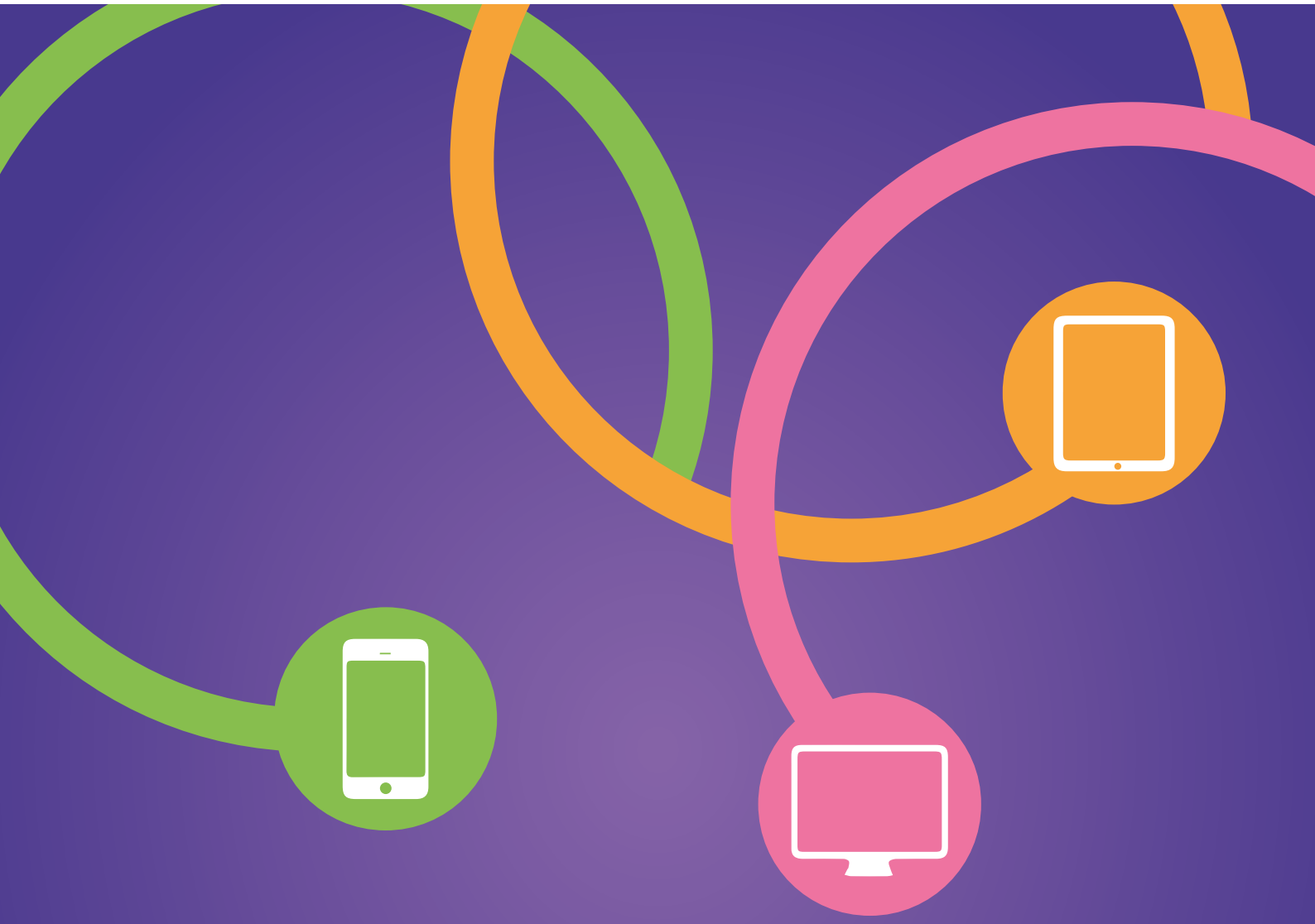
Home & Mobile Health Monitoring

Digital Health & Care Scotland

TEC Technology Enabled Care



Home and Mobile Health Monitoring Evaluation

Economic Case Studies

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July, 2019

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AT A GLANCE

Scotland's Technology Enabled Care (TEC) Home & Mobile Health Monitoring (HMHM) Programme enabled people with (or suspected of having) high blood pressure (BP) and Chronic Obstructive Pulmonary Disease (COPD) to benefit.

