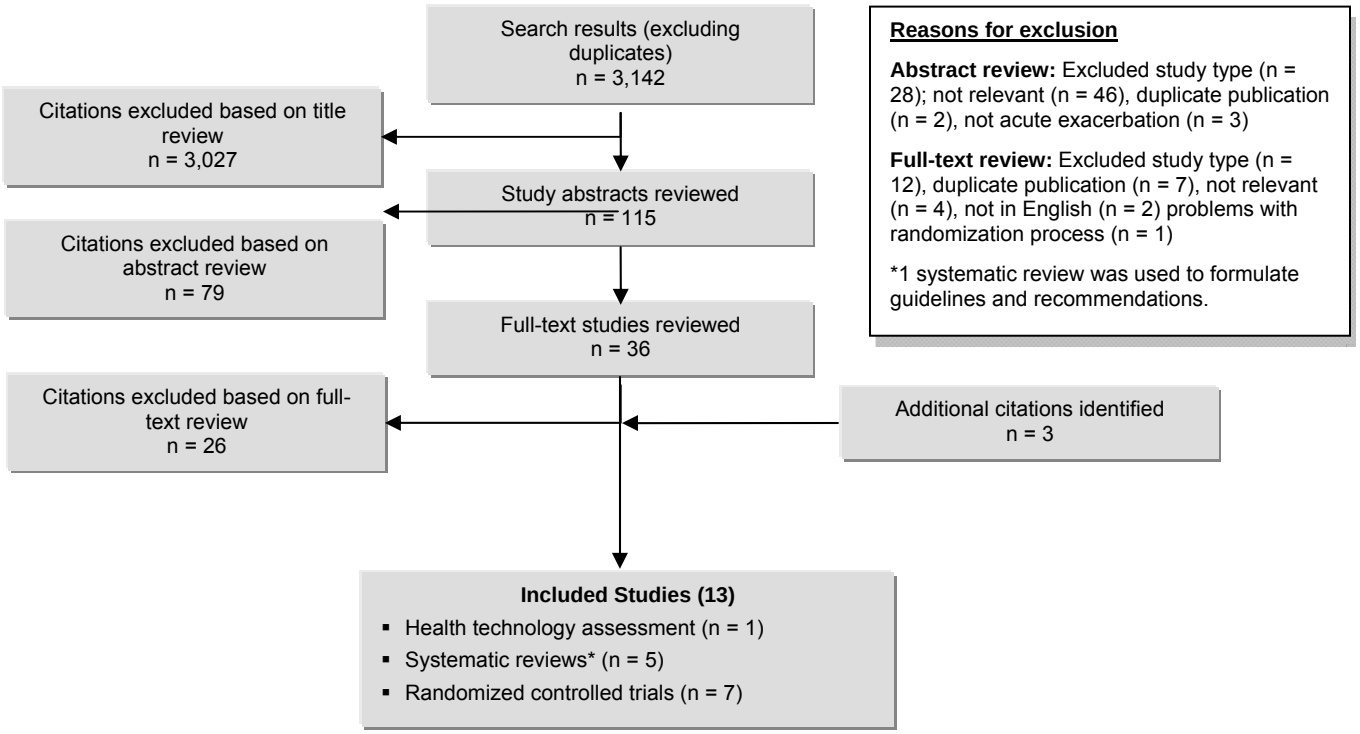

Figure 2: Citation Flow Chart

For each included study, the study design was identified and is summarized below in Table 1, which is a modified version of the hierarchy of study design by Goodman. (12)

Table 1: Body of Evidence Examined According to Study Design*

Study Design	Number of Eligible Studies
RCT Studies	
Systematic review of RCTs	6†
Large RCT‡	3
Small RCT	4§
Observational Studies	
Systematic review of non-RCTs with contemporaneous controls	
Non-RCT with contemporaneous controls	
Systematic review of non-RCTs with historical controls	
Non-RCT with historical controls	
Database, registry, or cross-sectional study	
Case series	
Retrospective review, modelling	
Studies presented at an international conference or other sources of grey literature	
Expert opinion	
Total	13

*Abbreviations: RCT, randomized controlled trial.
†Includes 1 health technology assessment and 5 systematic reviews.
‡Large RCT was defined as a trial with more than 100 patients.
§Two of the small RCTs reported results for the same study.

Health Technology Assessments

The National Institute for Clinical Excellence (NICE) in the United Kingdom conducted a systematic review of the effectiveness and cost-effectiveness of numerous interventions for COPD, including hospital-at-home care versus inpatient hospital care for acute exacerbations of COPD. (13) Guidelines and recommendations were developed based on the findings of the systematic reviews. Literature published in MEDLINE (1966 to 2003), EMBASE (1980 to 2003), and CINAHL (1982 to 2003) was reviewed, and 4 RCTs, 1 qualitative study, 1 survey, and 1 service evaluation relevant to the hospital-at-home versus inpatient hospital care question were identified. (13)

The main findings of the systematic review are summarized below:

- There were no significant differences between those patients cared for as part of a hospital-at-home program and those cared for in hospital for the following outcomes:
  - forced expiratory volume in 1 second (FEV_1) (Ib evidence)[1]
  - readmission rates (Ib evidence)
  - number of additional days readmitted patients spent in hospital (Ib evidence)
  - number of days in care (Ib evidence)
  - mortality rates (Ib evidence)
  - symptom scores (Ib evidence)

[1] NICE defines Ib evidence as evidence from at least 1 RCT. (13)

  - additional support services (Ib evidence)
  - patient and caregiver satisfaction scores (Ib evidence) (13)
- The HRQOL results were conflicting: 2 studies showed no statistically significant difference, whereas 1 study showed a significant improvement in the St. George's Respiratory Questionnaire (SGRQ) and Chronic Respiratory Disease Questionnaire between the hospital-at-home and inpatient hospital groups. (13)
- There was limited and inconsistent evidence on the comparative cost of hospital-at-home compared with inpatient hospital care, with 1 study showing an increased cost and another a decreased cost associated with hospital-at-home care. (13)

Based on the results of the systematic review, NICE made the following recommendations:

R138: "Admission discharge and early discharge hospital-at-home programs are safe and effective and should be used as an alternative way of caring for those patients with exacerbations of COPD who would otherwise need to be admitted to or stay in hospital." (GRADE A)[2] (13)

R139: "The multiprofessional team required to operate these schemes should include allied health professionals with experience in managing COPD, and may include nurses, physiotherapists, occupational therapists, and generic health workers." (GRADE D)[3] (13)

R140: "There are currently insufficient data to make firm recommendations about which patients with an exacerbation are most suited for hospital-at-home or early discharge. Patient selection should depend on the resources available and on the absence of factors associated with worse prognosis, for example, acidosis." (GRADE D) (13)

R141: "Patients' preferences for treatment at home or in hospital should be considered." (GRADE D) (13)

MAS Comments

Recommendation 138 is based on the lack of significant differences between hospital-at-home and inpatient hospital care for most of the outcomes examined in this review. Since the included studies were designed as superiority trials, nonsignificant results cannot be used to conclude that hospital-at-home is a safe and effective alternative; such a conclusion requires evidence from equivalency trials.

Systematic Reviews

Of the 11 studies that met the inclusion criteria, 3 were systematic reviews conducted by the Cochrane Collaboration. Ram et al (14) conducted a systematic review of the evidence for hospital-at-home care compared with inpatient hospital care for acute exacerbations of COPD published until August 2003. Seven RCTs were included.

Only the results for the 2 primary outcomes—readmission rates and mortality—could be pooled due to substantial differences in the way the secondary outcomes were measured across studies. The main results comparing hospital-at-home and inpatient hospital care are as follows:

- Based on 7 studies (n = 754), the difference in hospital readmission rates for the hospital-at-home and inpatient hospital care groups was not statistically significant (relative risk [RR], 0.89; 95% confidence interval [CI], 0.72–1.12; $P = 0.33$). (14)

[2] NICE defines GRADE A as evidence based on hierarchy I evidence, which includes systematic reviews, meta-analyses of RCTs, or RCTs. (13)

[3] NICE defines GRADE D as evidence based on hierarchy IV evidence, which includes evidence from expert committee reports or options and/or clinical experience of respected authorities or evidence that is extrapolated from hierarchy I, II, or III. (13)

- Based on 6 studies (n = 729) with 2- to 3-month follow-up, individuals in the hospital-at-home group were 39% less likely to die than those in the inpatient hospital group (RR, 0.61; 95% CI, 0.36–1.05; *P* = 0.08). (14)
- One study identified a statistically significant reduction in the risk of hospital ED visits (with no inpatient admission) in the hospital-at-home group (RR, 0.44; 95% CI, 0.22–0.86; *P* values not reported) over 2 months of follow-up. (14)
- One study found that hospital-at-home patients who were readmitted to hospital during the 3-month follow-up tended to have longer durations of stay than patients in the inpatient hospital group, but this difference was not statistically significant (median days of readmission, 5 vs. 0; *P* = 0.08). (14)
- The studies that measured lung function did not find any statistically significant differences in the changes in FEV_1, forced vital capacity (FVC), or in FEV_1/FVC ratio between the 2 groups. (14) Three studies found no difference in HRQOL between the 2 groups based on the SGRQ. (14)
- No statistically significant difference was observed between the 2 groups in terms of patient or caregiver satisfaction with care (patient satisfaction: RR, 1.04; 95% CI, 0.88–1.24; caregiver satisfaction: RR, 0.97; 95% CI, 0.79–1.19; *P* values not reported). (14)
- More of those patients who were treated at home and more of their caregivers preferred hospital-at-home than patients (RR, 1.17; 95% CI, 1.17–2.04) who were treated in hospital and their caregivers (RR, 1.52; 95% CI, 1.08–2.14). (14)
- A pooled analysis of 2 studies that reported a mean cost analysis found a cost savings of £540 (GBP) per patient with hospital-at-home care compared with inpatient hospital care. (14)
- The reported economic analyses in the included studies were heterogeneous. One study did find a higher mean hospital cost in the hospital-at-home group, but this difference was not statistically significant (£1,389 [GBP] vs. £1,198 [GBP]). (14)
- In the 7 included studies, 26.7% (744/2786) of the patients who presented to the ED for acute exacerbations of COPD were eligible for hospital-at-home care. (14)

The authors concluded that there was no significant difference between hospital-at-home care and inpatient hospital care based on readmission and mortality rates 2 to 3 months after the initial exacerbation. Although hospital-at-home care was determined to be safe, effective, and the preferred option for suitable patients, Ram et al (14) identified the need for further research to determine which patient groups are most suitable; what components of care (including who should deliver the care) provide the greatest benefits; and the cost-effectiveness (considering both the direct and indirect costs) of hospital-at-home care for the treatment of acute exacerbations of COPD. (14)

MAS Comments

The conclusion of this systematic review that hospital-at-home care is safe and effective for suitable patients is based on statistically nonsignificant results from superiority trials, and is hence inappropriate.

The 2 other Cochrane reports were systematic reviews of RCT evidence published up to January 2008 on early discharge hospital-at-home programs and admission avoidance hospital-at-home programs. (8;9) These reviews were conducted in parallel and together represent an update to a previous 2005 Cochrane review. Both reviews analyzed published and unpublished data consisting of individual patient data that were obtained from the authors of many of the included studies.

The Shepperd et al (8) review of early discharge hospital-at-home studies identified 26 RCTs, of which 13 contributed individual patient data. Three of these studies included patients with COPD, whereas the

remainder also included patients with a variety of other medical conditions such as recovery from stroke, hip fractures, and total knee replacement. The analyses stratified the results into 3 groups: patients recovering from strokes, older people with a mix of conditions, and patients having elective surgery. The COPD studies were included in the second group. (8)

Shepperd et al (8) found the following[4]:

- There was a nonsignificant small increase in mortality in the hospital-at-home group using the individual patient data (hazard ratio [HR], 1.06; 95% CI, 0.69–1.61) and published data (RR, 1.12; 95% CI, 0.77–1.63) for the subgroup of older people with a mix of conditions. (8) The direction of the pooled analysis of the published data for the COPD studies alone was the opposite, showing a statistically nonsignificant reduction in mortality in the hospital-at-home group (RR, 0.50; 95% CI, 0.23–1.09). (8)
- There was a significant increase in hospital readmissions for the older people with a mix of conditions in the hospital-at-home care group based on the individual patient data (HR, 1.57; 95% CI, 1.10–2.24) and the published data (RR, 1.35; 95% CI, 1.03–1.76). (8)
- Only 1 of these studies included patients with COPD, and COPD was the diagnosis for only 6% (32/538) of patients in the study. In this study, a nonsignificant increase in hospital readmissions was found in both the COPD patients only and in the study as a whole. (15) (8)
- The COPD trials that measured functional status and/or quality of life found no statistically significant difference between the 2 groups. (8)
- The 5 trials (1 of which included COPD patients) that measured psychological well-being in the subgroup of older people with a mix of conditions found no significant differences between the groups at follow-up. (8)
- Three trials (including 2 with COPD patients) in the subgroup of older people with a mix of conditions found statistically significant increased levels of satisfaction in the hospital-at-home group, although the results in 1 of these studies found improved patient satisfaction for only some of the measured domains. (8)
- Three trials (2 of which included COPD patients) found no statistically significant differences in terms of caregiver satisfaction or burden; however, 1 of the COPD trials found that a significantly greater number of caregivers in the hospital-at-home group were happier with hospital-at-home care. (8)
- The 3 COPD trials found a reduction in hospital stay (range, 1.5–3 days) for the hospital-at-home group, but this reduction was statistically significant in only 1 study. (8)
- Two of the COPD trials measured total days in care, which included both days in hospital and in hospital-at-home care, and found a statistically significant increase in total days of care in the hospital-at-home group. (8)
- Two of the 3 studies with COPD patients found a lower mean health service cost using the average cost per bed-day for patients in the hospital-at-home group, but the third study reported a significant increase in costs when the different resources used during a patient's inpatient admission were taken into account (mean difference, £1,132.00 [GBP]; $P < 0.01$). (8)

Based on the evidence for all of the medical conditions examined, Shepperd et al (8) concluded that there was insufficient objective evidence of economic benefit or improved health outcomes associated with early discharge hospital-at-home programs. Further primary research was recommended in the area of early discharge hospital-at-home for patients recovering from a stroke, patients with an acute exacerbation of COPD, and older patients with medical conditions requiring an acute inpatient hospital stay. (8)

[4] Since only the results that include the COPD patients are relevant for this analysis, the other results are not discussed here.

