Modelling telehealth

Chronic obstructive pulmonary disease

AUDIT SCOTLAND

Prepared for the Auditor General for Scotland
October 2011

Auditor General for Scotland

The Auditor General for Scotland is the Parliament's watchdog for helping to ensure propriety and value for money in the spending of public funds.

He is responsible for investigating whether public spending bodies achieve the best possible value for money and adhere to the highest standards of financial management.

He is independent and not subject to the control of any member of the Scottish Government or the Parliament.

The Auditor General is responsible for securing the audit of the Scottish Government and most other public sector bodies except local authorities and fire and police boards.

The following bodies fall within the remit of the Auditor General:

- directorates of the Scottish Government
- government agencies, eg the Scottish Prison Service, Historic Scotland
- NHS bodies
- further education colleges
- Scottish Water
- NDPBs and others, eg Scottish Enterprise.

Audit Scotland is a statutory body set up in April 2000 under the Public Finance and Accountability (Scotland) Act 2000. It provides services to the Auditor General for Scotland and the Accounts Commission. Together they ensure that the Scottish Government and public sector bodies in Scotland are held to account for the proper, efficient and effective use of public funds.

Contents

Summary

1. Audit Scotland published its national report, *A review of telehealth in Scotland*, on 13 October 2011. This report is available at www.audit-scotland.gov.uk. As part of our review, we commissioned James Robertson to undertake economic modelling to compare telehealth intervention with conventional care for patients with chronic obstructive pulmonary disease (COPD). The aim of this work was to assess whether telehealth has the potential to achieve savings or free up capacity to help NHS boards manage increasing demand for their services. This supplement accompanies our national report and presents the findings from the economic modelling work.

2. This supplement is in four parts:
   - Introduction to modelling (Part 1)
   - Modelling the two alternative patient pathways (Part 2)
   - Results of the modelling (Part 3)
   - Conclusions (Part 4)

Background

Using telehealth to manage patients with COPD

3. COPD is a serious lung disease which can make it hard to breath, and includes conditions such as emphysema and chronic bronchitis. There are thought to be about 100,000 people in Scotland living with COPD. Audit Scotland estimated that the direct cost of COPD to the NHS in Scotland in 2004/05 was around £100 million per year and predicted that the prevalence of the condition would increase by a third between 2007 and 2027.[1] COPD is the third most common reason for hospital admission in Scotland and in 2003/04, 19 per cent of patients admitted to hospital with COPD were subsequently readmitted once more and 16 per cent at least twice more.[2] Scotland has many of the highest localities for COPD admissions in the UK.[3]

4. Given the need to manage COPD for a large number of patients in Scotland, and the likely growth in the prevalence of the condition, there is considerable interest in new forms of healthcare provision, one of which is telehealth. Telehealth is the provision of healthcare to patients at a distance using a range of technologies such as mobile phones, internet services, digital televisions, video-conferencing and self-monitoring equipment. A number of pilots have been run in Scotland to test the feasibility, patient experience and costs of using telehealth to manage patients with COPD in their home.

1 *Managing long-term conditions*, Audit Scotland, August 2007.

2 *COPD in Scotland: the possible roles for telehealth,* J Haughney and I Small, commissioned by the Scottish Centre for Telehealth, 2008. www.ltcas.org.uk/documents/COPDReportfinal.doc

3 Ibid

5. These home-monitoring initiatives mainly use 'pods' or 'hubs' which are pieces of equipment placed in a patient's home allowing them to measure things like their breathing and pulse rate. The data measured are transmitted from the patient's home to a health professional such as a GP or a respiratory nurse specialist via broadband or a mobile phone, so they can review it and take any necessary action.

6. Home-monitoring equipment is designed to enable the patient to remain at home and be confident that they will receive prompt attention from a healthcare professional when needed. It can also help patients look after their health more effectively and take more control over their own treatment. Other potential benefits of the telehealth approach include reductions in emergency admissions and earlier discharge from hospital for patients.

Economic modelling

7. This report examines the cost effectiveness of a telehealth approach compared to conventional management of patients with COPD. The work was conducted with the assistance of a panel of people with relevant experience who helped develop the methodology and provided invaluable knowledge and experience (Appendix 1).

8. Appendix 2 presents an overview of the methodology and outlines specific uncertainties with the data used. Appendix 3 outlines data limitations more widely, and the implications for the modelling work. A separate excel workbook showing the data used in the modelling accompanies this report and is available at www.audit-scotland.gov.uk. The economic modelling took account of COPD telehealth infrastructure and monitoring costs, GP practice based personnel and travel costs for home visiting, and the cost of hospital admissions for the NHS. In the absence of the required data, the work was not extended to assess any improved patient experience, or patient travel cost/time savings.

9. Evaluations of COPD telehealth pilots in Scotland provided valuable cost and outcomes data, but the pilots were small scale, with associated statistical uncertainties. The pilots each had different approaches tailored to local conditions so it was not feasible to pool data. It was therefore necessary to model the costs of two individual pilots compared to conventional COPD management, limiting the reliability of the results and the extent to which these can be generalised.

10. Data for the costs of conventional management in primary and secondary care were limited. They were obtained from a range of sources, sometimes using substitutes such as information on respiratory disease in general rather than for COPD specifically. Some data from England were also used where information from Scotland was not available (eg, data on GP consultation time). A number of assumptions were made when necessary, based on the most relevant available data. Individual and combined sensitivity analyses were used to explore the effects of changing the main assumptions and to allow for the uncertainties in the telehealth COPD pilot data.

Summary of findings

11. It was possible to cost two COPD telehealth pilots relative to conventional management. The results of the modelling work suggest that compared to conventional patient management, telehealth offers the potential to help NHS boards avoid costs. This is through reduced demand on GP-based health services and, in particular, fewer hospital admissions.

12. While there are a number of significant uncertainties, it is estimated that telehealth management of patients with COPD at home might help NHS boards avoid costs of around £1,000 per patient per year. Even after changing to more negative assumptions in the sensitivity analysis, the findings still support the conclusion that using telehealth for home-monitoring of COPD has the potential to help NHS boards reduce activity for those patients and reduce costs. An important factor driving this is the reduction in the rate of hospital admissions under telehealth management for patients with COPD, compared to conventional management.

13. The costs avoided by using telehealth, for example from lower hospital admissions rates, may not necessarily be cash releasing savings, unless hospital capacity is reduced to match lower demand. It is also not possible to say at what point the roll-out of COPD telehealth initiatives would be enough to start to reduce hospital capacity or to accurately scale up pilot results to a national level.

14. The results from the modelling work should not be taken as an endorsement for the telehealth approach. The uncertainties in the data and assumptions underlying the modelling, and the specific nature of the pilots on which the modelling is based, mean that any proposed COPD telehealth initiative needs to be considered fully and carefully.