Hypertension was selected as a case study because so many people attend their GP surgery for it, meaning considerable costs could be avoided by remote monitoring. It was also the most frequently monitored condition during the HMHM Programme.

COPD was chosen because avoiding exacerbations is good for patients and the cost of any hospital admissions is considerable. The numbers using HMHM for COPD are lower, but the benefits have the potential to outweigh the costs.

This report is about the return on investment in HMHM for some local areas. It balances investment, start-up and running costs against staff time and contacts saved. This is not a theoretical report, but based on the real costs and benefits for some of our HMHM partner areas.

HMHM improves other outcomes for people with high blood pressure and COPD, including increased self-management, condition control, and access to services. The savings from this have not been included in this economic modelling.

COPD

The key benefits of using HMHM for COPD monitoring that were considered in this analysis were avoided A&E attendances, NHS24/ ambulance calls, COPD prescribing and emergency hospital admissions. Although the savings are not cash releasing, they do release staff capacity.

HMHM is cost-effective for COPD over a 10 year period. When the cost of emergency admissions avoided is included, a comparison with and without HMHM shows:

- NPV over 10 years is between £26m and £28m in Ayrshire & Arran per 100 patients
- NPV over 10 years is between £496k and £1.4m in West Dunbartonshire per 100 patients
- NPV over 10 years is approximately £23m in Highland per 100 patients

People using HMHM for COPD had **fewer NHS24 and ambulance service call-outs** for respiratory and used fewer emergency admission bed days for their COPD in the six months after starting monitoring compared to the six months before.

- In Ayrshire & Arran and Highland they also had fewer A&E attendances in the six months after starting HMHM than before. (This data was not available for West Dunbartonshire)

People using HMHM for COPD had an **increased number of items prescribed** for their condition in the six months after starting monitoring compared to the six months before.

No break-even analyses could be conducted for the COPD case studies. Costs associated with the workflows were determined to be running costs (which rise linearly with the number of patients monitoring) rather than implementation costs.

Hypertension

The key benefits of using HMHM for blood pressure monitoring that were considered in this analysis were avoided face to face contacts and reduced need to 24 hour Ambulatory BP monitoring. Although the savings are not cash releasing, they do release staff capacity. Any longer term benefits such as improved BP control leading to reductions in heart disease and strokes have not been included in the modelling.

Use of **HMHM is cost-effective** for hypertension over a 10 year period and all the scenarios in the modelling are net positive. Comparing costs with and without HMHM shows:

- Net Present Value over 10 years is between £52k and £73k in Ayrshire & Arran per 100 patients
- Net Present Value over 10 years is between £15k and £67k in Lanarkshire per 100 patients
- Net Present Value over 10 years is between £62k and £85k in the Western Isles per 100 patients

Capacity is released using HMHM for hypertension. Comparing costs and benefits shows:

- Between 56 and 76 patients need to use HMHM for hypertension in Ayrshire & Arran to break-even
- Between 42 and 68 patients need to use HMHM for hypertension in Lanarkshire to break-even
- Between 13 and 18 patients need to use HMHM for hypertension in the Western Isles to break-even

Patient travelling time is avoided by using HMHM for hypertension. It is estimated that between 33 and 50 hours of travelling time and £105 in travel costs is avoided per 100 patients.

Productivity is increased by using HMHM for hypertension. It is estimated that £1,800 in loss of earnings is avoided per 100 patients having their blood pressure monitored remotely.

Savings can be increased by the use of service models that encourage recycling of the blood pressure monitors i.e. returning them for use by other patients. This has not been included in the economic modelling but is of growing interest.