MAS Comments
The overall conclusions are based on a combination of studies that included patients with conditions other than COPD, so the conclusions may not all be appropriate for the COPD patient population specifically.

The related review on admission avoidance hospital-at-home compared with inpatient hospital care by Shepperd et al (9) identified 10 studies, 5 of which contributed individual patient data. Two of the studies included COPD patients only, whereas the other studies recruited patients with other conditions—recovering from stroke (2 studies), with cellulitis (1 study), with community-acquired pneumonia (1 study), and frail, elderly with dementia (1 study). The results from the studies were pooled and are summarized below[5]:

- The individual patient data from 5 studies (1 of which included COPD patients) showed a nonsignificant reduction in mortality at 3 months (HR, 0.77; 95% CI, 0.54–1.09; $P = 0.15$) and a significant reduction at 6 months (HR, 0.62; 95% CI, 0.45–0.87; $P = 0.005$). (9)
- Three trials (1 of which included COPD patients) found a statistically nonsignificant increase in the rate of hospital readmissions in the hospital-at-home group at the 3-month follow-up (HR, 1.49; 95% CI, 0.96–2.33) using the individual patient data and the published data (RR, 1.18; 95% CI, 0.83–1.67). (9)
- The 5 studies that measured functional ability (including 1 with COPD patients) found nonsignificant differences in most measures. (9)
- One of the COPD studies found that patients in the hospital-at-home group were significantly more likely to be prescribed an antibiotic (difference, 18%; 95% CI, 1.4%–34.6%). (9)
- One of the COPD studies found a lower mean health service cost for patients in the hospital-at-home group using diagnostic-related group categorization to calculate hospital costs (cost per episode mean difference, – £1,798 [GBP], $P < 0.01$). (9)
- One of the COPD trials found an increase in referrals for social support in the hospital-at-home group compared with the inpatient group (24% vs. 6%; difference, 18%; 95% CI, 7.3%–28.6%). (9)

Based on the evidence for admission avoidance hospital-at-home, Shepperd et al (9) concluded that there was no evidence to suggest that admission avoidance hospital-at-home leads to outcomes that differ from inpatient hospital care. As such, they concluded that admission avoidance hospital-at-home can provide an effective alternative to inpatient care for a selected group of elderly patients requiring hospital admission.

MAS Comments
The conclusions of this review are based on nonsignificant results from superiority trials, which is inappropriate. In addition, the overall conclusions are based on a combination of studies that included patients with conditions other than COPD, so the conclusions may not all be appropriate for the COPD patient population.

Soderstrom et al (16) focused on the health and cost effects of hospital-at-home care in a systematic review of the literature published between 1975 and early 1998 on hospital-at-home care for acute conditions, including COPD acute exacerbations. One RCT, which included COPD patients, was identified and rated as a class 1 study based on 6 internal validity criteria developed by the authors (class 1 studies are believed to present valid results despite some methodological issues). This study reported no

[5] Since only the results that include COPD patients are relevant for this analysis, the other results are not discussed here.

difference between hospital-at-home care and inpatient hospital care with regard to patients' health, caregivers' health, or caregivers' and patients' costs. A statistically significant effect, however, was found for social costs[6] and health system costs. (16) The review concluded that hospital-at-home care had no notable effect on health outcomes compared with inpatient hospital care, although the effects on social and health system costs vary by condition. The study recommended further research to determine the appropriate use of acute hospital-at-home care. (16)

> ***MAS Comments***
> The overall conclusions are based on a combination of studies that included patients with conditions other than COPD, so the conclusions may not all be appropriate for the COPD patient population specifically.

The final systematic review identified was published by the British Thoracic Society Guideline Development Group; (17) however, the systematic review component of this paper reviewed the literature on certain questions related to hospital-at-home for COPD exacerbations such as how, where, and by whom should patients be assessed for suitability, and what should comprise hospital-at-home care for the purposes of making recommendations and guidelines. Therefore, the results of this paper are presented in the Guideline section of this evidence-based analysis.

Randomized Controlled Trials

Seven RCTs that met the inclusion criteria were identified and included in this review. Two of the studies reported on the same trial by Shepperd et al (15;18); these papers were not counted as a duplicated publication because they reported on different outcomes, but they are treated as 1 combined study in the following tables and discussion. The general study characteristics, such as the type of hospital-at-home service, and details of the characteristics of the patients included in the studies are shown in Tables A1, A2, and A3 in Appendix 2.

Overall, 3 studies evaluated early discharge programs, 2 studies evaluated admission avoidance hospital-at-home programs, and 2 studies included both early discharge and admission avoidance hospital-at-home programs. In 6 of the 7 studies, specialist nurses conducted the hospital-at-home visits, whereas 1 study used a combination of both physicians and nurses for patient follow-up. The acuity of care provided at home varied widely across the studies; patients in some studies received only basic care and monitoring, whereas patients in others received a variety of additional services including education, counselling, and rehabilitation.

A comparison of the baseline patient population characteristics in Tables A2 and A3 (Appendix 2) show some differences across the study populations:

- In the study by Aimonino Ricauda et al (19), the mean age of patients was higher, the percentage of current smokers was lower, the percentage of nonsmokers was higher, and the percentage of patients with support at home was higher compared with the other studies.
- There was a lower percentage of men in the Shepperd et al (15;18) study compared with the other studies.
- The percentage of patients using home oxygen before the exacerbation was lower in the Skwarska et al (6) study.
- The mean FEV_1 was lower in the Davies et al and Skwarska et al (6;20) trials.

[6] The social cost effect was defined as the effect of home care on public and private costs, including the hospital cost savings from shorter inpatient stays, the public and private costs of the home care program including drugs, supplies, services, etc., and the change in non-health-system costs borne by patients and caregivers including babysitting, transportation, and value of time to manage the condition. (16)

The majority of the identified differences were related to the baseline population characteristics rather than the patients' clinical parameters; however, since the clinical parameters, such as partial pressure of oxygen, were less consistently reported, a thorough comparison of the patient populations is not possible. These differences may account for some of the heterogeneity observed when the results are pooled in the analyses below.

Hospital-at-Home Care Follow-Up Details

The average number of follow-up visits that patients in the hospital-at-home programs received varied substantially between studies (Table 2). Patients in the Aimonino Ricauda et al trial (19) tended to receive the most follow-up home visits, especially as they received visits from both nurses and physicians, whereas patients in the Skwarska et al trial (6) tended to have the fewest visits.

Table 2: Hospital-at-Home Follow-Up Details*

Author, Year	Number of Follow-Up Home Visits, Mean (SD)	Mean Duration of HaH Care, days
Cotton et al, 2000 (21)	Median, 11	Median, 24
Davies et al, 2000 (20)	11 (3)	14†
Ojoo et al, 2002 (22)	NR	NR
Aimonino Ricauda et al, 2008 (19)	Nurse visits: 14.1 (range, 3 – 38); median, 11 Physician visits: 9.9 (range, 2 – 28); median, 8	NR
Shepperd et al, 1998 (15;18)	NR	NR
Skwarska et al, 2000 (6)	3.8	NR

*Abbreviations: HaH, hospital-at-home; NR; not reported; SD, standard deviation.
†Exacerbations settled within 14 days in 96 patients (20).

Eligibility for Hospital-at-Home

In the included studies, only a portion of the patients presenting to the ED or admitted to hospital wards for acute exacerbations of COPD were eligible for hospital-at-home care. The reasons for exclusion varied by study (see Table 3), but the most common reasons were absence of or poor home/social support, severe acidosis or alkalosis, severe comorbidities (e.g., cancer, dementia, renal failure, etc.), and acute chest radiograph changes. Overall, the percentage of patients with COPD exacerbations who were eligible for hospital-at-home care ranged from 20.7% to 36.7% (Table 3).

Table 3: Percentage of Patients Eligible for Hospital-at-Home Care and Refusals

Author, Year	Eligible Patients, % (n)*	Refused Patients, % (n)†
Cotton et al, 2000 (21)	36.7 (151)	24.5 (37)
Davies et al, 2000 (20)	32.9 (192)	21.9 (42)
Ojoo et al, 2002 (22)	34.4 (182)	42.9 (78)
Aimonino Ricauda et al, 2008 (19)	20.7 (208)	11.5 (24)
Shepperd et al 1998 (15;18)	29.0 (95)	36.8 (35)
Skwarska et al, 2000 (6)	–	–

*Eligible Patients indicates the percentage of patients assessed who were deemed eligible for hospital-at-home programs.
†Refused Patients indicates the percentage of patients who were eligible to participate in the trial but who declined.

However, this may underestimate the true number of patients with acute exacerbations of COPD who are eligible for hospital-at-home programs. The early discharge studies generally included only patients who could be discharged within several days of hospitalization (for example, patients in the Davies et al (20) study had to be discharged within 3 days of admission to hospital). Also, many of the programs excluded patients who lived further than a particular distance from the hospital (for example, in Ojoo et al (22), patients were excluded if they lived more than 15 miles from the hospital; in Aimonino Ricauda et al (19), 28% of patients [148 of 529 patients assessed] were excluded because they lived outside of the hospital area). Furthermore, almost all of the trials only included patients who presented to the ED or were admitted to the hospital during particular hours of the day and/or days of the week. In practice, the number of eligible patients could be increased by including patients who have been admitted for longer periods of time in early discharge hospital-at-home programs, by expanding hospital boundaries, particularly in urban areas, and by including patients assessed/admitted on evenings and weekends.

Moreover, not all eligible patients were willing to participate in hospital-at-home programs: 11.5% to 42.9% of eligible patients refused to participate in the included trials (Table 3). It is possible that some of the refusals related to unwillingness to participate in a study rather than an established program.

Length of Stay

The length of stay in hospital-at-home care (includes both days spent in hospital for early discharge hospital-at-home programs and days spent in the hospital-at-home program) and inpatient hospital groups varied across the studies (Table 4). As a result of differences in reporting and measuring, length of stay could not be pooled across the studies. While Shepperd et al (15;18) observed similar lengths of stay in both groups, and Cotton et al (21) observed a shorter length of stay in the hospital-at-home group compared with the inpatient hospital group, 3 other studies observed longer lengths of stay in the hospital-at-home group. However, since many of the hospital-at-home programs did not require home visits every day, patients may have been enrolled in the program longer than was medically necessary simply because the nurse or physician did not visit the patient every day. (6)

Table 4: Length of Stay in First Admission (Hospital + Hospital-at-Home or Hospital)*

	Length of Stay, Mean (SD), days		
Author, Year	**HaH**	**H**	***P* Value**
Cotton et al, 2000 (21)	3.2 (range, 1 – 16)	6.1 (range, 1 – 13)	NR
Davies et al, 2000 (20)	NR	Median, 5 (IQ range, 4 – 7)	NR
Ojoo et al, 2002 (22)	7.4	5.9	0.14
Aimonino Ricauda et al, 2008 (19)	15.5 (9.5)	11.0 (7.9)	0.01
Shepperd et al, 1998 (15;18)	12.27 (3.69)†	12.12 (7.49)	NR
Skwarska et al, 2000 (6)	Median, 7‡	Median, 5	< 0.01

*Abbreviations: H, inpatient hospital care; HaH, hospital-at-home care; IQ, interquartile range; NR, not reported; SD, standard deviation.
†The mean total length of stay includes both days in hospital care and in hospital-at-home care (mean ± SD days in hospital: 6.93 ± 3.39; mean ± SD days in hospital-at-home care: 5.33 ± 3.94). (15;18)
‡Nurse hospital-at-home visits were not always daily, so patients may be in the hospital-at-home program longer than needed. (6)

Mortality

Table 5 shows the number of deaths in the hospital-at-home and inpatient hospital groups. The pooled results (Figure 3) show a nonsignificant reduction in the risk of death during the overall follow-up period (range, 2–6 months) in the hospital-at-home group compared with the inpatient hospital group (RR, 0.68; 95% CI, 0.41–1.12; $P = 0.13$).

Table 5: Mortality Results*

Author, Year	Number of Deaths (%) HaH	H	*P* Value
Cotton et al, 2000 (21)	1 (2.4)	2 (5)	Difference, 2.6% (95% CI, −5.7% to 10.8%)
Davies et al, 2000 (20)	9 (9)	4 (8)	NS
Ojoo et al, 2002 (22)	1 (3.7)	3 (11)	NS
Aimonino Ricauda et al, 2008 (19)	9 (17)	12 (23)	0.72
Shepperd et al, 1998(15;18)	3 (20)	3 (18)	Difference, 2% (95% CI, −25% to 30%); *P* = NS
Skwarska et al, 2000† (6)	4 (3.3)	7 (11.3)	NR

*Abbreviations: CI, confidence interval; H, inpatient hospital care; HaH, hospital-at-home care; NR, not reported; NS, not significant

†All deaths in the hospital-at-home group occurred after discharge from the hospital-at-home program. One death in the inpatient hospital group occurred during the hospitalization period, and the others occurred after discharge from the hospital. (6)

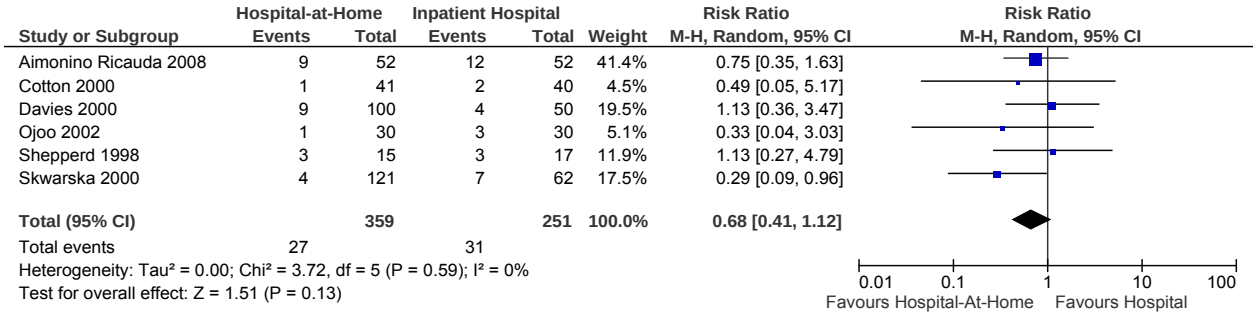

Figure 3: Forest Plot of Pooled Mortality Results*

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.