Part 1. Introduction to modelling

Overall approach to modelling

15. The aim of the economic modelling work was to assess whether telehealth has the potential to achieve savings or free up NHS capacity (eg, NHS staff time, appointments or hospital beds) to help NHS boards meet increasing demand for their services. For a given patient case mix, telehealth offers the potential for resource savings if it leads to fewer patients making use of GP-based services or going to hospital, compared to conventional management, and if those savings more than offset the cost of implementing and running telehealth. The modelling was not extended to value any patient experience or patient travel cost/time benefits, due to insufficient data.[4]

16. The modelling consisted of three stages:
    - defining a patient pathway for conventional and telehealth healthcare delivery options
    - assigning unit costs to the elements within the two alternative pathways
    - estimating and comparing total unit costs per patient per year under each pathway, taking account of differences in infrastructure and running costs, and the probability of a patient moving to different stages of the pathway (eg, the probability of a patient needing a GP home visit or of being admitted to hospital under each pathway).

17. The following sections of the report set out the approach adopted for each stage of the modelling. Appendix 2 provides more details of the steps involved and the uncertainties associated with the data.

Defining a group of patients with COPD for comparative costing purposes

18. In making comparisons between conventional and telehealth management of COPD, an important requirement is that the methodology and data used should relate to groups of patients having a similar if not identical case mix. This means that differences in costs can be clearly ascribed to the delivery route.

19. The COPD modelling panel was of the view that the modelling should focus on a patient group that would benefit most from home monitoring. The rationale for this approach was that any roll-out of COPD telehealth beyond the pilot stage at a time of constrained resources would be prioritised towards the group of patients in greatest need or who would benefit most. On the

4 Patients from remote locations may experience longer lengths of stay in hospital, with a potentially greater risk of early discharge requiring a return to hospital. Benefits to patients from telehealth may also have a NHS cost equivalent.

basis of medical considerations, the modelling panel considered this group of patients to be those with:

- poor lung function (measured by FEV1)
- high MRC breathlessness score (greater than three)
- frequent exacerbations (an acute worsening of respiratory symptoms)
- recent admission to hospital. [5,6,7]

20. Frequency of exacerbation is a relative term, given evidence that about half of patients with COPD experience one exacerbation per year.[8] US evidence based on a number of longitudinal studies suggests that the mean rate of exacerbations is approximately two a year.[9] 'Frequent' exacerbations can therefore be taken as in excess of two or three per year. This frequency corresponds approximately to 'severe COPD', defined as Stage 3 of the GOLD guidelines.[10]

Patient pathways for the defined group of patients with COPD

Defining the pathways

21. A number of issues need to be considered when defining care pathways for a particular group of patients. Pathways could be based on typical current practice, but this might not necessarily conform to good practice such as that laid down in relevant guidelines produced by the National Institute for Health and Clinical Excellence (NICE) or by Healthcare Improvement Scotland.[11] An alternative choice of pathway would be one based on achieving the best possible outcomes, without regard to the cost or feasibility of providing the medical requirements for a large group of patients. In reality this alternative pathway is not possible.

22. A better approach in principle would be to choose the pathway that optimises intervention with regard to cost and outcomes. An optimal patient pathway in this sense is one where the

5 A slightly wider set of criteria on which selection could be based is the 'BODE' composite measure, based on **b**ody mass index, airflow **o**bstruction, **d**yspnoea, and **e**xercise capacity.

6 FEV1 is the volume of air that can be forced out in one second after taking a deep breath, compared to an expected value. This is one important measure of pulmonary function.

7 The MRC breathlessness scale was first developed by the Medical Research Council Pneumoconiosis Unit in the 1940s. It quantifies disability associated with breathlessness occurring when it should not (Grades 1 and 2), or the extent of exercise limitation (Grades 3–5).

8 *COPD in Scotland: the possible roles for telehealth,* J Haughney and I Small, commissioned by the Scottish Centre for Telehealth, 2008. This reports audit data from NHS Grampian suggesting that about half of patients with COPD experience one exacerbation a year, 27 per cent three or more, and 12 per cent five or more exacerbations a year.

9 'Managing patients with recurrent acute exacerbations of chronic bronchitis: a common clinical problem', S Sethi and TM File, *Current Medical Research Opinion 20(10),* October 2004, pages 1511-21. http://www.medscape.com/viewarticle/491051_4

10 *Global Initiative for Chronic Obstructive Lung Disease Guidelines*, National Institute for Health and World Health Organisation, 2010. http://www.goldcopd.com/Guidelineitem.asp?l1=2&l2=1&intId=1116

11 Healthcare Improvement Scotland COPD standards are at http://www.healthcareimprovementscotland.org/programmes/long_term_conditions/copd_resources/copd_service_standards.aspx.

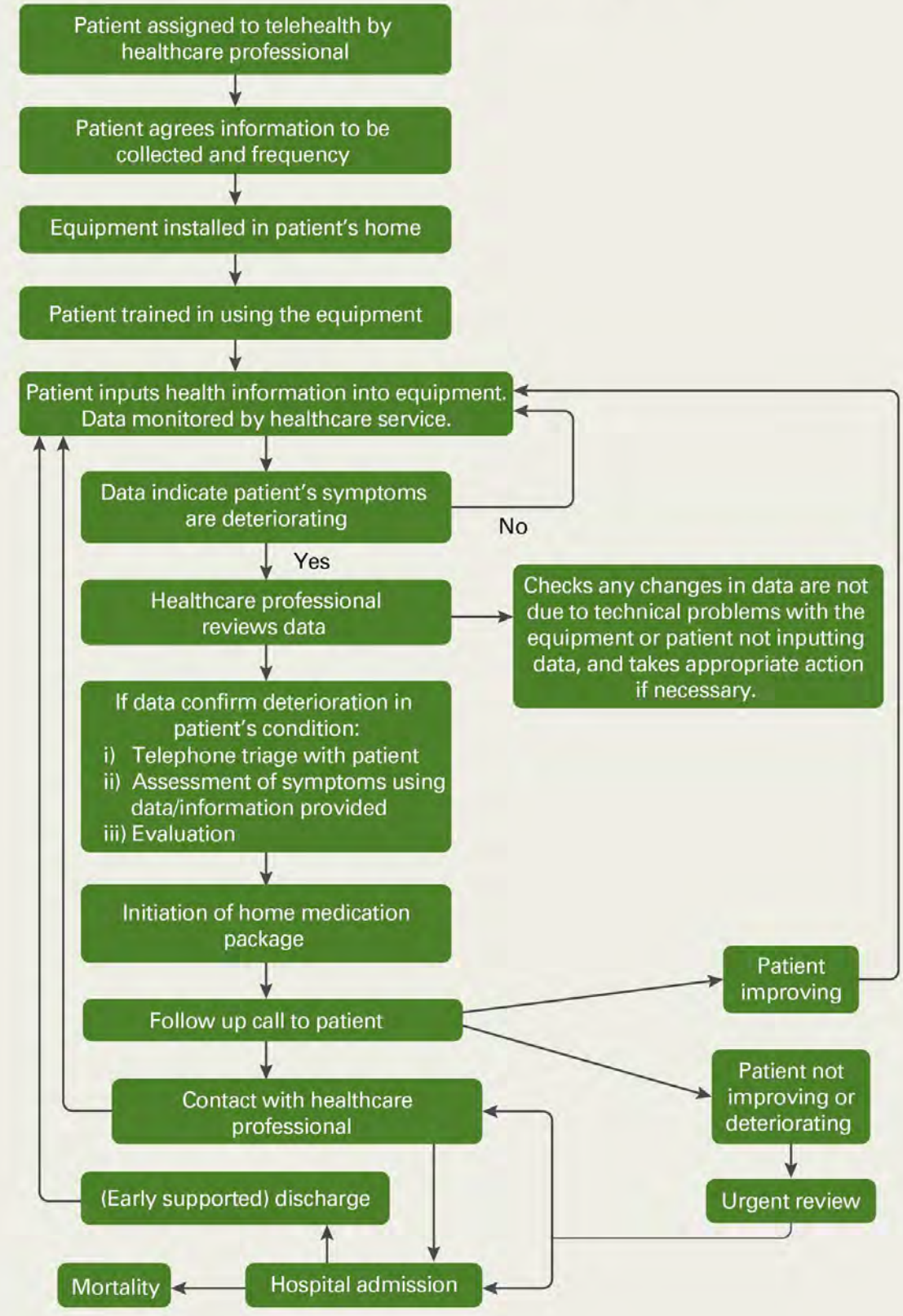
standard of care is increased until a small improvement (with an associated additional marginal cost) produces additional outcomes of the same value. This could be quantified, for example using the monetary value attached to a quality-adjusted life year (QALY). In practice, defining an optimised pathway of this sort is problematic, with difficulties in determining marginal costs, the associated change in outcomes, and the value to be placed on a QALY. The optimising approach as described also assumes that patient preferences are determined solely by outcomes. Other relevant factors in the choice of management approach would be the convenience and patient experience, particularly for a technologically based approach such as telehealth, many aspects of which may be unfamiliar to patients.