FOREWORD

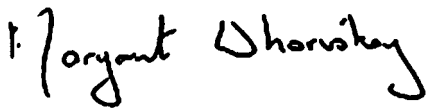
I am very pleased to share our economic evaluation of Home and Mobile Health Monitoring (HMHM) with you. This report provides a detailed analysis of the costs associated with remotely monitoring blood pressure (BP) and Chronic Obstructive Pulmonary Disease (COPD) in different parts of Scotland and elegantly illustrates the considerable complexity such an endeavour entails.

The results move the national Technology Enabled Care (TEC) programme forward, by providing detailed insight into the many benefits and continued investments required to deliver digitally enabled technology services at scale. It acknowledges that the many benefits that digital technology can bring have to be paid for.

The HMHM Programme established important foundations that have led to an acceleration in the number of people in Scotland who are now able to benefit from remote monitoring. The recent launch of Scale-Up BP is the next phase of work that aims to build on the first three years and take hypertension HMHM to a level where real costs can be avoided, for staff and patients. The work included in this report demonstrates where some of the savings can be realised.

This is a partner report to last year's national HMHM Evaluation (Alexander, 2018) which captured the pace of change alongside the important outcomes that HMHM had contributed to. It also recognised that we needed specific action plans to address the barriers and issues that were detracting from scale-up and spread of HMHM, something that is being implemented for Scale-Up BP. This economic evaluation encourages us to recognise that there will be a break-even point with scale-up that moves us into resource savings, or, as a minimum, releasing staff capacity to ensure our services are able to meet the level of need into the future.

This report would not have been possible without a number of people besides the authors. My special thanks go to the HMHM partners who shared their data for this economic analysis (Ayrshire and Arran, Highland, Lanarkshire, West Dunbartonshire, and Western Isles) and to everyone in the local areas who played their part. I am very grateful to Nils, Caroll and Helen for all their work over the time that has been needed to get the report right. And I would like to thank the National HMHM Evaluation Steering Group, and in particular Michelle Brogan, who guided this work to fruition.



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1. INTRODUCTION AND BACKGROUND

1.1 Technology Enabled Care Programme in Scotland

The Scottish Government's Technology Enabled Care (TEC) Programme is a £9 million a year programme designed to increase people's choice and control in their health and well-being. The first phase ran from 2014 to 2018 and the second phase now has a focus on scale-up of the technologies involved.

Technology Enabled Care is defined as 'where outcomes for individuals in home or community settings are improved through the application of technology as an integral part of quality, cost-effective care and support'. The TEC Programme is positioned within the Digital Health and Care Strategy (Scottish Government, 2018) in support of service transformation. The TEC Delivery Plan for 2019/20 (Scottish Government, 2019) sets out four priorities:

- Innovating for transformation
- Developing approaches once for Scotland
  - An additional 35,000 citizens benefiting from remote health monitoring
- Redesigning services
- Facilitating digital skills and knowledge

1.2 Home and Mobile Health Monitoring (HMHM)

Home and Mobile Health Monitoring is defined in the National Service Model (Scottish Government, 2017):

'Home and mobile health monitoring (remote monitoring) describes those activities that enable patients outside of healthcare settings to acquire, record and relay clinically relevant information about their current condition to an electronic storage system where it can be used to inform or guide self-management decisions by the patient and/or to support diagnosis, treatment and care decisions by professionals'

1.3 HMHM Year 3 evaluation

At the end of the first three years of HMHM funding, the detailed learning around what outcomes remote monitoring had contributed to, along with progress in scale-up, spread and sustainability (Alexander, 2018). This economic analysis builds on that Year 3 evaluation by exploring case studies on two of the conditions HMHM is most frequently used for, namely hypertension and Chronic Obstructive Pulmonary Disease (COPD). Five of the HMHM Programme partners agreed to provide data for the economic evaluation, namely Ayrshire & Arran, Highland, Lanarkshire, West Dunbartonshire and the Western Isles. Variations in their deployment of HMHM and data gathering were a complication that had to be worked around.