When the results are stratified by the length of the follow-up period (Figure 4), there is a statistically significant reduction in the risk of death at the 2-month follow-up (RR, 0.32; 95% CI, 0.11–0.93; *P* = 0.04), but the results for the 3- and 6-month follow-up remain nonsignificant (3 months: RR, 0.95; 95% CI, 0.42–2.17; *P* = 0.91; 6 months: RR, 0.75; 95% CI, 0.35–1.63; *P* = 0.47). The 2-month results may be more meaningful than the longer follow-up time points because hospital-at-home care is an acute intervention for a complex disease that may not have lasting effects once an exacerbation is treated.

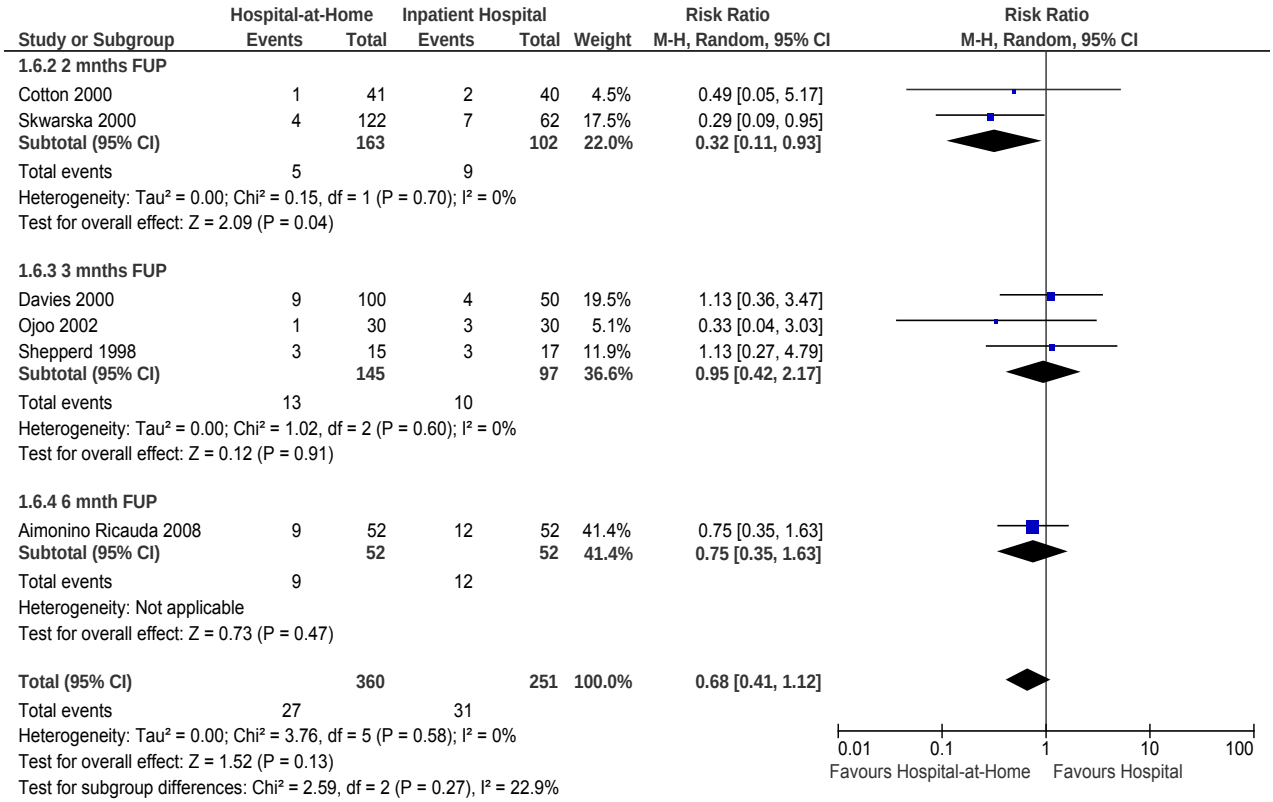

Figure 4: Forest Plot of Pooled Mortality Data by Time Point*

*Abbreviations: CI, confidence interval; FUP, follow-up; M–H, Mantel–Haenszel; mnth, month.

Figures 5 and 6 show the stratified pooled mortality rates by type of program (admission avoidance versus early discharge hospital-at-home) and level of acuity of hospital-at-home care[7]. The trend of a nonsignificant reduction in the risk of death in the hospital-at-home group compared with the inpatient hospital group was maintained for most of the subgroups, but a significant reduction was observed for the early discharge hospital-at-home group (RR, 0.33; 95% CI, 0.13–0.85; $P = 0.02$).

[7]Low acuity hospital-at-home programs were defined as programs in which patients were monitored and treatment adjusted as needed, but no additional care was provided; high acuity programs included additional services such as social support, physical therapy, pulmonary rehabilitation, education, etc.

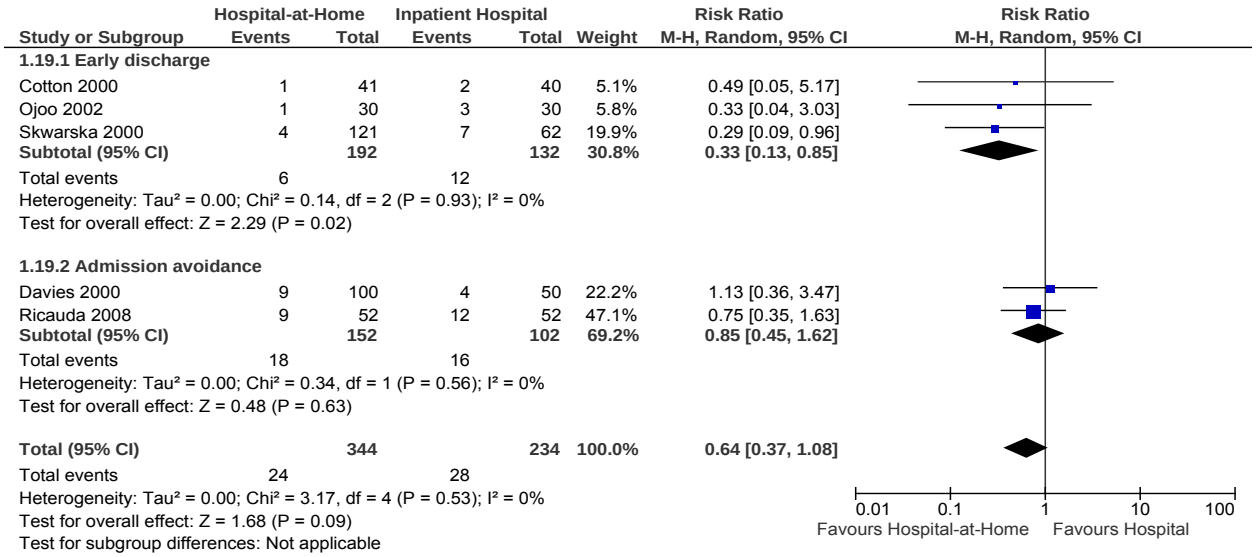

Figure 5: Forest Plot of Pooled Mortality Results by Type of Hospital-at-Home Program*

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.
Note: Results for Shepperd et al (15;18) are excluded from the forest plot because this program included both early discharge and admission avoidance hospital-at-home programs.

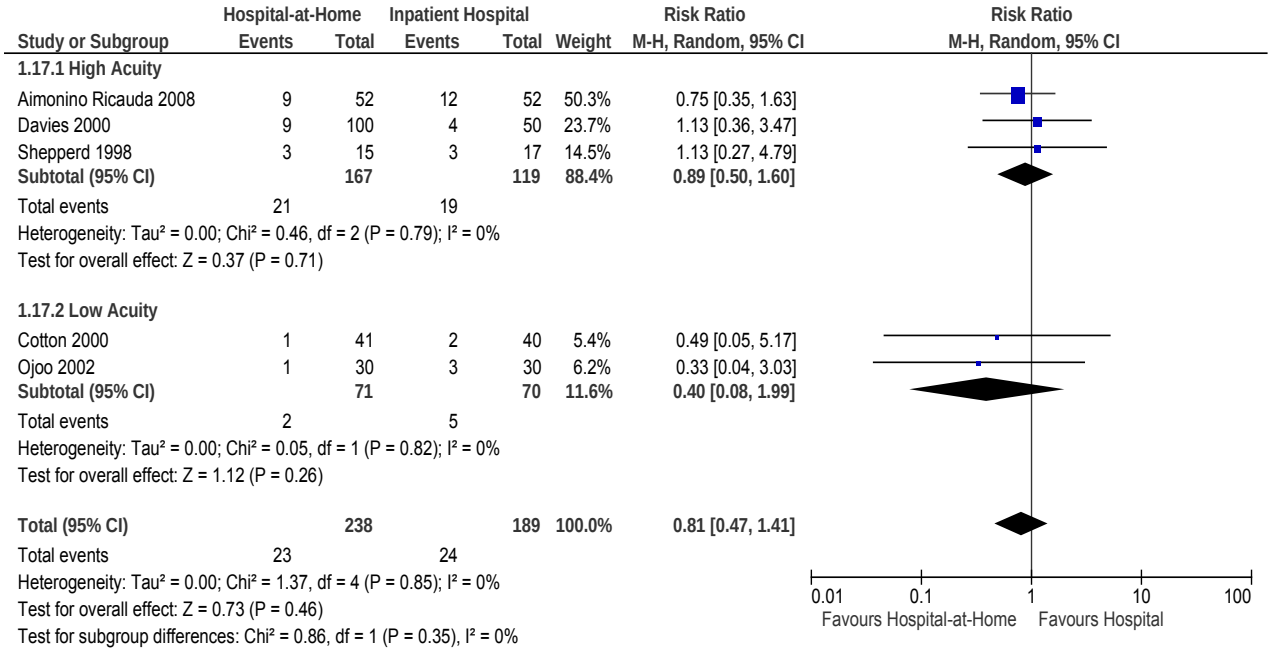

Figure 6: Forest Plot of Pooled Mortality Data by Acuity of Hospital-at-Home Program

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.
Note: Results for Skwarska et al (6) are removed from the pooled data by acuity of hospital-at-home program because it was unclear from the published study whether it involved high or low acuity care.

Hospital Readmissions

Table 6 summarizes the number of patients readmitted to hospital in the hospital-at-home and inpatient hospital groups in the included studies (readmissions to hospital include any patients that were readmitted to the hospital after discharge in the inpatient hospital group and any patients readmitted to the hospital after entry into the hospital-at-home group or after discharge from the hospital-at-home program).

Table 6: Hospital Readmission Results*

Author	Number of Readmissions (%)		
	HaH	H	*P* Value
Cotton et al, 2000 (21)	12 (29.3)	12 (30)	NR
Davies et al, 2000 (20)	37 (37)†	17 (34)	NS
Ojoo et al, 2002 (22)	12 (40.0)‡	13 (44.4)	NS
Aimonino Ricauda et al, 2008 (19)	20 (38)§	34 (87)	0.001‖
Shepperd et al, 1998 (15;18)	8 (53)	6 (35)	NS
Skwarska et al, 2000 (6)	39 (32.0)¶	21 (33.9)#	NR

*Abbreviations: H, inpatient hospital care; HaH, hospital-at-home care; NR, not reported; NS, not significant; SD, standard deviation.

†It is unclear from the study results whether the 37 patients readmitted to hospital included the 9 patients readmitted during the first 14 days after randomization or if it only includes patients readmitted after being discharged from hospital-at-home care. So as to not count these patients twice, it was assumed that the 9 patients were included in this total. The authors were contacted to confirm this assumption, but no response has yet been received.

‡While the trial reported only 10 patients (33.3%) in the hospital-at-home group, 2 patients in this group were readmitted to hospital due to clinical deterioration before being discharged from hospital-at-home care. The authors counted these patients as failures to complete the trial, although it would be more appropriate to count them as readmissions to hospital. As a result, they have been added to the 10 other readmissions reported in the table above.

§While the published results reported only 17 patients being readmitted, this did not include the 3 patients in the hospital-at-home group who were readmitted not because of their own health but because of their caregivers' failing health. As a result, 20 readmissions are counted in this analysis.

‖The reported *P* value is based on the comparison between 17 patients in the hospital-at-home group and 34 in the inpatient hospital group and does not take into account the additional 3 patients in the hospital-at-home group who were readmitted during the hospital-at-home treatment phase.

¶ Of the readmitted patients, 12 were readmitted during the hospital-at-home follow-up period (9 for respiratory reasons and 3 for nonrespiratory reasons) and 27 were readmitted during the follow-up period after discharge from the hospital-at-home program (23 for respiratory reasons and 4 for nonrespiratory reasons). (6) Statistical significance was calculated only for readmissions after hospital-at-home discharge and before final follow-up; this comparison was not statistically significant.

#All 21 patients were readmitted during the follow-up period after discharge from the hospital, 19 for respiratory reasons and 2 for nonrespiratory reasons.

When the readmission results are pooled (Figure 7), there is a nonsignificant reduction in the risk of hospital readmissions during the overall follow-up period (2 to 6 months) in the hospital-at-home group compared with the inpatient hospital group (RR, 0.90; 95% CI, 0.70–1.16; $P = 0.41$).

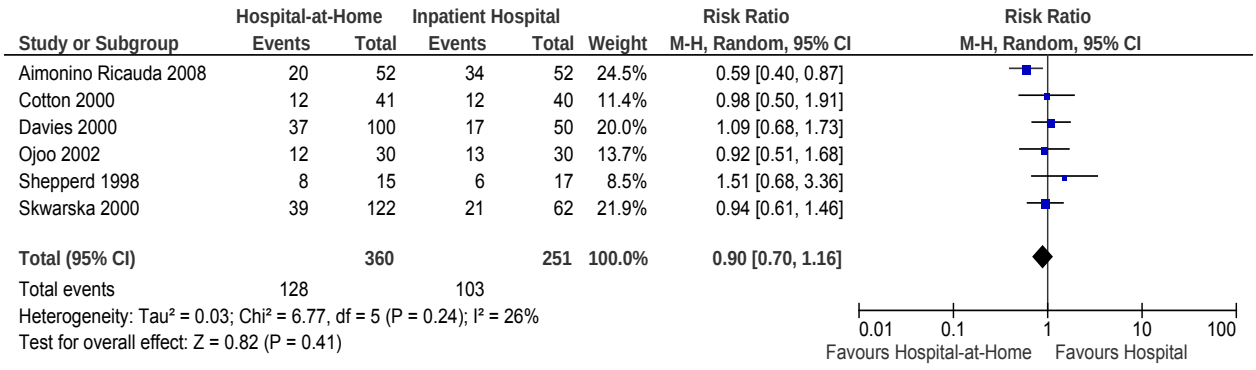

Figure 7: Forest Plot of Pooled Hospital Readmissions*

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.