23. The approach adopted was to model the patient pathway used in the COPD telehealth pilots and a good practice conventional COPD patient pathway. The pathways used in the COPD telehealth pilots were not identical, but they were similar enough to indicate a generic version as set out in Exhibit 1 (page 10). The equivalent conventional COPD pathway used in the modelling Exhibit 2, (page 11) was recommended by the COPD modelling panel.[12] Both pathways begin with the assignment of a patient to a disease management option, given that the pathway to presentation and diagnosis is common to the telehealth and conventional COPD management options.

12 James Robertson is grateful in particular to Colin Marchment and Dr John Haughney for their advice on the telehealth and conventional COPD patient pathways respectively.

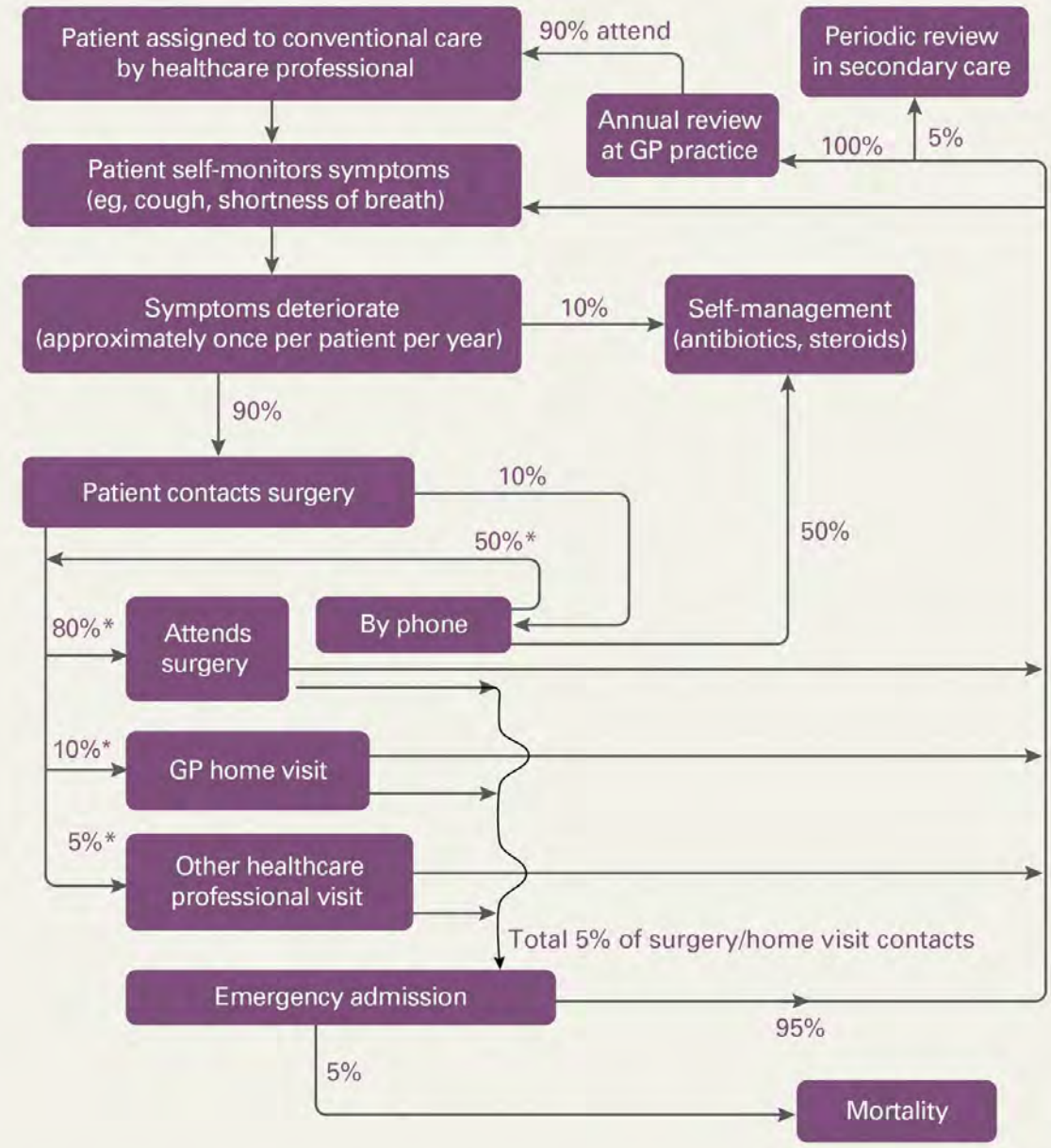
Exhibit 1

Generic patient pathway for telehealth management of COPD patients



Source: COPD modelling panel

Exhibit 2
Generic patient pathway for conventional management of COPD patients



Note: Percentages refer to proportions of those entering a step in the patient pathway, except *, where proportions (80 + 10 + 5 per cent) having face to face contacts with health professionals include 50 per cent of those initially contacting the surgery by phone (10 per cent of all those contacting the surgery).