1.4 Economic evaluation aims

The intention of this economic evaluation was to determine the cost-effectiveness of HMHM using case studies, the Return on Investment (ROI), and overall economic impact. The different components to be explored were:

- The monetary equivalent of capacity released
- The monetary equivalent of reductions in resource demands
- The costs of HMHM compared to baseline costs
- The number of cases that would need to be implemented to break-even

1.5 Economic evaluation approach

This economic evaluation balances the costs of HMHM investment, start-up and running the project against any reduction in staff time / avoided contacts. Although these benefits are not cash releasing they do free up capacity in the system. The analysis includes investment

in equipment, contractual obligations, and training, but excludes infrastructure and wider costs such as environmental or employment impacts. There is an additional discussion around the patient and staff benefits of avoided travel time and potential productivity gains. Alternative uses for the capacity released are not discussed.

It should be remembered that HMHM is likely to be one of a number of contributory factors in any successful intervention. Although benefits and future costs are calculated before and after HMHM, the influences will be wider, including aspects such as individual variation and input from other services not deploying technology. The claim is that HMHM is making a contribution, not that it is the sole cause.

A pragmatic approach was adopted to identify and measure added value by modelling the full cost benefit analysis. The case studies allow consideration of capacity release, travel avoidance, and productivity loss, an effective way of identifying HMHM return on investment at a holistic level. The two key measures used are Net Present Value (NPV) and break-even analysis.

1.5.1 Net Present Value (NPV)

NPVs calculate the sum of all future benefits, but in the present, minus the value of future costs. This essentially involves balancing the cost of HMHM and the monetary equivalent of the benefits realised. Cost and benefits are discounted at 3.5% and 1.5% respectively over 10 years using Treasury Green Book methodology (HM Treasury, 2019). NPVs are presented as a range, from the minimum benefits minus maximum cost to the maximum benefits minus minimum cost i.e. the most pessimistic estimates to the most optimistic assumptions. The calculations are tailored to local circumstances such as the likelihood of releasing capacity and how much input is needed to implement the technologies.

1.5.2 Break-even analysis

Break-even analysis shows how many patients would need to use the technologies to recover the upfront investment cost, bearing in mind that the benefits are not cash releasing. As with NPVs, range of break-even scenarios is provided including and excluding relevant investment costs. It should be noted that if the net benefit of any scenario is negative, break-even analysis cannot be used because a break-even point will never be reached.

1.6 Challenges in HMHM economic evaluation

The economic evaluation of HMHM across Scotland and elsewhere is still evolving and largely defined by the need to show a positive return on investment. This is challenging because the organisation or service making the investment is not necessarily the one which benefits e.g. NHS Boards or Health and Social Care Partnerships may fund HMHM developments, while the capacity is released in Primary Care. It is also difficult to quantify some of the benefits of prevention and self-management for patients and staff as they may be more nuanced and individualised than aspects such as appointments avoided. Further, the direct cost and productivity savings for some clinical outcomes may take some time to be realised, especially for long-term health conditions.

1.7 Rationale for choosing hypertension and COPD case studies

Hypertension was selected as a case study because so many people attend their GP surgery for it, with the potential to avoid considerable costs via remote monitoring. It was also the most frequently monitored condition during the HMHM Programme. HMHM was mainly used to confirm or reject a diagnosis of high

blood pressure or to determine the right level of medication titration. Although HMHM supported long-term monitoring of hypertension in Lothian, this was researched in detail with the University of Edinburgh, so not included as a case study for this evaluation. The Lothian study included a calculation of the direct intervention cost of scaling up blood pressure monitoring, which is summarised in Appendix A.

COPD was chosen because avoiding exacerbations is good for patients and the cost of any hospital admissions is considerable. The numbers using HMHM for COPD were lower, but the benefits have the potential to outweigh the costs. Use of HMHM for COPD was mainly to support self-management and early intervention.