In the hospital-at-home group, patients could be readmitted to the hospital either "early" during the hospital-at-home care period or "late" during the follow-up period (after discharge from hospital-at-home but before final follow-up). As shown in Table 7, both early and late readmissions occurred; readmissions during the hospital-at-home period accounted for 13% to 50% of the total readmissions in the hospital-at-home group (weighted average, 24.0%). These results should be considered with caution because readmissions were not always clearly defined as early and late in the published results[8], so some assumptions had to be made to reach the results shown in Table 7.

Table 7: Early Versus Late Readmissions in the Hospital-at-Home Group

Author, Year	Number of Early Readmissions* (% of total readmissions)	Number of Late Readmissions* (% of total readmissions)	Total Number of Readmissions
Cotton et al, 2000 (21)	6† (50)	6† (50)	12
Davies et al, 2000 (20)	9‡ (24)	28‡ (76)	37
Ojoo et al, 2002 (22)	2§ (17)	10§ (83)	12§
Aimonino Ricauda et al, 2008 (19)	3‖ (15)	17‖ (85)	20‖
Shepperd et al, 1998 (15;18)	1 (13)	7 (88)	8
Skwarska et al, 2000 (6)	9 (25)	27 (75)	36

*Early readmissions were defined as those that occurred before patients were discharged from the hospital-at-home program. Late readmissions were defined as readmissions that occurred after discharge from hospital-at-home and before final follow-up.
†The number of patients readmitted early compared with those readmitted late is not specified in the published results. Using the information that the average length of stay in hospital was 3.2 days and the median duration of nurse follow-up was 24 days, and according to Table 3 in the paper, 6 patients in the hospital-at-home group were readmitted to hospital within the first 30 days from the index admission. (21) The study authors were contacted to determine the exact number of early versus late readmissions, but no response has yet been received.
‡It is unclear from the results whether the 37 patients readmitted to hospital includes the 9 patients readmitted during the first 14 days after randomization, or if this only includes patients readmitted after being discharged from hospital-at-home care. So as not to count these patients twice, it was assumed that the 9 patients were included in this total, resulting in 28 patients being admitted in the late readmission category. The authors were contacted to confirm this assumption, but no response has yet been received.
§It is unclear in the published results whether any of the 10 reported readmissions occurred during the hospital-at-home period. Two patients in the hospital-at-home group were, however, excluded from the results of the trial because they were readmitted to hospital as a result of clinical deterioration. Given that the deterioration led to readmission, these 2 patients should have been treated as readmissions rather than excluded from the trial. It was assumed that none of the 10 readmissions reported occurred during the early follow-up period as they would have also been excluded. The authors of the study have been contacted for clarification, but no response has been received to date.
‖The 3 patients reported as being readmitted before discharge from the hospital-at-home program were readmitted due to failing caregiver health and not the patients' health. Based on information received from the authors of the study, these 3 patients were not included in the 17 reported readmissions.

When the results are stratified by the length of the follow-up period (Figure 8), there is a statistically significant reduction in the risk of hospital readmissions at the 6-month follow-up (RR, 0.59; 95% CI, 0.40–0.87; $P = 0.009$). The results remain nonsignificant at 2 and 3 months; however, the 3-month time point shows a nonsignificant increase in the risk of hospital readmissions in the hospital-at-home group instead of a reduced risk as shown at 2- and 6-months follow-up.

[8] Authors were contacted to clarify the number of early and late readmissions in their studies, but no responses have been received to date.

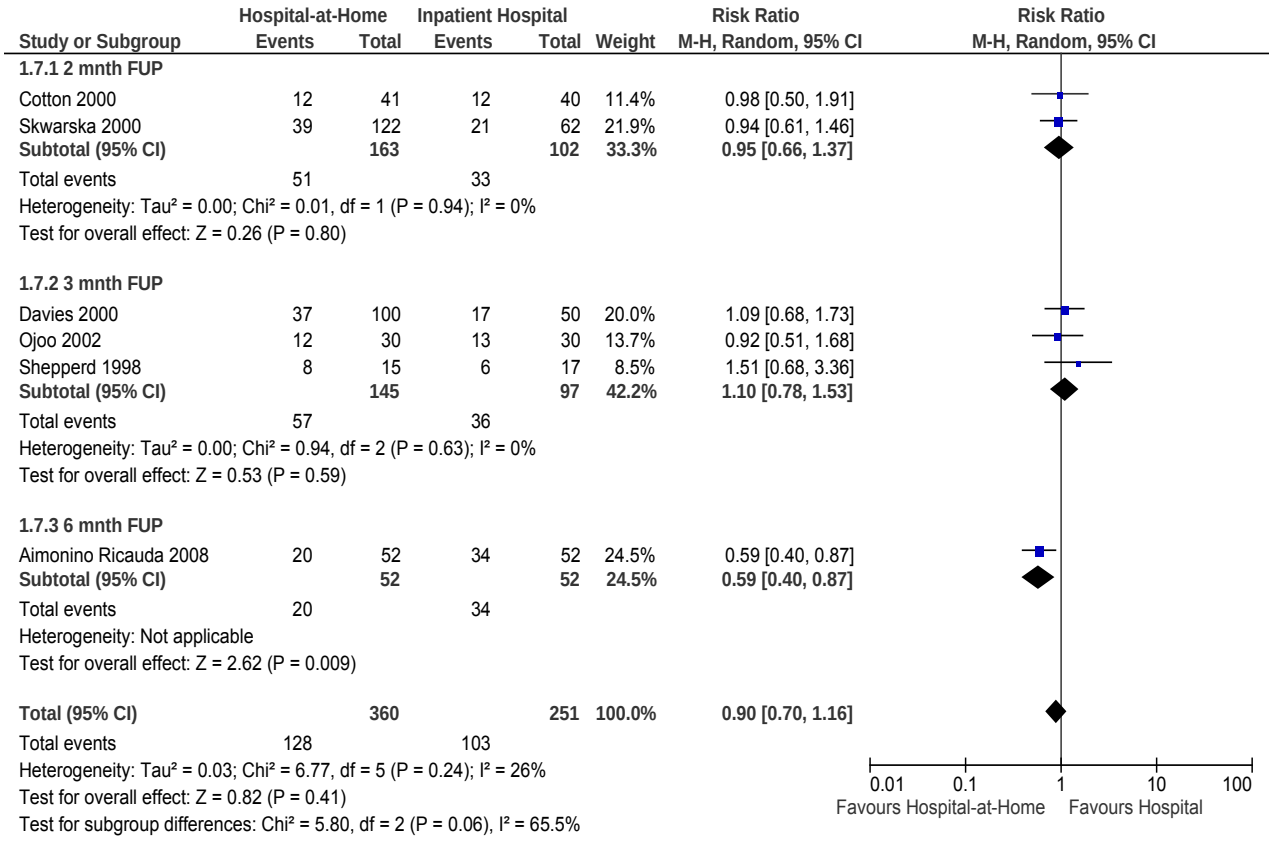

Figure 8: Forest Plot of Pooled Hospital Readmissions by Time Period*

*Abbreviations: CI, confidence interval; FUP, follow-up; M–H, Mantel–Haenszel; mnth, month.

When the results were stratified by type of hospital-at-home program and acuity of hospital-at-home care (Figures 9 and 10), there was a nonsignificant reduction in the risk of hospital readmissions for hospital-at-home care in all the subgroups.

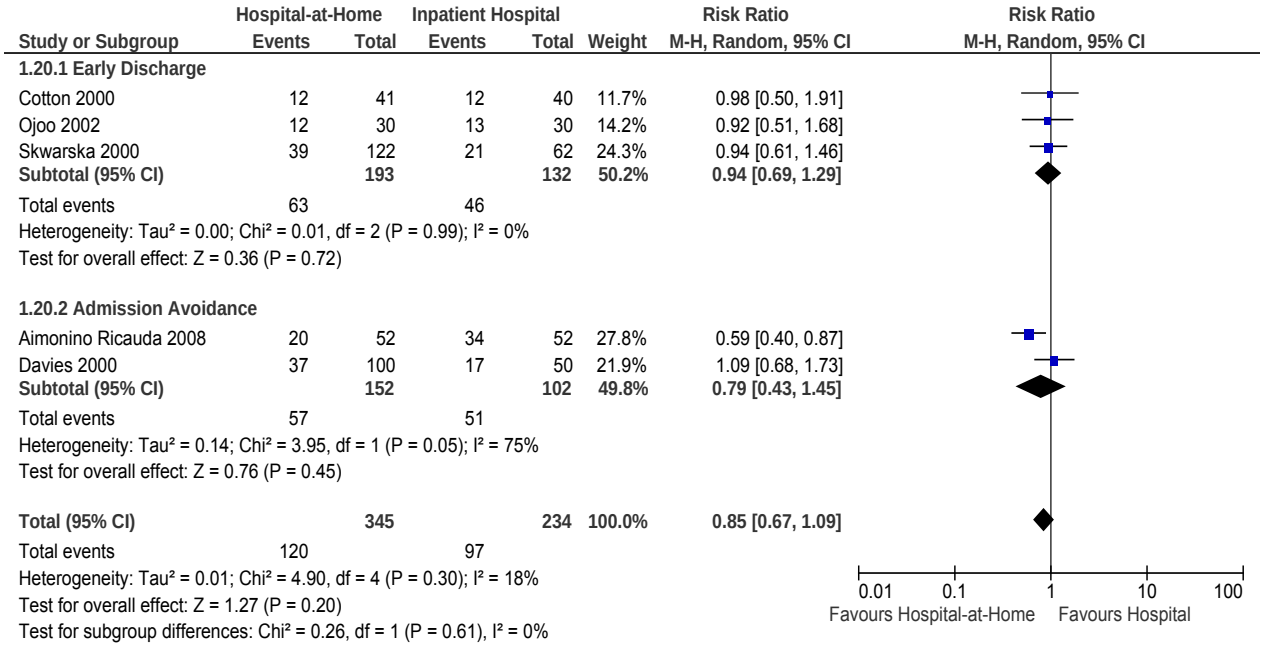

Figure 9: Forest Plot of Pooled Hospital Readmissions by Type of Hospital-at-Home Program*

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.
Note: The results from Shepperd et al (15;18) are excluded from the above analysis as it includes both early discharge and admission avoidance hospital-at-home programs.

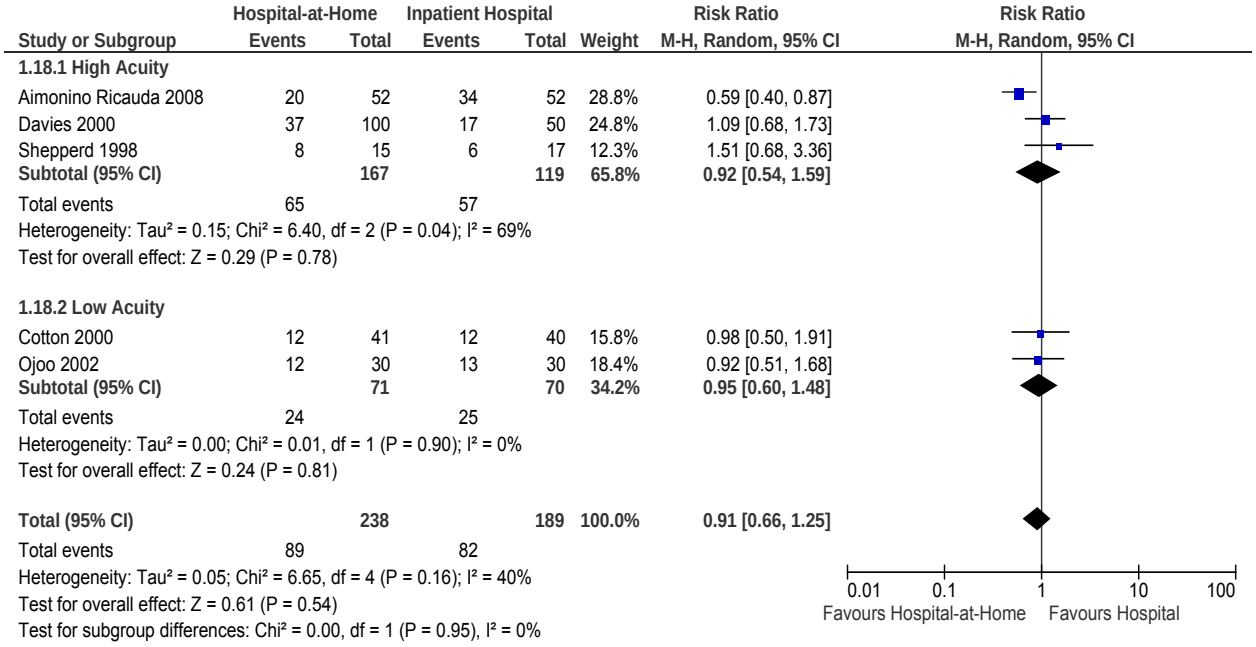

Figure 10: Forest Plot of Pooled Hospital Readmissions by Acuity of Hospital-at-Home Program*

*Abbreviations: CI, confidence interval; M–H, Mantel–Haenszel.
Note: The results from Skwarska et al (6) were excluded from the above analysis as it was unclear from published results if the hospital-at-home program provided low or high acuity care.