Source: COPD modelling panel

Scope of the pathways

24. Neither of the pathways shown in Exhibit 1 and Exhibit 2 includes a route to enter rehabilitation. Rehabilitation has been a feature of the COPD pilots, for patients who are able to strengthen their lung function to some degree through controlled exercise. Rehabilitation is not an option for all patients with COPD, especially those with more severe conditions and those less affected. It is an option available in principle under either management pathway,

and in this respect costing of COPD management is no different between conventional and telehealth options. There is a possibility that applicability of rehabilitation could increase with telehealth COPD management, because of the frequent patient monitoring and patient safeguard it enables. It may also be that telehealth can offer a way of providing exercise supervised remotely, for instance in a community facility or even in an individual's home. Rehabilitation has nevertheless been excluded from the modelling because of a lack of data at the current time to model the costs and benefits of the option with any degree of certainty.[13]

25. A further issue is that of co-morbidities (ie, patients having more than one health condition), which will affect the nature of the patient pathway. COPD may be associated with a wide range of other medical conditions including cardiovascular disease (the main cause of death in patients with COPD), coronary heart disease and cancer.[14] Neither of the pathways used for modelling here makes an explicit assumption about, or allowance for, the influence and possible costs of co-morbidities. In effect, this assumes that the types and prevalence of co-morbidities are the same for both the telehealth and conventional management route. However, this affects any attempt to generalise the results of modelling, as a wider group of patients with COPD may not have the same co-morbidities as the patients in the pilots.

13 Healthcare Improvement Scotland recently issued a pulmonary rehabilitation costing template, May 2011, http://healthcareimprovementscotland.org/programmes/long_term_conditions/copd_implementation/pr_improvement_resource.aspx

14 'Mortality in COPD: role of comorbidities', DD Sin, NR Anthonisen, JB Soriano, AG Agusti, *European Respiratory Journal, Vol 28,* 2006, pages 1245-1257. .

Part 2. Modelling the two alternative patient pathways

Overview

26. Once the patient pathways were defined, the modelling involved two further stages – determining unit costs and the probability of a patient moving to different stages of the pathway for telehealth and conventional COPD management. This enables a comparison, with a view to estimating the relative cost effectiveness of the two options. Each of the stages in the two pathways was costed on a per patient per year basis. Some of these costs are one-off, in the case of purchasing equipment, with the need to convert them to an annual equivalent per patient by making an assumption about the equipment's life span. Alternatively, some costs are of an ongoing nature, for example daily monitoring of patient health data. These costs are straightforward to express on a per patient per year basis, as long as the underlying cost data are available.

27. Total unit costs for the pathways as a whole can then be derived by summing the estimated unit costs per patient per year. Costs are weighted by the probabilities that patients follow various different routes through the pathways, each route having a specific financial cost. The calculations take account of the possibility that the probabilities will differ between the two pathways.

28. Given uncertainties in the cost estimates, ranges of values for key cost drivers were then used in sensitivity analysis, to indicate the impact on the comparison of cost effectiveness and the robustness of the results.

29. The following sections provides some context around the data sources used. Appendix 2 provides a more detailed discussion of the steps in the calculations of costs and the main uncertainties, while Appendix 3 explores the issues and limitations of the available data and its implications for the modelling work.

Information about COPD telehealth pilots in Scotland

30. Data for the costs and outcomes of COPD telehealth initiatives come from a number of Scottish pilots. The pilots considered as data sources for this report were those implemented by Argyll and Bute, Inverclyde Community Health Partnership (CHP), NHS Lanarkshire, NHS Lothian and Renfrewshire Council and CHP. All these pilots collected extensive qualitative information about useability of the systems, patient experiences and satisfaction. However, cost and outcomes data were more limited. The most comprehensive and complete information was available from Inverclyde CHP and NHS Lanarkshire, so the modelling work drew on the information from these two pilots.

31. Between August 2009 and August 2010, the Inverclyde CHP pilot recruited patients identified as being at risk of readmission to hospital via their GP practices. Criteria included two previous hospital admissions due to COPD exacerbation, and two or more exacerbations requiring oral steroids and antibiotics in the previous 12 months.[15] The pilot used monitoring equipment in patients' homes, allowing them to input symptoms and signs of their COPD at regular intervals. This information was transmitted via broadband to a respiratory nurse specialist, to review and decide if any intervention was necessary. The pilot provided detailed cost information for 15 COPD telehealth patients and identified key outcomes.[16]

32. The NHS Lanarkshire COPD telehealth pilot was a two year project implemented across a number of localities starting in 2008. It did not install monitoring equipment in patients' homes, instead it used a system which provides an electronic COPD patient record accessible to all healthcare professionals involved in the care of the patient. An automated voice response facility allows patients to interact with the system via a Freephone telephone call. Not using home monitoring equipment has the advantage of reducing telehealth infrastructure costs.

33. The eligibility criteria for the NHS Lanarkshire pilot identified patients specifically with severe COPD defined as FEV1 <50 per cent expected and MRC score ≥3, having a recent history of more than two exacerbations requiring medication and/or admission to hospital. The comprehensive evaluation of the pilot included information about outcomes for 38 patients recruited from a mix of urban and rural areas, covering admissions to hospital and length of stay, in the year before the pilot began and during the pilot. The evaluators also conducted an audit to assess changes in the extent and types of contact of the 38 patients with COPD with GP-based health services.[17]

34. In addition, NHS Lanarkshire provided information in its evaluation report for projected costs in the event of a wider roll out of a COPD telehealth service, resources permitting. The projections take account of the lessons from the pilot, which indicated how changes could be made to increase cost effectiveness.

35. The possible issues and limitations of COPD pilot telehealth data and the implications for the modelling work are explored in greater detail in Appendix 3.

15 *Utilising Telehealth to Facilitate Treatment of Chronic Obstructive Pulmonary Disease,* C Marchment, Inverclyde Community Health and Care Partnership, 2010.

16 The modelling assumed that the outcomes were those of ten patients, with the observed numbers of hospital admissions applied to 15 patients. The resulting lower admissions per patient per year reduces the difference between conventional and telehealth costs. This is a cautious approach with high percentage reductions in admissions rates. In addition, one patient died during the pilot, which may have reduced the during-pilot admission rate relative to that before.

17 *COPD Telehealthcare Evaluation Report,* S Tan, M Carroll, K Carson, A Mulligan, NHS Lanarkshire, 2010.

Sources of information for COPD primary and secondary care management in Scotland

36. Conventional management of COPD is GP practice based, but telehealth management also involves GPs and other practice professionals, though potentially to a different extent. Modelling requires unit costs for this sector. In addition, both the conventional and telehealth management options make referrals to secondary care, so these unit costs are needed as well. There is no single complete data set for either primary or secondary care costs. A number of sources were used in the modelling (Exhibit 3).

Exhibit 3

Sources for primary and secondary NHS care cost data

Item	Source	Data for
GP consultation, GP visit, other healthcare professional visit	Unit cost of health and social care, Personal Social Services Research Unit, University of Kent	England, all conditions
GP annual case review	Cost assumed to be same as GP consultation	England
Inpatient costs	Information Services Division, NHS National Services Scotland; Scottish cross boundary tariffs	Respiratory medicine, Scotland
Outpatient case review	Outpatient costs, Information Services Division, NHS National Services Scotland	Respiratory medicine, Scotland
COPD case mix severity (for weighting costs)	Based on data reported in *COPD in Scotland: the possible roles for telehealth,* J Haughney and I Small, commissioned by the Scottish Centre for Telehealth, 2008.	Scotland

Source: James Robertson, 2011.