Days to Readmission

Two studies reported the mean number of days to readmission. Both found a longer mean number of days before admission in the hospital-at-home group compared with the inpatient hospital group (29.6 days vs. 25.6 days in Cotton et al (21) and 75 ± 55 days vs. 37 ± 29 days in Aimonino Ricauda et al (19)). Therefore, comparing hospital-at-home and inpatient hospital care groups, the mean additional days before readmission ranged from 4 to 38 days. It was not possible to pool these results, however, because the studies reported different time periods (days from the day of the first admission in Cotton et al (21) versus days from the first day of discharge in Aimonino Ricauda et al (19)).

While both studies show that readmissions were delayed in patients in the hospital-at-home group, the absolute benefit varied greatly (difference: hospital-at-home group [HaH], 45.4 days; inpatient hospital group [H], 11.4 days). One reason for this variation is the difference between the hospital-at-home programs in the 2 trials. In the Cotton et al trial (21), the hospital-at-home program was limited to assessing and monitoring patients and did not include any additional services; in contrast, in the Aimonino Ricauda et al trial, the hospital-at-home patients received a range of additional services including physical therapy, occupational therapy, education and nutritional advice, as well as a full geriatric assessment. (19) These additional services may lead to benefits in patients' COPD disease management as well as management of other comorbidities and result in a longer delay in the amount of time before hospital readmissions.

Number of Additional Days in Hospital

Two studies also reported the mean number of additional days in hospital for the patients who were readmitted. Cotton et al (21) found that patients in the hospital-at-home group spent fewer additional days in the hospital than patients in the inpatient hospital group (7.83 vs. 8.75 days; difference, 0.92; 95% CI, −6.5 to 8.3). In contrast, Shepperd et al (18) found that the median number of days before readmission was longer in the hospital-at-home group compared with the inpatient hospital group (HaH: 5.00 days; interquartile range [IQ], 0.00–10.00; H, 0.00 days; IQ, 0.00–3.00), but this difference was not significant ($P = 0.08$).

Lung Function

Forced Expiratory Volume in One Second

Lung function was measured in 3 of the included studies, but it was not possible to pool these results because of different outcomes and methods of measurement. Two of the studies reported the mean change in FEV_1. Davies et al (20) reported the mean change in postbronchodilator FEV_1 between admission and the 3-month follow-up, and Ojoo et al (22) reported the mean change in FEV_1 between admission and discharge. As shown in Table 8, both studies observed mean improvements in FEV_1 in the hospital-at-home and inpatient hospital groups.

Table 8: Lung Function Results Using Mean Change in FEV_1*

		Change in FEV_1, Mean (SD), L		
Author, Year	Time of Assessment	HaH	H	*P* Value
Davies et al, 2000 (20)	3-months FUP	0.11 (0.34)	0.14 (0.32)	NR
Ojoo et al, 2002 (22)	At discharge	0.16 (0.26)	0.06 (0.27)	NS

*Abbreviations: FEV_1, forced expiratory volume in 1 second; FUP, follow-up; H, inpatient hospital; HaH, hospital-at-home; L, litres; NR, not reported; NS, not significant; SD, standard deviation.

Skwarska et al (6) reported FEV_1 at baseline, discharge, and final follow-up for comparisons within the hospital-at-home and inpatient hospital groups between baseline and discharge and discharge and final follow-up. In the hospital-at-home group, the study found a significant improvement in FEV_1 between baseline and discharge (mean change, 0.16 litres [L]; $P < 0.01$). The other changes in FEV_1 in the hospital-at-home and inpatient hospital groups were not significant. The study did not compare FEV_1 values or the mean changes in FEV_1 between the hospital-at-home and hospital groups; however, the FEV_1 at the time of discharge was substantially higher in the hospital-at-home group than in the hospital group (HaH, 0.92 L; H, 0.72 L), and it remained slightly higher at the end of follow-up (HaH, 1.05 L; H, 0.94 L).

Other Lung Function Measures

Skwarska et al (6) also measured the change in respiratory rate, peak expiratory flow, and oxygen saturation between admission and discharge and between discharge and final follow-up for the hospital-at-home and inpatient hospital groups. There were significant mean improvements between admission and discharge for respiratory rate, peak expiratory flow, and oxygen saturation in both hospital-at-home and inpatient hospital groups, and for the mean change in oxygen saturation between discharge and final follow-up in the inpatient hospital group. The mean change between the 2 arms of the study was not compared, but the peak expiratory flow was substantially lower in the inpatient hospital group at all time points (H vs. HaH: 146.8 L vs. 175.3L; 168.8 L vs. 215.6 L; 171.0 L vs. 233.3 L; and 181.3 L vs. 220.7 L at admission, discharge, discharge, and final follow-up, respectively). (6)

Ojoo et al (22) measured the mean improvement in FVC between admission and discharge and found no significant difference between the hospital-at-home and inpatient hospital groups (mean improvement [SD]: 0.12 [0.65] vs. 0.17 [0.55]; *P* = not significant).

Health-Related Quality of Life

Five studies reported HRQOL results. Since each used different scales or reported the results differently, it was not possible to pool the results. Table 9 summarizes the results by study. Overall, the HRQOL results are inconsistent across the included studies: 1 study observed statistically significant improvements in the hospital-at-home group for some HRQOL measures, whereas 4 studies found no statistically significant differences in HRQOL between the groups.

Table 9: Summary of HRQOL Results*

Author	HRQOL Measure	Overall Results
Davies et al, 2000 (20)	SGRQ	No significant difference between baseline and follow-up values in either H or HaH groups for all domains†
Ojoo et al, 2002 (22)	Symptom score‡	No significant difference between groups
Aimonino Ricauda et al, 2008 (19)	Geriatric Depression Scale Nottingham Health Profile Activities of Daily Living score Instrumental Activities of Daily Living score Mini-Mental State Examination score Mini-Nutritional Assessment score Relatives' Stress Scale score	Significant improvement in Geriatric Depression Scale ($P < 0.01$) and Nottingham Health Profile score ($P = 0.04$) in the HaH group compared with the H group
Shepperd et al, 1998 (15;18)§	Dartmouth CO-OP Charts Chronic Respiratory Disease Questionnaire	No significant differences observed between groups for any domains of the Dartmouth CO-OP Charts or Chronic Respiratory Disease Questionnaire
Skwarska et al, 2000 (6)	Chronic Respiratory Disease Questionnaire	No significant difference between the groups on any domain‖

*Abbreviations: H, inpatient hospital; HaH, hospital-at-home; HRQOL, health-related quality of life; SGRQ, St. George's Respiratory Questionnaire.
†No comparison between the mean change in score between the hospital-at-home and the inpatient hospital groups was provided in the paper. (21)
‡Symptom score was calculated by assessing breathlessness, cough, ability to walk, anxiety, sputum production, sputum consistency, and sputum colour. (22)
§HRQOL baseline results were defined as HRQOL measurements at 1-month follow-up. (15;18)
‖Actual results were not provided in the paper. (6)

With the exception of Ojoo et al (22), the studies examined HRQOL at the end of the follow-up period, ranging from 2 to 6 months after the patient was enrolled in the study. The nonsignificant differences between the groups could be due to the time point at which HRQOL was measured. An improvement in HRQOL attributable to treatment at home instead of in the hospital might be best measured during or immediately after the treatment of the exacerbation, rather than several months later, by which time, the exacerbation has resolved and the patient is back in his/her home. Furthermore, the trials that examined HRQOL were not powered to look at this outcome, so type II error may explain a lack of significant difference between the groups.

Although Ojoo et al (22) examined HRQOL at a more appropriate time point—comparing mean symptom scores at admission and discharge—the paper was unclear as to whether the calculated symptom score was a validated tool that was adequately sensitive to detect differences in HRQOL between the groups.

Patient and Caregiver Preference

Ojoo et al (22) measured preference of hospital-at-home versus inpatient hospital care by asking patients and caregivers in the respective groups whether they would prefer hospital-at-home care. Patients in the hospital-at-home group were significantly ($P = 0.001$) more likely to prefer hospital-at-home care than patients in the inpatient hospital group: 96.3% (26/27) of patients in the hospital-at-home group preferred hospital-at-home care, whereas only 59.3% (16/27) of patients in the inpatient hospital group preferred hospital-at-home care. (22) Similarly, caregivers in the hospital-at-home group were significantly ($P = 0.01$) more likely to prefer hospital-at-home care than caregivers in the inpatient hospital group: 85.7% (17/20) compared with 42.9% (6/14) caregivers preferred hospital-at-home care in the hospital-at-home and inpatient hospital groups, respectively. (22) The authors suggest that these results are due to the positive experiences that patients/caregivers are receiving in the hospital-at-home program.

Since Ojoo et al (22) measured patient and caregiver preference after completion of the care, the study does not provide information on patients' preference for hospital-at-home care before their enrolment in a program. The results suggest that once patients have experienced hospital-at-home care, they are substantially more likely to prefer this treatment option for future exacerbations. The results also suggest that some patients and caregivers may be hesitant to enter hospital-at-home, which reinforces the previous finding that 12% to 43% of patients may refuse to enter hospital-at-home programs. (This refusal rate may be falsely high because the hospital-at-home programs were in the context of RCTs and may lack external validity.) While this information may be useful if such a program were implemented, also needed is a comparison of patients' and caregivers' preference for hospital-at-home care between the groups at baseline.

Patient and Caregiver Satisfaction with Care

Of the included studies, 3 measured patient satisfaction with care and 1 measured caregiver satisfaction with care. (6;19;22) Overall, most patients were satisfied with the care in both the hospital-at-home and inpatient hospital groups (Table 10). None of the studies observed a significant difference between the 2 groups. Similarly, Ojoo et al (22) did not find a significant difference between the hospital-at-home and inpatient hospital caregivers' satisfaction (mean satisfaction score: HaH, 92.70%; H, 91.30%). Type II error must be taken into consideration, however, because the studies were not adequately powered to examine satisfaction with care.

Table 10: Summary of Patient Satisfaction Results*

		Satisfaction Results (% of Patients)		
Author	**Satisfaction Measure**	**HaH**	**H**	***P* value**
Ojoo et al, 2002 (22)	Mean satisfaction score (%)	91.7	88.1	NS
Aimonino Ricauda et al, 2008 (19)	Number of patients (%) who rated care as very good/excellent at discharge	49 (94)	46 (88)	0.83
	% patients completely satisfied with care	95	–†	n/a
Skwarska et al, 2000 (6)	% patients felt they were cared for as well or better than care would have been if hospitalized	90	–†	n/a

*Abbreviations: H, inpatient hospital; HaH, hospital-at-home; n/a, not applicable; NS, not significant
†Patients in the inpatient hospital group were not asked about their satisfaction with care.

Other Reported Outcomes

Medical Complications

Aimonino Ricauda et al (19) found a significant reduction in the incidence of urinary tract infections in the hospital-at-home group compared with the inpatient hospital group (HaH vs. H: 6% vs. 1%; $P = 0.049$). The incidence rates for other medical complications were not significantly different between the groups, but these results must be considered with caution because the risk of type II error is high. (19)

Place of Residence after Discharge

Aimonino Ricauda et al (19) observed a nonsignificant reduction in the risk of transfer to long-term care after resolution of the exacerbation: 6 patients in the inpatient hospital group (n = 52 patients) were transferred to long-term care after discharge compared with no patients in the hospital-at-home group (n = 52). While this difference was not statistically significant, the risk of type II error for this outcome is high.

Additional Health Care Use

Skwarska et al (6) compared visits to general practitioners and informal caregiver visits between the hospital-at-home and inpatient groups during the follow-up period. While the number of general practitioner visits per 100 patient-days (1.07 vs. 0.70) and the number of caregiver visits (36 vs. 21) were higher in the inpatient hospital group compared with the hospital-at-home group, these differences were not significant. (6) Once again, the risk of type II error for these outcomes is high.

Quality of Evidence

The analysis is based on RCT evidence, but, according to the information available in the published papers,[9] the majority of the studies had serious methodological issues, including lack of allocation concealment, unclear methods used for randomization, unclear blinding of those conducting outcome assessment, inadequate sample sizes to eliminate type II error (based on post hoc sample size calculations when possible), and improper ITT analyses (withdrawals/dropouts ignored) (summarized in Table A4 in Appendix 3).

The quality of the overall body of evidence on hospital-at-home care for acute exacerbations of COPD was evaluated using the GRADE system (Table A5 in Appendix 3) and was found to be **low to very low**. (11) Due to the uncertainty associated with low and very low quality evidence, further research is likely to have an impact on the confidence in the estimate of effect and is likely to change the estimate. (11)

[9] It is possible that some of the methodological flaws which were identified in these studies were not actual flaws but the result of incomplete reporting in the published methods.

Economic Analysis

The results of the economic analysis are summarized in issue 12 of the COPD series entitled *Cost-Effectiveness of Interventions for Chronic Obstructive Pulmonary Disease Using an Ontario Policy Model*. This report can be accessed at: www.hqontario.ca/en/mas/tech/pdfs/2012/rev_COPD_Economic_March.pdf.

The results from the systematic review of the clinical evidence for hospital-at-home programs for the treatment of acute exacerbations of COPD were not included in the economic model because of the low to very low quality of evidence and the lack of significant findings for the model inputs.

Conclusions

The following conclusions are based on low to very low quality of evidence. The reviewed evidence was based on RCTs that were inadequately powered to observe differences between hospital-at-home and inpatient hospital care for most outcomes, so there is a strong possibility that type II error is an issue. Given the low to very low quality of evidence, these conclusions must be considered with caution.

- Approximately 21% to 37% of patients with acute exacerbations of COPD who present to the ED may be eligible for hospital-at-home care.
- Of the patients who are eligible for care, some patients may refuse to participate in hospital-at-home care.
- Eligibility for hospital-at-home care may be increased depending on the design of the hospital-at-home program such as the size of the geographical service area for hospital-at-home and the hours of operation for patient assessment and entry into hospital-at-home.
- Hospital-at-home care for acute exacerbations of COPD was associated with a nonsignificant reduction in the risk of mortality and hospital readmissions compared with inpatient hospital care during 2- to 6-months follow-up.
- Limited, very low quality evidence suggests that hospital readmissions are delayed after hospital-at-home care compared with inpatient hospital care (mean additional days before readmission comparing hospital-at-home to inpatient hospital care ranged from 4 to 38 days).
- There is insufficient evidence to determine whether hospital-at-home care, compared with inpatient hospital care, is associated with improved lung function.
- The majority of studies did not find significant differences between hospital-at-home and inpatient hospital care for a variety of HRQOL measures at follow-up. The follow-up time point chosen to measure HRQOL, however, may be too late to observe an impact of hospital-at-home care on HRQOL.
- Due to limited and inconsistent evidence, conclusions about the effect of hospital-at-home care on length of stay (defined as days in hospital or days in hospital plus hospital-at-home care for inpatient hospital and hospital-at-home, respectively) for the initial exacerbation, could not be determined.
- Patient and caregiver satisfaction with care is high for both hospital-at-home and inpatient hospital care.