37. A number of caveats apply to the primary and secondary care costing sources in Exhibit 3:

- Information is not always disaggregated to the level of COPD specifically. Data for 'all conditions' or for 'respiratory disease' have been used for some costs. It is not possible to say if actual COPD costs are significantly different.
- The data used are for Scotland, with the exception of GP and other practice staff costs, which are based on NHS England. These costs are a small part of the total. Any differences to Scottish costs are unlikely to affect the overall results of the modelling.
- COPD case mix information by severity is limited. In particular, this factor affects the level of confidence in the unit costs of inpatient admissions. Sensitivity analysis (see page 19) has been used to assess the importance of varying the costs.
- Some assumptions are needed even after using data from a range of sources. For example, GP practice contact rates were not recorded in a number of the COPD

telehealth pilots and the rate is taken from a pilot that did (Argyll and Bute). This introduces a further loss of accuracy, but it is unavoidable. However, it is likely to be a small factor overall, as the costs involved are not great. Information on changes in prescribing costs was not available. There is some evidence that prescribing rose significantly within a telehealth regime.[18]

Other data requirements

Pathway probabilities

38. Probabilities for COPD telehealth management are taken from the pilot evaluations, which record the rate (or a rate per patient can be readily calculated) of events such as hospital admissions. No official data are available for the equivalent probabilities in the conventional COPD pathway. The probabilities for GP practice related costs have been taken as those shown in Exhibit 2 reflecting the views of the COPD modelling panel.

39. Probabilities for secondary care admissions are not based on Exhibit 2 but on the pre-pilot rates of admission reported by the COPD telehealth pilots. Though subject to the limitation of small numbers in the pilots, as discussed above, the probabilities relate to a given group of patients with COPD. The probabilities pre-pilot and during are directly comparable and are preferable to an average for all patients with COPD, even if the data were available.

Treatment of fixed costs

40. A number of costs are one-off, such as telehealth equipment costs. A range of assumptions can be made to convert fixed costs to annual per patient costs, using information on the physical or economic life of the equipment and when it becomes cheaper to replace than repair. In the absence of information in the pilots, home-based equipment has been assumed to have a service life of 18 months on average, and then be replaced. Other costs are semi-fixed, such as training. There may be one-off costs for staff new to telehealth but there will also be relevant continuous professional development. Training costs are assumed to recur annually.

18 As in the Lothian region pilot - *A Pilot Study Report on Telemetry-Supported care for COPD in Lothian Region,* J Ure, A Tarling, G Kidd, E McCall Smith, B McKinstry, J Hanley, H Pinnock, C Pagliari, A Sheikh, W MacNee, P Corscadden, 2011. However, the drugs involved were thought to be low cost.

Part 3. Results of the modelling

Comparisons of estimated COPD telehealth and conventional management unit costs per patient per year

41. Total unit costs per patient per year for telehealth and conventional management were calculated using the sources and assumptions in Part 2 and in Appendix 2. All the data used in the modelling work and our workings can be found in a separate excel workbook that accompanies this report and is available on our website at www.audit-scotland.gov.uk

42. Allowances for the uncertainties have been made using sensitivity analysis around the central case, both for telehealth and conventional COPD management. For hospital admissions costs, the central case admission cost is a weighted average of the Scottish 2010/11 cross boundary flow tariff range, reflecting more or less complex cases and a distribution of severity of COPD cases (exacerbations per year). Sensitivities use a 'lower' and 'higher' hospital inpatient cost variant, based on the ends of the available range of hospital admissions costs and applied to both the telehealth and conventional costings. The upper end of the range of admission costs is more favourable for the economics of telehealth vs conventional management, since any reduction in hospital admission rates, a feature of almost all the COPD pilot findings, leads to greater savings the higher the cost of the admissions.

43. The second main variant used for both telehealth and conventional management is for the rate of hospital admissions. A less favourable variant assumes a rate of admission 20 per cent higher than the central case rate. A more favourable variant assumes a hospital admissions rate 10 per cent less than the central cases.

44. Exhibit 4 shows comparisons of telehealth and conventional unit costs per patient per year for both the Inverclyde CHP and NHS Lanarkshire COPD initiatives, for the central case and for the two sensitivity variants. The results for Inverclyde CHP are based on costings for the pilot (using a cautious variant), while NHS Lanarkshire costs are based on projections incorporating ways of achieving efficiencies learned from the telehealth COPD pilot. As outlined earlier, more detailed information and the full workings behind how we derived these figures can be found in the excel workbook that accompanies this report.

Exhibit 4

Estimated COPD telehealth unit cost savings (£ per patient per year) for Inverclyde CHP and NHS Lanarkshire pilots, compared to conventional management

		Worse telehealth result	Central admissions telehealth result per pp pa**	Better telehealth result
Inverclyde CHP	Low admission cost	+£1,000	£0	£0
	Central admission cost*	+£3,000	+£2,000	+£1,000
	High end admission cost	+£14,000	+£11,000	+£10,000
NHS Lanarkshire	Low admission cost	£0	£0	£0
	Central admission cost*	£0	£0	£0
	High end admission cost	+£1,000	+£1,000	+£1,000

* Central case = weighted average 2010/11 COPD/bronchitis inpatient spell tariff Scotland: £2,800
Low cost case = minimum cost 2010/11 COPD/bronchitis inpatient spell tariff Scotland: 1,971
High cost case = maximum 2010/11 COPD/bronchitis inpatient spell tariff Scotland: £8,465

** Central case hospital admission rate as observed in telehealth pilot

Source: James Robertson, 2011.

45. Exhibit 4 indicates that all cases show either neutral unit costs per patient per year or savings, comparing COPD telehealth to conventional management.[19] The high end admissions costs show the largest savings, reflecting avoided high costs of hospital spells for patients with the most severe conditions of COPD. On the other hand, there is a reduction in the savings for any given level of admissions cost in Exhibit 4, as the admissions rate is progressively assumed to be more favourable. This reflects the application of the more favourable admissions rate to both telehealth and conventional management. Given the small numbers in the COPD telehealth pilots and the associated pre-pilot audits of healthcare, similar uncertainties are present in estimates for both types of management.[20]

19 'Neutral' in this context means an estimated saving of zero when rounded to the nearest £1,000.
20 The justification for the approach is discussed below.

46. The Inverclyde CHP telehealth pilot recorded a reduction of about 80 per cent (33 pre-pilot to seven admissions in pilot), and the NHS Lanarkshire pilot showed a 35 per cent reduction, (17 to 11 admissions).

47. Overall, the modelling indicates that COPD telehealth management has the potential to avoid costs, as well as the patient benefits measured by a reduced rate of admissions to hospital. The next section investigates this more through further sensitivity testing.

Sensitivity analysis

48. There are several variables which impact on unit costs, including the rates of admission to hospital and the associated costs. The other important factor is the non-admissions costs of telehealth, including home-based equipment, IT infrastructure and NHS staff involved in monitoring patients. Home visiting costs are another cost. There are therefore many possible combinations of sensitivities. One methodology to handle such complexity is a sampling approach across estimated distributions of the variables in question. Latin hypercube sampling (LHS) is one such method. LHS selects values across the distributions of the variables in question, divided into equally probable intervals, then repeatedly combining values selected at random for a sensitivity test, ensuring that the whole distribution of the variables in question is sampled in a systematic way. The set of sensitivity calculations is used to estimate a distribution of outcomes for the issue of interest, in the current case, the difference between the cost of telehealth and conventional COPD management.