Existing Guidelines for Hospital-at-Home for Acute Exacerbations of COPD

The British Thoracic Society Guideline Development Group developed guidelines for hospital-at-home care for COPD acute exacerbations using the National Institute for Health and Clinical Excellence (NICE) Guideline Development Methods to answer the following questions:

- How, where, and by whom should patients be assessed for suitability for hospital-at-home?
- Should hospital-at-home aim to avoid admission or to implement early supported discharge?
- Should the service be limited to 9:00 to 17:00 hours Monday to Friday or should its hours of operation be more extended?
- What proportion of patients with exacerbations of COPD will be suitable for hospital-at-home?
- Should the hospital-at-home team be composed of specialist practitioners or could it be generic?
- Does hospital-at-home require modification of treatment policy?
- What competencies are necessary to deliver hospital-at-home?
- What should comprise hospital-at-home care?
- How many visits will be necessary and for how long?
- Would stable COPD patients benefit from intermediate care? (17)

The Guideline Development Group conducted a systematic review of the literature published between 1966 and April 2005 (as well as any additional studies identified by members of the group published after the inclusion dates) to identify studies that helped to answer the above questions. (17) Based on review of the evidence and using the NICE levels of evidence and recommendations, the Guideline Development Group recommended that:

- A hospital should use an assessment proforma, protocol, or integrated care pathway (ICP) if setting up an integrated care service in order to deliver uniform care and facilitate audit. (Grade D) (17)
- Hospital-at-home should not be offered to patients with:
  - impaired level of consciousness (Grade C),
  - acute confusion (Grade C),
  - pH < 7.35, if arterial blood gases have been measured (Grade C),
  - acute changes on chest radiograph (Grade C),
  - concomitant medical problem requiring inpatient stay (Grade C),
  - insufficient social support, no telephone, residence geographically removed from hospital (Grade C), and/or
  - new hypoxemia (saturation level of oxygen in haemoglobin measured by pulse oximetry [SpO_2] ≤ 90%) – a contraindication if oxygen cannot be provided at home (Grade D). (17)
- Blood tests need not be routinely performed when considering patients for home management of their exacerbation but should be available if they are indicated after assessment. (Grade D) (17)
- Routine sputum culture before referral to hospital-at-home is not necessary. (Grade D) (17)
- An electrocardiogram need not be routinely performed when considering a patient for home management of their exacerbation but is indicated if the resting heart rate is < 60 beats/minute or > 110 beats/minute. (Grade D) (17)

- Pulse oximetry should be performed on all subjects being considered for home management. Arterial blood gas measurements should be performed if SpO_2 is < 90%. These should be repeated after 1 hour on the intended therapeutic flow rate of oxygen aiming for 90% < SpO_2 < 94% and an arterial blood pH > 7.35. (Grade NICE) (17)
- A chest radiograph should be performed on all subjects being considered for home management. (Grade D) (17)
- Baseline spirometry should be carried out to confirm the diagnosis in cases where this is the patient's first presentation with presumed COPD. (Grade D) (17)
- In busy inner city hospitals, if staffing levels permit, the combined approach of admission avoidance and early supported discharge is practicable but might be expensive. Eligibility for hospital-at-home varies from 30% to 35%, with readmission from hospital-at-home care of 10%. (Grade A) (17)
- In hospitals with fewer admissions for COPD or limited respiratory staffing levels, early inpatient assessment for supported discharge is the favoured model for hospital-at-home. Eligibility for hospital-at-home varies from 35% to 40%. (Grade A) (17)
- Recruitment for hospital-at-home following direct referral from a general practitioner is not recommended because of large numbers of inappropriate referrals. (Grade C) (17)
- For inner city hospitals with high COPD admission rates, a 24-hour/7-day service should be set up in order to maximize admission avoidance. (Grade C) (17)
- For hospitals with fewer COPD admissions, hours of operation should correspond to the peak times of COPD referrals and a Monday-to-Friday service may be most cost-effective. (Grade C) (17)
- After recruitment to hospital-at-home, clinical responsibility and out-of-hours cover should be undertaken by the acute trust. (Grade C) (17)
- When the patient is discharged from hospital-at-home, clinical responsibility should be formally transferred back to primary care either by fax or by email. (Grade C) (17)
- The lead clinician should be a consultant respiratory physician, supported by trainee junior medical staff. (Grade C) (17)
- The hospital-at-home care team should be lead by a specialist respiratory nurse, physiotherapist, or appropriately qualified health professional. (Grade C) (17)
- Inner city hospitals should aim for specialist teams, but district hospitals in provincial or rural areas should consider generic teams which may deal with several hospital-at-home services. (Grade C) (17)
- Key skills for members of the hospital-at-home teams include:
  - ability to take a comprehensive clinical history,
  - proficiency in assessing clinical condition,
  - familiarity with pharmacological and nonpharmacological approaches,
  - knowledge of current guidelines in COPD management,
  - excellent communication skills,
  - excellent team working skills. (Grade D based on consensus) (17)
- Useful but nonessential team member skills include:
  - ability to perform chest auscultation,
  - venous and arterial blood sampling,
  - performance of and basic interpretation of an electrocardiogram,

  - interpretation of a chest radiograph,
  - performance of spirometry,
  - understanding of airway clearance techniques. (Grade D based on consensus) (17)
- The first visit should be carried out on the day after recruitment to hospital-at-home. (Grade D) (17)
- Details of levels of dyspnea, cough, and sputum volume/colour should be recorded. (Grade D) (17)
- Vital signs, including pulse, blood pressure, respiratory rate, and temperature, should be measured. (Grade D) (17)
- Oxygen saturation should be measured by oximetry and the SpO_2 documented alongside the fraction of inspired oxygen (F_{IO2}). (Grade D) (17)
- A copy of the clinical notes and observations should be left in the patient's home. (Grade D) (17)
- Serial spirometry may be useful as objective confirmation of improvement or worsening during an exacerbation and should always be measured before discharge. (Grade D) (17)
- Treatment compliance and nebulizer/oxygen usage should be assessed. (Grade D) (17)
- Telephone contact with respiratory practitioner should be encouraged. (Grade D) (17)
- Weekly team meetings should be held. (Grade D) (17)
- Hospital-at-home care should be completed in fewer than 14 days and with fewer than 10 visits. (Grade C) (17)
- Failure to comply with the above recommendations requires team discussion. (Grade C) (17)
- There should be written agreement between management and medical/nursing staff defining the scope and objectives of an early discharge service. (Grade D) (17)
- Patients should be given an information leaflet about the service. (Grade D) (17)
- The process of discharge should be streamlined. (Grade D) (17)
- There is insufficient evidence to justify setting up telemetry in hospital-at-home at present. (Grade C) (17)
- Plans for new hospital-at-home services should include a formal health economics evaluation. (Grade C) (17)
- Regular administration of short-acting bronchodilators (β-agonist/anticholinergic or both) should be administered to all patients during hospital-at-home care. (Grade NICE) (17)
- Nebulized delivery is the mode of choice in hospital-at-home. (Grade C) (17)
- Prednisolone 30 mg/daily should be given for 7 to 14 days to all patients unless there is a specific contraindication to steroid therapy. (Grade NICE) (17)
- Oxygen therapy is a cornerstone of treatment of an exacerbation of COPD and should be made available to patients if they are hypoxemic. (Grade C) (17)
- Supplementary oxygen should be administered in a controlled fashion aiming for $90\% < SpO_2 < 94\%$. (Grade C) (17)
- Patients who remain in respiratory failure should be referred for consideration of long-term oxygen therapy. (Grade C) (17)
- Antibiotic therapy should be offered to patients with 2 or more symptoms of breathlessness, increased sputum, and increased sputum purulence. (Grade A) (17)
- Patients with a high risk of treatment failure or unusual pathogens benefit from tailored antibiotic therapy. (Grade B) (17)

- Hospital-at-home should not prevent patients gaining access to broader COPD care such as pulmonary rehabilitation or smoking cessation programmes. (Grade D) (17)
- Selected physiotherapeutic techniques and nutritional support may be beneficial. (Grade D) (17)

Grade C recommendations are directly based on evidence from nonexperimental descriptive studies such as comparative studies, correlation studies, and case control studies, or extrapolated from higher quality of evidence. Grade D recommendations are directly based on evidence from expert committee reports or opinions and/or clinical experience of respected authorities or extrapolated from high quality evidence. (13;17) As indicated by the recommendation grades noted with each recommendation, the majority are based on low quality evidence or extrapolated from RCTs that were not specifically designed to test the specific issues dealt with by the recommendations, such as the components of care. For example, recommendations regarding which individuals should be excluded from hospital-at-home care are based on the inclusion and exclusion criteria in the various RCTs that compare hospital-at-home care with inpatient hospital care. These studies, however, do not actually test whether these patients are the most appropriate patients to exclude from care. Furthermore, as most of these studies were carried out in Europe and the recommendations are designed to fit with the British health care system, some recommendations may not be generalizable to Ontario. For these reasons, the recommendations must be considered with caution in the context of developing a hospital-at-home program in Ontario.

Based on the evidence and recommendations, the Guideline group reached the following conclusions:

- Hospital-at-home care should be offered to patients with exacerbations of COPD unless there is impairment of consciousness, confusion, acidosis, serious co-morbidity, or inadequate social support. (17)
- After suitability for hospital-at-home is confirmed by assessment in hospital, a treatment package is prescribed that includes antibiotics, steroids, nebulized bronchodilators, and oxygen if necessary. (17)
- Hospital-at-home care should be delivered by specialist respiratory nurses/physiotherapists or in generic teams by district nurses. (17)
- For most hospitals the preferred model of hospital-at-home should be early supported discharge rather than admission avoidance. (17)
- The role of intermediate care in stable COPD is not yet clearly defined and initiatives in this area should be conducted as experimental and controlled interventions. (17)

Glossary

6 Minute Walking Test (6MWT)	A measure of exercise capacity which measures the distance that a patient can quickly walk on a flat, hard surface in a period of 6 minutes. A widely used outcome measure in respiratory rehabilitation of patients with COPD.
Acute exacerbations of chronic obstructive pulmonary disease (AECOPD)	A change in baseline symptoms that is beyond day-to-day variation, particularly increased breathlessness, cough, and/or sputum, which has an abrupt onset.
Admission avoidance hospital-at-home program	Treatment program for patients experiencing acute exacerbations of COPD which allows patients to receive treatment in their home and avoid admission to hospital. After patients are assessed in the emergency department for an acute exacerbation, they are prescribed the necessary medications and additional care needed (e.g., oxygen therapy) and then sent home where they receive regular visits from a medical professional until the exacerbation has resolved.
Ambulatory oxygen therapy	Provision of oxygen therapy during exercise and activities of daily living for individuals who demonstrate exertional desaturation.
Bilevel positive airway pressure (BiPAP)	A continuous positive airway pressure mode used during noninvasive positive pressure ventilation (see definition below) that delivers preset levels of inspiratory and expiratory positive airway pressure. The pressure is higher when inhaling and falls when exhaling, making it easier to breathe.
Cost-effectiveness acceptability curve (CEAC)	A method for summarizing uncertainty in estimates of cost-effectiveness.
Cor pulmonale	Right heart failure, as a result of the effects of respiratory failure on the heart.
Dyspnea	Difficulty breathing or breathlessness.
Early discharge hospital-at-home program	Treatment program for patients experiencing acute exacerbations of COPD which allows patients to receive treatment in their home and decrease their length of stay in hospital. After being assessed in the emergency department for acute exacerbations, patients are admitted to the hospital where they receive the initial phase of their treatment. These patients are discharged early into a hospital-at-home program where they receive regular visits from a medical professional until the exacerbation has resolved.
Forced expiratory volume in 1 second (FEV_1)	A measure of lung function used for COPD severity staging; the amount of air that can be forcibly exhaled from the lungs in the first second of a forced exhalation.
Forced vital capacity (FVC)	The amount of air that can be forcibly exhaled from the lungs after taking the deepest breath possible.
Fraction of inspired oxygen (FiO_2)	The percentage of oxygen participating in gas exchange.

Hypercapnia	Occurs when there is too much carbon dioxide in the blood (arterial blood carbon dioxide > 45 to 60 mm Hg).
Hypopnea	Slow or shallow breathing.
Hypoxemia	Low arterial blood oxygen levels while breathing air at rest. May be severe ($PaO_2 \leq 55$ mm Hg), moderate (56 mm Hg $\leq PaO_2 <$ 65 mm Hg), or mild-to-moderate (66 mm Hg $< PaO_2 \leq$ 74 mm Hg).[10]
Incremental cost-effectiveness ratio (ICER)	Ratio of the change in costs of a therapeutic intervention to the change in effects of the intervention compared to the alternative (often usual care).
Intention-to-treat analysis (ITT)	An analysis based on the initial treatment the participant was assigned to, not on the treatment eventually administered.
Invasive mechanical ventilation (IMV)	Mechanical ventilation via an artificial airway (endotracheal tube or tracheostomy tube).
Long-term oxygen therapy (LTOT)	Continuous oxygen use for about 15 hours per day. Use is typically restricted to patients fulfilling specific criteria.
Multidisciplinary care	Defined as care provided by a team (compared to a single provider). Typically involves professionals from a range of disciplines working together to deliver comprehensive care that addresses as many of the patient's health care and psychosocial needs as possible.
Nicotine replacement therapy (NRT)	The administration of nicotine to the body by means other than tobacco, usually as part of smoking cessation.
Noninvasive positive pressure ventilation (NPPV)	Noninvasive method of delivering ventilator support (without the use of an endotracheal tube) using positive pressure. Provides ventilatory support through a facial or nasal mask and reduces inspiratory work.
Partial pressure of carbon dioxide ($PaCO_2$)	The pressure of carbon dioxide dissolved in arterial blood. This measures how well carbon dioxide is able to move out of the body.
Partial pressure of oxygen (PaO_2)	The pressure of oxygen dissolved in arterial blood. This measures how well oxygen is able to move from the airspace of the lungs into the blood.
Palliative oxygen therapy	Use of oxygen for mildly hypoxemic or nonhypoxemic individuals to relieve symptoms of breathlessness. Used short term. This therapy is "palliative" in that treatment is not curative of the underlying disease.
Pulmonary rehabilitation	Multidisciplinary program of care for patients with chronic respiratory impairment that is individually tailored and designed to optimize physical and social performance and autonomy. Exercise training is the cornerstone of pulmonary rehabilitation programs.
Pulse oximetry	A noninvasive sensor, which is attached to the finger, toe, or ear to detect oxygen saturation of arterial blood.