49. Though an efficient way of exploring sensitivities, LHS remains critically dependent on the values chosen for the end points of the distributions of the variables and on assumptions about the shape of the distributions for variables being used. Sensitivity cases cannot be selected randomly for correlated variables. There are insufficient data to make subjective decisions on variable ranges, distributions and correlations needed to apply LHS in the present case.

50. In addition, the central interest is not in estimating the full distribution of cost outcomes from telehealth, but in the robustness of the conclusion above that telehealth has the potential to offer unit cost savings over conventional COPD management. Robustness is measured by the extent to which adverse assumptions can be made and COPD telehealth continues to offer the prospect of savings over conventional management. In other words, a useful approach is to examine a combination of sensitivities that are only worse than the central case.

51. The sensitivity tests in Exhibit 4 are based on applying combined admission rates and admission costs sensitivities for both telehealth and conventional COPD management. Doing this reduces the impact on the differences between the costs of the two COPD management options. Clearly the alternative of increasing telehealth costs and holding constant or reducing conventional costs will reduce savings. The rationale for doing this is not strong, given that many of the uncertainties apply equally in the same direction to both telehealth and conventional management.

52. Hospital admissions rates are uncertain, but the uncertainty is not in the rates observed before and during the pilots. It is that a different group of patients would tend to demonstrate different rates. Statistically, the alternative group of patients might well show worse health outcome results under telehealth management than the group in the pilots. Holding outcomes fixed, (rather than worse as well), under conventional management for the same group of patients implies that the second group of patients have characteristics, other than their symptoms, that make them better suited to conventional than telehealth management. This would apply, for instance, if the second group of telehealth patients, unlike the original, was unable to operate home monitoring equipment. In practice, the telehealth COPD initiatives have included criteria that exclude patients intrinsically less likely to receive health benefits.[21]

53. Similarly, hospital admission costs are uncertain, but it seems unreasonable to assume, for a given case mix, that hospital costs are lower than the estimated central case value for admission via conventional COPD management but higher for admission via telehealth management. The speed with which a patient is identified as needing hospital treatment will be a factor even with the same case mix, but if anything, daily monitoring under telehealth is likely to pick up changes in condition quickly and reduce hospital costs relative to conventional management. The same principle applies to any change in length of hospital stay. The pilots pointed to reductions, and implied lower relative costs, but without better data, length of stay was assumed to be the same for admissions via telehealth and conventional management.

54. The arguments point to the use of combined sensitivities for admission rates and admission costs applied in the same direction to both telehealth and conventional management, as in Exhibit 4. This consideration parallels that of correlated variables in LHS.

55. Therefore, the third sensitivity variable that needs testing is the non-admissions costs, covering infrastructure and running costs, as well as consultations with GPs and home visits. It also allows notionally for any staff on-costs not included in the information supplied by the pilots. The case for applying adverse sensitivities equally to both telehealth and conventional management is less strong. The non-admissions costs of telehealth are uncertain in their own right, as a novel approach. There are uncertainties about the non-admissions costs for conventional management, for instance due to the use of cost data for NHS England, but the measurement issues are separate to and independent of the uncertainty of operating a new management configuration.[22]

56. We examined the effects of a three way combination of sensitivities, in the same way we undertook for Exhibit 4 for admission rates and costs, applying equally to telehealth and conventional management, but with 50 per cent uplift for non-admissions costs for only telehealth.

21 For example, on the grounds of dementia or co-morbidity not amenable to telehealth management.

22 This is not quite the case in practice, as the modelling uses the same unit cost for a home visit for both telehealth and conventional management. In addition, home visiting rates may be wrong in the same direction for both telehealth and conventional management if there is uncertainty about them, for the same patients.

57. This additional analysis indicated that the savings results worsened in some cases. Where the model assumes low admissions costs, the results for the Inverclyde CHP telehealth pilot were that telehealth is now more expensive than conventional management, in the region of between £1,000 - £2,000 per patient. However assuming the high end admissions costs, telehealth still showed savings when compared to conventional management. The result is for three combined sensitivities assuming that non-admission costs are 50 per cent higher. This is arguably a severe test. The results for NHS Lanarkshire are not sufficiently affected to change when rounded to the nearest £1,000. The results are influenced by the low non-admission costs, arising from a configuration that did not use home-based monitoring equipment.

Overall results from the modelling

58. The overall results from our modelling, when looking at the average of the combined results from Inverclyde CHP and NHS Lanarkshire, suggest that compared to conventional patient management, telehealth offers the potential to help NHS boards avoid costs. This is through reduced demand on GP-based health services and, in particular, fewer hospital admissions. As discussed throughout the course of this report, there are a number of significant uncertainties; however we estimate that telehealth management of COPD patients at home might avoid costs of around £1,000 per patient per year (Exhibit 5).

59. We have seen that even after changing the assumptions in the sensitivity analysis to more negative assumptions, the findings still support the conclusion that using telehealth for home-monitoring of COPD has the potential to help NHS boards reduce hospital admissions for those patients and reduce costs.

Exhibit 5
Results from our modelling work
Telehealth management of COPD has the potential to help NHS boards avoid costs.

Average estimated cost per patient per year[1]	
Conventional GP-based COPD management	
Estimated non-admissions cost of conventional GP-based care	£500
Estimated costs of hospital admissions	£3,700
Estimated total cost of conventional COPD management	**£4,200**
Range of total costs after applying sensitivity analysis for number of hospital admissions and cost per admission[2]	£2,900–£14,000
Telehealth COPD management	
Estimated costs of telehealth equipment	£400
Estimated NHS staff costs for monitoring data and GP-based medical intervention when necessary	£1,800
Estimated costs of hospital admissions	£1,100
Estimated total cost of telehealth COPD management	**£3,300**
Range of total costs after applying sensitivity analysis for number of hospital admissions and cost per admission[2]	£2,900–£6,100
Estimated savings (by using telehealth compared to conventional management)	**£1,000[3]**

Notes:
1. All figures are to the nearest £100. The modelling work assumes all other costs in each pathway are equal.
2. The lowest end of the range of costs assumes that hospital admissions are ten per cent lower and applies the cost of a hospital stay for a less severe case mix; the highest end assumes admissions are 20 per cent higher and applies the cost for a severe case mix.
3. Difference shown is based on unrounded total costs for telehealth and conventional COPD management.

Source: Audit Scotland

Illustrative national roll out

60. The reliability of generalising the telehealth COPD results is an important issue discussed in Part 2. The ability to increase coverage depends on NHS boards' practical capacity to do so and on the availability of cash resources, even if there is a potential for resource savings longer term. It is important to note that not all patients with COPD are suitable candidates for telehealth management given their condition and co-morbidities, which also makes an assumption for the size of a wider roll-out problematic.

61. With the securing of funding for the Delivering Assisted Living Lifestyles at Scale (DALLAS) programme in Scotland, NHS 24, in conjunction with NHS boards and local authorities across Scotland, will be developing new models of care delivery. The programme aims to demonstrate how technology can be used to help improve the quality of life of older people and people living with long-term conditions, by delivering telehealth services to at least 10,000 patients. The new models will utilise the infrastructure and resources within existing NHS 24 services, to support a substantial expansion of integrated telehealth and telecare services for

COPD and other long-term conditions. NHS 24 expects that the proposed configuration will bring reductions in unit costs compared to the telehealth COPD pilots.

Part 4. Conclusions

62. There are considerable uncertainties in the data used for modelling, and the results of the pilot COPD telehealth initiatives have limitations due to small numbers involved and other factors. As a result, it is not possible at this point in time to give a definitive statement of the comparative costs of telehealth and conventional COPD care.

63. The results of the modelling do, however, give weight to the view that COPD telehealth offers a potential for lower unit costs than conventional management (plus any non-health outcome patient experience advantages such as the convenience of home based monitoring). An important reason for the estimated savings is reduced hospital admissions, even after allowing for the capital and running costs of COPD telehealth including NHS staff time. Sensitivity testing indicates that favourable relative cost outcomes are possible over a range of scenarios with more adverse assumptions than the central case.

64. The savings in question will not be cash releasing unless NHS capacity is reduced in line with lower demand, though the resource savings allow other patient groups to be treated sooner, reducing waiting times. If health demand generally is increasing over time, the resource savings could defer or avoid the need for increased hospital capacity.

65. Despite the results from the modelling, it should not be assumed automatically that COPD telehealth will offer cost advantages. The COPD telehealth pilots show that a cost effective outcome depends on the configuration adopted for home monitoring, its costs, the prevailing rate of hospital admissions and the likely reduction in the rate following the adoption of telehealth management and the costs of hospital stays for the case mix in question. Developments in technology, or ways of providing telehealth services, may lead to cost structures which differ from those of the COPD telehealth pilots. New COPD telehealth initiatives should therefore be considered carefully on a case-by-case basis.

Appendix 1

Membership of the COPD modelling panel

Audit Scotland would like to thank members of the COPD modelling panel for their input and advice throughout the audit.

Member	Organisation
Michael Bews	Patient Delivery Specialist, British Lung Foundation
Lynn Garrett	Project Manager, Argyll and Bute Community Health Partnership
Professor David Godden	Co-Director, Centre for Rural Health, University of Aberdeen
Dr John Haughney	General Practitioner and Research Fellow, University of Aberdeen
Colin Marchment	Respiratory and Tuberculosis Clinical Nurse Specialist, Inverclyde Community Health and Care Partnership
Christine McClusky	Service Development Manager, Scottish Centre for Telehealth, NHS 24
Gillian McCready	Service Manager - Older People, Inverclyde Community Health and Care Partnership
Professor Brian McKinstry	General Practitioner and Research Fellow, University of Edinburgh

Appendix 2

Methodology

	Methodology	Data uncertainties / limitations
COPD telehealth management		
1	Establish number of patients covered in each pilot	Used to calculate per patient costs.
2	Establish length of time pilot audit data covered	Cost per patient estimates to be grossed up to 12 month costs if audit ran for less that a year, assuming that the same group of patients and outcomes for the pilot months are replicated in the rest of the year.
3	Use COPD telehealth management patient pathway to identify cost elements, add estimates of following unit costs per patient per year:	
	• Capital costs for home monitoring equipment (assumed to be per year)	Depends on system utilised. Some systems do not use home equipment. Where home equipment is installed, its average life is assumed to be 1.5 years (although there is no evidence on this).
	• Ongoing infrastructure costs (eg, broadband connections / installation and maintenance / vehicle and driver)	
	• NHS and other staff training costs	Based on staff costs. All staff cost estimates subject to uncertainty given estimated fractions of year involved with small pilot telehealth initiatives.
	• NHS staff costs for monitoring data	As above.

	Methodology	Data uncertainties / limitations
	• NHS management overhead cost	As above.
	• Extra prescription costs (if known)	Costs not generally known, but extra prescribing tends to be low cost drugs.
	• Home visit costs	Used home visits rate per patient from Argyll and Bute COPD telehealth evaluation and primary care cost. Data are for small patient numbers so imprecise. Argyll and Bute data used as proxy for other pilots, as information not available for other pilots, so source of inaccuracy. Cost per home visit based on weighted average for 'GP and other professionals' estimated primary costs (see primary care below).
	• Hospital admission costs *	Used pilot average rate of admissions per patient year. Admission rate from COPD telehealth pilot evaluation. Single patients can affect estimates substantially given the small numbers in pilots. Unit costs come from secondary care (see below).
4	Calculate overall telehealth COPD management cost per patient per year	
COPD conventional management		
1	Estimate / obtain primary and secondary care unit costs (eg, GP consultation cost, home visit costs, admission cost per stay in hospital)	Wide variety of sources. Data may not be specifically for COPD but for respiratory disease. Data may be for England, so approximations and uncertainties introduced.
2	Establish probabilities for flow through specific routes of the COPD conventional management patient pathway	No general data. Based on advice from the modelling panel (Appendix 1) on percentages of patients flowing through different routes in the pathway. Also used information from COPD telehealth pilots, where available, on use of health service prior to pilot. This is the main approach used here, although it is not a true control group approach and so may raise statistical issues.
3	Calculate weighted average cost for one exacerbation, excluding home visits and	Generic method - use unit cost information from step 1 and probabilities to estimate weighted cost of an exacerbation, reflecting how many patients take which path and at what cost.

	Methodology	Data uncertainties / limitations
	admissions	Subject to issues in steps 1 and 2. Pilot based method - as far as possible, use information about rates of home visits and hospital admissions from the pre-pilot period. Incomplete information and so some generic information has to be used (for GP / consultant consultations) but results are a better reflection of local COPD patient health needs. There is a trade-off with the quality of data.
4	Assume level of exacerbations to calculate total cost per patient per year, excluding home visit and admission costs	Number of exacerbations based on severity criteria in COPD pilot recruitment strategies, which while similar did vary, so approximation.
5	Add home visit cost per patient per year	Weighted average of costs for GP and other health professionals, including time and transport. In absence of better data and for consistency with telehealth management, using Argyll and Bute proxy data. Conventional home visit rate is the Argyll and Bute pre-pilot rate and same unit cost as for telehealth management. Approximations involved.
6	Add hospital admission cost per patient per year *	Rate of admissions assumed equal to pre-pilot rate. Costs based on weighted average admission cost using data on frequency of admissions and cost applicable to admissions of a given frequency. Limited data availability for frequency of admissions and associated costs, assumptions made based on Scottish tariffs according to case severity, introducing uncertainty in estimates.
7	Calculate overall conventional COPD management cost per patient per year	

* No allowance is made for emergency department costs prior to hospital admissions in the costings for either telehealth or conventional COPD management.