[10] The mild-to-moderate classification was created for the purposes of the report.

Quality-adjusted life-years (QALYs)	A measure of disease burden that includes both the quantity and the quality of the life lived that is used to help assess the value for money of a medical intervention.
Respiratory failure	Respiratory failure occurs when the respiratory system cannot oxygenate the blood and/or remove carbon dioxide from the blood. It can be either acute (acute respiratory failure, ARF) or chronic, and is classified as either hypoxemic (type I) or hypercapnic (type II) respiratory failure. Acute hypercapnic respiratory failure frequently occurs in COPD patients experiencing acute exacerbations of COPD.
Short-burst oxygen therapy	Short-duration, intermittent, supplemental oxygen administered either before or after exercise to relieve breathlessness with exercise.
Sleep apnea	Interruption of breathing during sleep due to obstruction of the airway or alterations in the brain. Associated with excessive daytime sleepiness.
Smoking cessation	The process of discontinuing the practice of inhaling a smoked substance.
Spirometry	The gold standard test for diagnosing COPD. Patients breathe into a mouthpiece attached to a spirometer which measures airflow limitation.
SpO_2	Oxygen saturation of arterial blood as measured by a pulse oximeter.
Stable COPD	The profile of COPD patients which predominates when patients are not experiencing an acute exacerbation.
Supplemental oxygen therapy	Oxygen use during periods of exercise or exertion to relieve hypoxemia.
Telemedicine (or telehealth)	Refers to using advanced information and communication technologies and electronic medical devices to support the delivery of clinical care, professional education, and health-related administrative services.
Telemonitoring (or remote monitoring)	Refers to the use of medical devices to remotely collect a patient's vital signs and/or other biologic health data and the transmission of those data to a monitoring station for interpretation by a health care provider.
Telephone only support	Refers to disease/disorder management support provided by a health care provider to a patient who is at home via telephone or videoconferencing technology in the absence of transmission of patient biologic data.
Ventilator-associated pneumonia (VAP)	Pneumonia that occurs in patients undergoing mechanical ventilation while in a hospital.

Acknowledgements

Medical Information Officer

Kellee Kaulback

Editorial Staff

Joanna Odrowaz
Irina Alecu

COPD Expert Advisory Panel

The role of the expert panel was to provide direction on the scope of the project and the relevant outcomes measures of effectiveness, to review the evidence-based analyses and to identify any societal or systemic issues that are relevant to intervention effectiveness. However, the statements, conclusions and views expressed in this report do not necessarily represent the views of the expert panel members.

Jeremy Grimshaw, MD, MBChB, PhD (Chair)
Senior Scientist, Ottawa Hospital Research Institute
Professor, Department of Medicine, University of Ottawa

Dina Brooks, PhD
Professor, Department of Physical Therapy, University of Toronto

Debbie Coutts, RRT, CRE

Andrea Gershon, MD, MSc, FRCP(C)
Scientist, Institute for Clinical Evaluative Sciences
Respirologist, Sunnybrook Health Sciences Centre
Assistant Professor, Departments of Medicine and Health Policy, Management and Evaluation, University of Toronto

Mita Giacomini, BSc, MPH, MA, PhD
Professor, Department of Clinical Epidemiology & Biostatistics, McMaster University

Ron Goeree, BA, MA
Director, PATH Research Institute, St. Joseph's Hospital (Hamilton)
Associate Professor, Department of Clinical Epidemiology & Biostatistics, McMaster University

Roger Goldstein, MBCHB, FRCP(C), FRCP(UK)
NSA Chair in Respiratory Rehabilitation Research
Director, Respiratory Services, and Senior Scientist, West Park Healthcare Centre
Professor, Medicine and Physical Therapy, University of Toronto

Alan G Kaplan, MD, CCFP(EM), FCFP
Chairperson, Family Physician Airways Group of Canada
Chairperson, Special Interest Focused Care Group in Respiratory Medicine, College of Family Physicians of Canada
Clinical Lecturer, Department of Family and Community Medicine, University of Toronto

DE O'Donnell, MD, FRCP(C)
Director, COPD Centre, Kingston General Hospital
Professor, Department of Medicine, Queen's University

Asad Razzaque, MD
Family Physician

Holger Schünemann, MD, PhD, MSc, FRCP(C)
Michael Gent Chair in Healthcare Research
Chair, Department of Clinical Epidemiology & Biostatistics, McMaster University
Professor, Department of Clinical Epidemiology & Biostatistics and Medicine, McMaster University

Tasnim Sinuff, MD, PhD, FRCP(C)
Clinician Scientist, Sunnybrook Health Sciences Centre
Assistant Professor, Department of Medicine, University of Toronto

Laura Watling, RRT, BSc(HK)
Clinical Practice Leader/Clinical Coordinator, Respiratory Therapy, West Park Healthcare Centre

Appendices

Appendix 1: Literature Search Strategies

Search date: August 5, 2010
Databases searched: OVID MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, OVID EMBASE, Wiley Cochrane, CINAHL, Centre for Reviews and Dissemination/International Agency for Health Technology Assessment

Database: Ovid MEDLINE(R) <1950 to July Week 4 2010>
Search Strategy:
---
1 exp Pulmonary Disease, Chronic Obstructive/ (14057)
2 (chronic obstructive adj2 (lung* or pulmonary or airway* or airflow or respiratory) adj (disease* or disorder*)).ti,ab. (20996)
3 (copd or coad).ti,ab. (15985)
4 chronic airflow obstruction.ti,ab. (486)
5 exp Emphysema/ (6925)
6 ((chronic adj2 bronchitis) or emphysema).ti,ab. (22569)
7 or/1-6 (53015)
8 exp Community Health Services/ (416785)
9 exp Community Health Centers/ (8823)
10 exp After-Hours Care/ (637)
11 exp House Calls/ (1945)
12 (community* or home care or hospital at home).ti,ab. (210944)
13 or/8-12 (579476)
14 7 and 13 (2849)
15 limit 14 to (english language and humans and yr="1990 -Current") (2007)

Database: EMBASE <1980 to 2010 Week 30>
Search Strategy:
---
1 exp chronic obstructive lung disease/ (46998)
2 (chronic obstructive adj2 (lung* or pulmonary or airway* or airflow or respiratory) adj (disease* or disorder*)).ti,ab. (25339)
3 (copd or coad).ti,ab. (20580)
4 chronic airflow obstruction.ti,ab. (548)
5 exp emphysema/ (25279)
6 exp chronic bronchitis/ (6508)
7 ((chronic adj2 bronchitis) or emphysema).ti,ab. (25265)
8 or/1-7 (86627)
9 exp home care/ (43432)
10 exp community care/ (81462)
11 (community* or home care or hospital at home).ti,ab. (240281)
12 or/9-11 (320084)
13 8 and 12 (2959)
14 limit 13 to (human and english language and yr="1990 -Current") (2014)

Database: CINAHL

#	Query	Results
S12	S11 Limiters - Published Date from: 19900101-20101231	958
S11	S9 and S10	995
S10	(S1 or S2 or S3 or S4 or S5)	7280
S9	S6 or S7 or S8	193
S8	(community* or home care or hospital at home)	106964
S7	(MH "Home Health Care+")	24877
S6	(MH "Community Health Services+")	177846
S5	chronic bronchitis or emphysema	1556
S4	(MH "Emphysema+")	951
S3	copd or coad	4025
S2	(chronic obstructive and (lung* or pulmonary or airway* or airflow or respiratory) and (disease* or disorder*))	5497
S1	(MH "Pulmonary Disease, Chronic Obstructive+")	4248

Appendix 2: Summary Tables

Table A1: General Study Characteristics*

Author, Year	Sample Size	Type of Service	Service Details				HaH Details (Patient Follow-up)				Reasons for Ineligibility for HaH
			Referral	Who Evaluates Patients	When are Patients Evaluated	Hours of Operation	Who	Frequency	After Hours Coverage	Types of Care Offered	
Cotton et al, 2000 (21)	81	EDHaH	Hospital medical wards	Specialist respiratory nurse	Mornings after admission	Monday -- Friday (hours NR)	Specialist respiratory nurse Changes in txt adjusted by respiratory med staff member discussed with nurse	Morning after discharge then discretion of nurse	Patients' GP	Assessment of pt progress based on subjective feelings, pulse, blood pressure, respiratory rate, temperature, oxygen saturation, chest auscultation, spirometry, sputum appearance, advice on use of meds. No additional services, such as social services or rehabilitation, were provided	Not resident of Glasgow, homeless (including hostel dwellers), unable to give informed consent, no access to telephone, patients required inpatient management or investigation for some other medical problem, patients with life-threatening respiratory failure (H* > 45 nM) at time of assessment, not waiting for results from investigational tests
Davies et al, 2000 (20)	150	AA	ED	Specialist nurses with additional COPD training	During operating hours	7 d/wk, 8 AM – 6 PM	Specialist nurse	2 visits/day for first 3 days then at discretion of the nurse	Agreement with district nurses	Social support if needed, nebulized ipratropium bromide, salbutamol with a compressor, oral prednisolone for 10 days, antibiotics for 10 days, additional services or testing performed NR	Personal history of asthma, marked use of accessory muscles, suspected underlying malignancy on chest x-ray film, pneumothorax or pneumonia, uncontrolled left ventricular failure, acute changes on ECG, requires full-time nursing care, requires IV therapy, FEV_1 > 80% predicted, FEV_1/FVC ratio < 70%, Mini-Mental State Score < 7, pulse rate > 100 beats/min, pH < 7.35, PaO_2 < 7.3 kPa, $PaCO_2$ > 8 kPa

Author, Year	Sample Size	Type of Service	Service Details				HaH Details (Patient Follow-up)				Reasons for Ineligibility for HaH
			Referral	Who Evaluates Patients	When are Patients Evaluated	Hours of Operation	Who	Frequency	After Hours Coverage	Types of Care Offered	
Ojoo et al, 2002 (22)	60	EDHaH	Medical wards	NR	Morning after admission during hours of operation	Monday – Thursday 9 AM – 5 PM	Respiratory outreach nurses	Daily	Telephone access through Medical Chest Unit direct line	Monitored treatment of patients and carried out patient and caregiver education and reassurance (limited information provided)	Concomitant medical conditions requiring admission, residence over 15 miles from hospital, complications of exacerbation (acidosis, cor pulmonale, acute changes on chest radiograph), newly diagnosed type 2 respiratory failure, social exclusion (discretionary and based on level of domiciliary support and performance status of pt)
Aimonino Ricauda et al, 2008 (19)	104	AA	ED†	NR	NR	7 d/wk (hrs NR)	MDs and nurses‡ HaH team mtgs daily to discuss pt needs & pt care plans	MD + nurse both visit daily in first few days, then nurse every day and MD every 2–3 days as needed	HaH staff available at all times	Blood tests, pulse oximetry, ECG, echo and Doppler US, oral and IV meds admission incl. antimicrobials and cytotoxic drugs, oxygen therapy, blood transfusion, central venous access, PT, OT, patient and caregiver education, advice on SC, nutrition, ADLs, energy conservation, meds, health maintenance, early recognition of exac., multidimensional geriatric assessment	Patients < 75 years, absence of family and social support, severe hypoxemia (PaO_2 < 50 mmHg), severe acidosis or alkalosis (pH < 7.35 or > 7.55). Suspected pulmonary embolism, suspected MI, severe comorbid illness as defined by presence of need for hemodialysis, severe renal impairment (glomerular filtration rate < 20mL/min), cancer (except skin cancer), hepatic failure or severe dementia (Mini-Mental State Examination score <14)

Author, Year	Sample Size	Type of Service	Service Details				HaH Details (Patient Follow-up)				Reasons for Ineligibility for HaH
			Referral	Who Evaluates Patients	When are Patients Evaluated	Hours of Operation	Who	Frequency	After Hours Coverage	Types of Care Offered	
Shepperd et al, 1998 (15;18)	32§	AA & EDHaH ‖	GP or hospital ward	Unclear	NR	NR	Unclear, may include nurses and GPs	NR	NR	Observation, administration of drugs (including IV meds), rehabilitation including nursing, physiotherapy, occupational therapy, pathology, and speech therapy¶ Nursing care was available 24 hrs/d if needed	Age > 60 yrs, home not suitable for hospital-at-home care (minimum requirements were hot and cold running water, indoor sanitary facilities, room for patient's bed to be moved downstairs if needed), caregiver, if applicable, consented to trial
Skwarska et al, 2000 (6)	184	EDHaH	All admitted through ED but 99% pts referred to ED by GP, 1% by self-referral	Nurses provide tests then decision for inclusion made by respirator y team (i.e., consultant and registrar)	When admitted or morning after depending on hours of operation (present on weekends excluded)	Monday – Friday, 9 AM – 5 PM	Acute respiratory assessment service nurses Weekly team mtgs with nurse & consultant in charge of trial to assess progress of pts	Day after discharge then at 2–3 day intervals	NR	Monitored the need for patient treatment. No details provided about how level of care provided differed, whether any extra services were provided, and what the nurses could do at the home	Admitted on the weekend, required obligatory admission (impaired level of consciousness, acute confusion, new acute changes on radiograph, arterial pH < 7.35, coexistence of another medical condition, poor social circumstances which preclude home supported discharge

*Abbreviations: AA, admission avoidance hospital-at-home program; ADL, activities of daily living; d, day; ECG, electrocardiogram; echo, echograph; EDHaH, early discharge hospital-at-home program; ED, emergency department; exac, exacerbation; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; GP, general practitioner; HaH, hospital-at-home; hr, hour; incl., including; IV, intravenous; MD, doctor; meds, medications; MI, myocardial infarction; mtgs, meetings; NR; not reported; OT, occupational therapy; $PaCO_2$, partial pressure of carbon dioxide in arterial blood; PaO_2, partial pressure of oxygen in arterial blood; pt, patient; PT, physiotherapy; SC, smoking cessation; txt, treatment; US, ultrasound; wk, week.

†The hospital-at-home program in this study only recruited patients who presented to the ED, but the hospital-at-home program also receives direct GP referrals as well as hospital inpatients who are entered into early supported discharge programs.

‡The multidisciplinary team that runs the hospital-at-home program also includes a social worker, a counsellor, and 2 physiotherapists. However, it was unclear in the report whether they also visited patients.

§The total sample size in the Shepperd et al trial was 538, but only 32 were COPD patients. Only the outcomes relevant for the COPD patient group included in the study are listed. (15;18)

‖Patients included in this trial included both patients referred directly from primary care for an admission avoidance hospital-at-home program and patients admitted from hospital wards for an early discharge program. (15;18)

¶Some of the services provided to patients may not be relevant to the COPD patient population. (15;18)

Table A2: Characteristics of the Patients in the Included Studies*

	Sample Size		Mean Age (SD), years		% Male		Smoking Status											
							Current, %		Ex, %		Non, %		Pack-Years, Mean (SD)		Home Oxygen Use, %		Support at Home, %†	
Author, Year	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H
Cotton et al, 2000 (21)	41	40	66 (1.6)	68 (1.2)	46	40	NR	NR	NR	NR	NR	NR	NR	NR	20	13	73	67
Davies et al, 2000 (20)	100	50	70 (8)	70 (8)	45	60	34	38	60	60	6	2	41 (31)	43 (24)	NR	NR	69‡	
Ojoo et al, 2002 (22)	30	30	70	70	53	50	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	§	§
Aimonino Ricauda et al, 2008 (19)	52	52	80 (3.2)	79 (3.1)	56	75	13	11	65	67	21	21	20 (7)‖	21 (15)‖	35	23	100	100
Shepperd et al, 1998 (15;18)	15	17	71 (7.2)	73 (10.1)	33	18	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Skwarska et al, 2000 (6)	122	62	69 (range, 39 – 84)	70 (range, 51 – 86)	52	39	41	38	58	60	NR	NR	NR	NR	7	6	74¶	61¶

*Abbreviations: Ex, indicates ex-smokers; H, inhospital care; HaH, hospital-at-home care; non, nonsmokers; SD, standard deviation.

†Support at home is defined as participants who do not live alone.

‡Results were not reported separately for the hospital-at-home and inpatient hospital groups.

§ Based on reported categories, it was not possible to determine how many patients had support at home given potentially overlapping reported categories.

‖Mean number cigarettes smoked per day ± SD.

¶The reported baseline characteristics include a category about home help. However, inadequate information is provided in the reported results to determine which categories should be included in support at home. Thus, it is possible that some of the individuals who live alone may nevertheless receive help and therefore should have been categorized as support at home.

Table A3: Further Characteristics of the Patients in the Included Studies*

	Arterial Blood Gas, Mean (SD)													
	pH		Partial Pressure O_2, kPa		Partial Pressure CO_2, kPa		Mean FEV_1 (SD), L		% of predicted FEV_1		FEV_1/FVC (SD)		Mean Respiratory. Rate (SD), B/min	
Author, Year	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H	HaH	H
Cotton et al, 2000 (21)	39.3 (0.8) (nM)	40.0 (0.1) (nM)	8.5 (.4)	9.2 (0.4)	6.0 (0.3)	5.5 (0.2)	0.95 (0.1)	0.94 (0.1)	41 (3)	44 (3)	45 (2)	46 (2)	24.0 (0.7)	24 (0 .7)
Davies et al, 2000 (20)	7.4 (0.05)	7.39 (0.04)	9.7 (2.9)	9.0 (1.2)	5.2 (1.0)	5.2 (0.8)	0.71 (0.3)	0.65 (0.2)	36 (17)†	35 (15)†	NR	NR	24 (4)	23 (4)
Ojoo et al, 2002 (22)	NR	NR	NR	NR	NR	NR	1.00 (0.40)	0.85 (0.30)	NR	NR	NR	NR	NR	NR
Aimonino Ricauda et al, 2008 (19)	7.40 (0.10)	7.41 (0.10)	69 (19)‡	65 (14)‡	44 (12)‡	46 (12)‡	0.92 (0.40)	1.04 (0.50)	38	47	NR	NR	24 (5)	25 (7)
Shepperd et al, 1998 (15;18)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Skwarska et al, 2000 (6)	NR	NR	NR	NR	NR	NR	0.77	0.66	NR	NR	NR	NR	22.8	23.2

*Abbreviations: B, breaths; CO_2, carbon dioxide; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; H, inhospital care; HaH, hospital-at-home care; L, litres; NR, not reported; O_2, oxygen; Resp., respiratory; SD, standard deviation.

†Percent of predicted post-bronchodilator FEV_1.

‡The measurement unit is mmHg rather than kPa.

Appendix 3: Quality of Evidence and GRADE Tables

Table A4: Summary of Study Methodological Characteristics that Impact Study Quality*

Study	N	Adequate Randomization Methods	Adequate Allocation Concealment	Blinding	Power	Loss to FUP	Intention-to-Treat
Cotton et al, 2000 (21)	81	✓ (random numbers)	✓	NR	No a priori sample size calculation Underpowered based on post hoc sample size calculations	✓	Methods say ITT but does not account for withdrawals
Davies et al, 2000 (20)	150	Methods not reported	Unclear (opaque envelopes not specified)	NR	A priori sample size calculation Underpowered based on post hoc sample size calculations	✓	Methods say ITT but does not account for withdrawals
Ojoo et al, 2000 (22)	60	Methods not reported	Unclear (opaque envelopes not specified)	NR	No a priori sample size calculation Underpowered based on post hoc sample size calculations	20%	NR
Aimonino Ricauda et al, 2008 (19)	104	✓ (random numbers)	✓	✓ (outcome assessment blinded)	A priori sample size calculation Adequate power for readmissions Underpowered for mortality and other outcomes based on post hoc sample size calculations	✓	Methods say ITT but does not account for withdrawals
Shepperd et al, 1998, (15;18)	32†	✓ (computer-generated random numbers)	✓	NR	A priori sample size calculation (HRQOL outcome) Underpowered based on post hoc sample size calculations	NR	Methods say ITT but not clear if analysis accounts for withdrawals
Skwarska et al, 2000 (6)	184	✓ (computer-generated random numbers)	NR	NR	No a priori sample size calculation Underpowered based on post hoc sample size calculations	30%	NR

*Abbreviations: FUP, follow-up; ITT, intention-to-treat; N, sample size; NR, not reported.
†The total sample size of the Shepperd et al (15;18) study is 538, but only 32 of those are COPD patients and therefore included in this analysis.

Table A5: GRADE Quality of Evidence*

Number of Studies	Design	Study Quality	Consistency	Directness	Imprecision	Other Modifying Factors	Overall Quality of Evidence
Outcome: Mortality							
6	RCT	Very serious limitations†	Serious limitations‡	No serious limitations	No serious limitations	n/a	Very Low
Outcome: Hospital Readmissions							
6	RCT	Very serious limitations†	No serious limitations	No serious limitations	No serious limitations	n/a	Low
Outcome: Lung Function							
3	RCT	Very serious limitations§	No serious limitations	No serious limitations	Sparse data‖	n/a	Very Low
Outcome: HRQOL							
5	RCT	Very serious limitations¶	No serious limitations#	Serious limitations**	Sparse data††	n/a	Very Low
Outcome: Mean Length of Stay							
5	RCT	Very serious limitations‡‡	Serious limitations§§	No serious limitations	No serious limitations	n/a	Very Low
Outcome: Patient Satisfaction							
3	RCT	Very serious limitations‖ ‖	No serious limitations	No serious limitations	Sparse data¶¶	n/a	Very Low
Outcome: Caregiver Satisfaction							
1	RCT	Very serious limitation##	n/a	No serious limitations	Sparse data***	n/a	Very Low
Outcome: Patient Preference							
1	RCT	Very serious limitations##	n/a	Serious limitations†††	Sparse data***	n/a	Very Low
Outcome: Caregiver Preference							
1	RCT	Very serious limitations##	n/a	Serious limitations†††	Sparse data***	n/a	Very Low

*Abbreviations: HRQOL, health-related quality of life; ITT, intention-to-treat; n/a, not applicable; RCT, randomized controlled trial.

†Study quality was downgraded for the mortality and hospital readmission outcomes because of very serious limitations in many of the studies, including unknown or inadequate allocation concealment (3 of 6 studies); unclear randomization process based on published trials (2 of 6 studies); unclear whether assessor was blinded (single blind) (5 of 6 studies); lack of a priori power calculations (4 of 6 studies) and inadequately powered studies based on post-hoc sample size calculations (mortality: 6 of 6 studies; readmissions: 5 of 6 studies), withdrawals/dropouts > 20% (1 of 6 studies) or unknown (1 of 6 studies) , and ITT analysis not used (unknown for 2 studies) or withdrawals/dropouts not considered in ITT analysis (3 of 4 studies).

‡Downgraded due to lack of consistency between the point estimates.

§Study quality was downgraded for lung function outcomes because of very serious limitations in the studies including: unknown or inadequate allocation concealment (3 of 3 studies); unclear randomization process based on published information (2 of 3 studies); unknown whether assessor was blinded (single blind) based on published information (3 of 3 studies); lack of a priori power calculations (2 of 3 studies) and likely underpowered studies but not possible to calculate post-hoc sample size calculations based on information provided (3 of 3 studies), withdrawals/dropouts > 20% (1 of 3 studies), and ITT analysis not used (unknown for 2 studies) or withdrawals/dropouts not considered in ITT analysis (1 of 3 studies).

‖Downgraded due to sparse data, as the studies each reported different measures of lung function, so there was only 1 study per lung function outcome.

¶Study quality was downgraded for HRQOL because of very serious limitations in the studies including unknown or inadequate allocation concealment (3 of 5 studies); unclear randomization process based on published information (2 of 5 studies); unknown whether assessor was blinded (single blind) based on published information (4 of 5 studies); lack of a priori power calculations (3 of 5 studies) and likely underpowered studies but not possible to calculate post-hoc sample size calculations based on information provided (5 of 5 studies), withdrawals/dropouts > 20% (1 of 5 studies), and ITT analysis not used (unknown for 2 studies) or withdrawals/dropouts not considered in ITT analysis (3 of 5 studies).

#While the GRADE for HRQOL was not downgraded due to inconsistent results because the majority of the studies (4 of 5) showed nonsignificant differences between the hospital-at-home and inpatient hospital groups, there was some inconsistency in the results as 1 study did find a significant difference between the groups for some HRQOL scales.

**Downgraded because HRQOL was measured at 2- to 6-months follow-up rather than during the exacerbation itself, and this time point may be too late to observe a change in HRQOL associated with the intervention.

††Downgraded due to sparse data because 4 of the 5 studies reported different measures of HRQOL, so there was only 1 study per HRQOL outcome.

‡‡ Study quality was downgraded for length of stay because of very serious limitations in the studies, including unknown or inadequate allocation concealment (2 of 5 studies); unclear randomization process based on published information (2 of 5 studies); unknown whether assessor was blinded (single blind) based on published information (4 of 5 studies); lack of a priori power calculations (2 of 5 studies) and likely underpowered studies but not possible to calculate post-hoc sample size calculations based on information provided (5 of 5 studies), withdrawals/dropouts > 20% (1 of 5 studies), and ITT analysis not used (unknown for 2 studies) or withdrawals/dropouts not considered in ITT analysis (3 of 5 studies).

§§Downgraded due to lack of consistency across studies: 1 study reported similar length of stay between groups, 1 study a shorter length of stay in the hospital-at-home group, and 3 studies a longer length of stay in the hospital-at-home group. Some results were significantly different and some were not.

‖‖ Study quality was downgraded for patient satisfaction with care because of very serious limitations in the studies including unknown or inadequate allocation concealment (2 of 3 studies); unclear randomization process based on published information (1 of 3 studies); unknown whether assessor was blinded (single blind) based on published information (2 of 3 studies); lack of a priori power calculations for this outcome and likely underpowered studies but not possible to calculate post-hoc sample size calculations based on information provided (3 of 3 studies), withdrawals/dropouts > 20% (1 of 3 studies), and ITT analysis not used (unknown for 2 studies) or withdrawals/dropouts not considered in ITT analysis (1 of 3 studies).

¶¶Downgraded due to sparse data as none of the studies use the same outcomes to measure satisfaction with care, so there was only 1 study for each outcome.

##Study quality was downgraded for caregiver satisfaction and for patient and caregiver preference because of very serious limitations in the study including: unknown allocation concealment (1 of 1 study); unclear randomization process based on published information (1 of 1 study); unknown whether assessor was blinded (single blind) based on published information (1 of 1 study); lack of a priori power calculations for this outcome and likely underpowered but not possible to calculate post-hoc sample size calculations based on information provided (1 of 1 study), withdrawals/dropouts > 20% (1 of 1 study), and unknown whether intention-to-treat (ITT) analysis was used (1 of 1 study).

***Downgraded due to sparse data as there was only 1 study that reported this outcome.

†††Patient and caregiver preference for hospital-at-home care was measured during the study after patients had begun their treatment either in hospital or in hospital-at-home care. Thus, patients and caregivers in the hospital-at-home group had experience with the program, whereas patients and caregivers in the inpatient hospital group did not. While this provides some information that suggests patients and caregivers become more comfortable and accepting of hospital-at-home care after they have experienced it (which may have policy implications), a comparison of patient/caregiver preferences for hospital-at-home care between the groups at baseline is needed and would be less biased.

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Health Quality Ontario
130 Bloor Street West, 10th Floor
Toronto, Ontario
M5S 1N5
Tel: 416-323-6868
Toll Free: 1-866-623-6868
Fax: 416-323-9261
Email: MASinfo@hqontario.ca
www.hqontario.ca

ISSN 1915-7398 (online)
ISBN 978-1-4435-7016-9 (PDF)