Appendix 3

Data limitations and implications for modelling

Gathering data for modelling from the COPD telehealth pilots highlighted a number of issues:

- difficulties validating some cost data
- differences across pilots
- incomplete information
- small numbers of patients in the pilots
- lack of formal evaluation control groups
- relevance of results from the pilot evaluations for modelling a larger programme. [23]

Audit data validation

Data for the COPD pilots were taken either from evaluation reports or were provided following direct requests to the pilot organisations. The data were validated as far as possible by reference to the underlying spreadsheets, but some cost information was supplied in summary format and it was not possible to cross check it against primary source material. There is no reason to suppose that the data contained any inaccuracies that would distort the modelling results. A second possible issue is the completeness of the coverage of the cost data. It was not possible to use a single cost template for the modelling, given different cost classifications used by the COPD telehealth pilots, and it was not possible to check that the costings have a fully comparable scope.

Differences across the pilots

The COPD pilots were not uniform in their patient recruitment criteria, the extent of evaluation and the evaluation approach adopted. These factors limit the extent to which inferences can be drawn about costs and benefits from the pilots as a whole. This affects to some degree the reliability of comparisons between telehealth and conventional COPD management.

Some differences were inevitable because the pilots were intended to address local needs. An important common central focus of all the pilots was the practicality of telehealth and the patient experience. While a factor, other differences should not be exaggerated. The pilots recruited patients using criteria close to those set out in paragraph 19. There were differences in the timing of the COPD pilots, which may have impacted on outcomes, as exacerbations have a seasonal

23 Similar to those reported in 'Insufficient evidence of benefit: a systematic review of home telemonitoring for COPD', CE Bolton, CS Waters, S Pierce, G Elwyn, *Journal of Evaluation in Clinical Practice*, 2010 http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2753.2010.01536.x/abstract and 'Home telehealth for COPD: a systematic review and meta-analysis', J Polisena, K Tran, K Cimon, B Hutton, S McGill, K Palmer, RE Scott, *Journal of Telemedicine and Telecare* (16), 2010, pages 120-127.

component.[24] The duration of the pilots, at least six months, is long enough to offset much of any possible impact. Given the differences between the pilots, no attempt was made to test statistically whether it was valid to pool data. The various results were instead used to provide a range of estimates.

Incomplete information

The full data set required for modelling the COPD telehealth pathway, compared to conventional management, consists of unit costs for each element, impact on patient/GP practice contacts and associated costs, changes in prescribing costs, changes in emergency or hospital admissions, and changes in length of stay in hospital. No one pilot provided all this information, and so it was necessary to estimate some values from one pilot to another as proxy data. All the evaluations of the pilots conducted some form of effectiveness analysis, but these were conducted to different extents, so there is an incomplete common data set for the outcomes of relevance. The evaluation work would have been more practical had a central reference set of COPD related costs been available, which could have been used by all the pilots in a common costing and cost effectiveness template.

There is no way of knowing if the use of proxy data to fill in data gaps (eg, using NHS England data as a proxy for unavailable Scotland data) imparts any bias up or down in the unit costings. One possible result is that the costings reflect not just the genuine differences between telehealth and conventional COPD management, but also differences in definitions between different data sets. Using mixed data sources increases the range of uncertainty of the cost estimates.

Small numbers of patients in the pilots

Individually, the pilots recruited small numbers of patients. This increases the uncertainty intervals around outcome data in particular, and therefore the reliability of estimates of overall cost effectiveness of telehealth compared to conventional COPD management. The small numbers in the pilot also meant that the overall results could be skewed substantially by just one patient becoming seriously ill during the pilot but not before. The number of patients in this category was one or two (if any) per pilot, but sufficient to affect the number of contacts with the NHS, the number of hospital admissions and the average length of stay in hospital for the pilot patients as a whole. The modelling work retained the high cost cases in the telehealth pilots, which acts on the side of caution in a comparison with conventional costs. Larger (though more expensive), pilots would have helped distinguish if these occurrences were unrepresentative statistical outliers or part of a real pattern.

Lack of formal evaluation control groups

None of the COPD telehealth pilots used the randomised controlled trial (RCT) methodology, regarded as the approach giving the most reliable results. Though expensive and yielding specific

24 *Evaluation Of The Met Office Health Forecasting Project for Primary Care and NHS Trusts,* London School of Hygiene and Tropical Medicine, 2006. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4136494.pdf

results that cannot always be generalised, the RCT 'gold standard' research design limits bias. Control groups not receiving the intervention in question help avoid flawed conclusions, for instance, attributing health gains to the intervention.

The pilot evaluation results were based on the 'before' and 'during' pilot outcomes for the same group of patients. The advantage is that comparability is not an issue, as opposed to using a general selection of patients receiving conventional management. While very valuable data, some potential positive bias due to a possible placebo effect cannot be ruled out. This would lead to overestimating the impact of telehealth.

A further issue is that any intervention aimed at a group or characteristic that is very different from the average will appear to be successful because of regression to the mean. [25] Outcomes that are not correlated over time (previous condition does not predict future), will result statistically in observations of improved health following a bad spell and vice versa. Improvements will then be attributed incorrectly to the intervention and not to chance.

The COPD telehealth pilots were focused, as above, towards the more severe end of the condition and had no control group that would have helped in separating out any statistical artefacts. Potentially, regression to the mean is therefore an issue for the modelling, especially if there is any expectation that telehealth will result in improved outcomes for patients.

The latest NICE COPD guidelines state that there is 'no predictable pattern', suggesting that outcomes at different times are not correlated. Equally, however, the guidelines recognise that COPD is a progressive disease.[26] The two statements can be reconciled by considering COPD to be a progressive condition, but one that is unpredictable in its rate of development. The progressive nature of the disease implies that improvements in a patient's COPD symptoms are less likely to be due to chance, and more likely to be a reflection of the positive impact of the management regime. The COPD modelling panel was also of the view that regression to the mean is not a consideration for the COPD telehealth evaluations.

Relevance of results from the pilot evaluations for modelling a larger programme

Unit cost and outcome data from the COPD telehealth pilots reflect their experimental nature. Pilots are intended to explore the feasibility of initiatives and they yield lessons which can be used to reduce costs and improve effectiveness. Larger scale applications can benefit from these improvements and, all else equal, would provide better cost effectiveness than indicated by the pilot results. To this extent, projections for a larger programme of COPD telehealth contain an element of caution. On the other hand, the estimates of relative costs are based on small numbers of patients, who were recruited to the pilots as having more severe symptoms than patients with COPD generally. This limits the applicability of the estimates to a wider roll-out programme, or if the estimates are used in this way, the uncertainty interval will be significant.

25 'Effect of regression to the mean on decision making in health care', V Morton, DJ Torgerson, *British Medical Journal*, May 17;326 (7398):1083-4, 2003.

26 *Chronic obstructive pulmonary disease: management of chronic obstructive pulmonary disease in adults in primary and secondary care,* Section 5.1, National Clinical Guideline Centre, June 2010.

Modelling telehealth

Chronic obstructive pulmonary disease

If you require this publication in an alternative format and/or language, please contact us to discuss your needs.

You can also download this document in PDF, black and white PDF or RTF at:
www.audit-scotland.gov.uk

Audit Scotland, 110 George Street, Edinburgh EH2 4LH
T: 0845 146 1010 E: info@audit-scotland.gov.uk
www.audit-scotland.gov.uk