1.8 HMHM technologies

The majority of partners across Scotland used Simple Telehealth (Florence) SMS software for HMHM. This system was developed within the NHS, but is run by a private company that sets the costs. Although not expensive for a relatively small number of users, the costs can become considerable as the size and scale of usage increases. Florence (or Flo as 'she' is commonly known) was used in both case studies on hypertension and COPD, although Ayrshire & Arran also deployed Telehealth managed service devices ('HomePod' touch screen tablet device with Bluetooth peripherals) as part of their COPD protocol. Highland had initially used home pods as well, but had found the costs prohibitive for use at scale.

1.9 Timescales

In order to allow full economic evaluation of the HMHM data provided, it was requested for the financial year 2017/18 where possible. Although the partners have moved on since then, typically increasing their number of HMHM users over time, the approach taken allows the calculations to be updated e.g. where 'per 100 patient' numbers are included. It also allows others deploying similar technology to layer their data into the relevant tables to generate local results.

It should be noted that there was a slight delay in completing this economic evaluation since permission to link the COPD HMHM data to other datasets required an application to the Public Benefit and Privacy Panel for Health and Social Care.

2. CASE STUDY 1: BLOOD PRESSURE MONITORING IN PRIMARY CARE

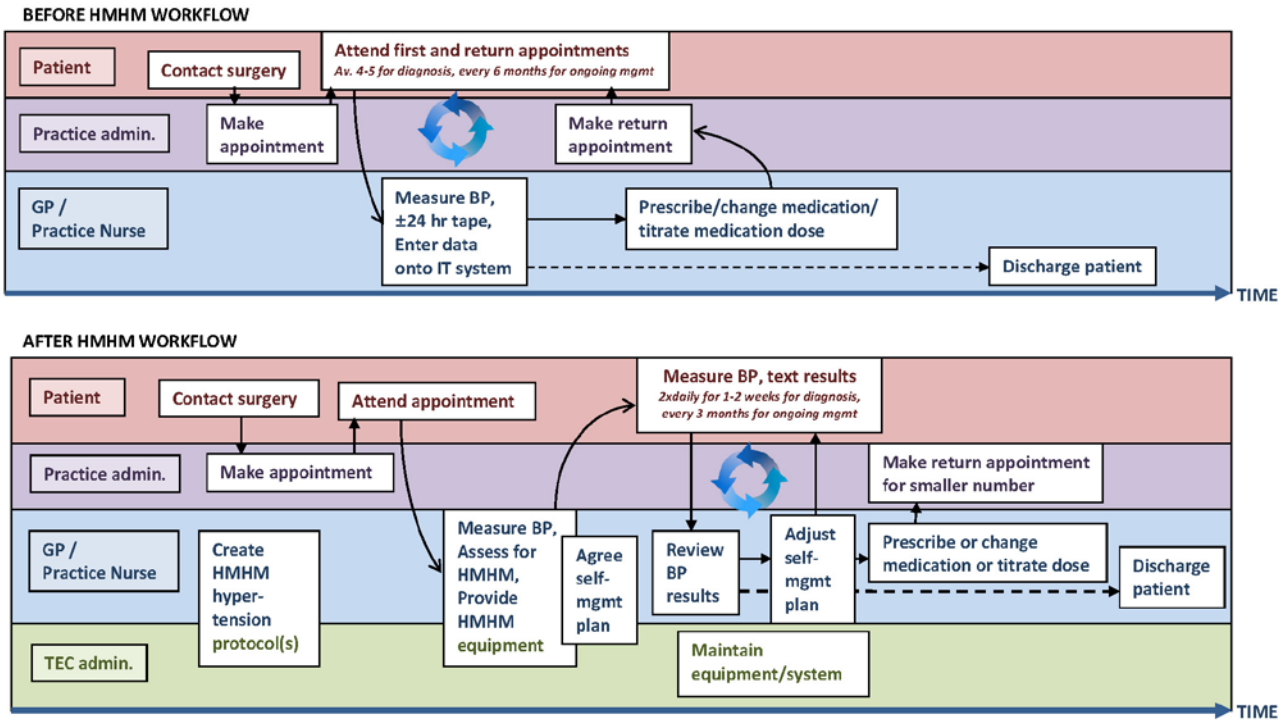
2.1 Workflows and variations

This case study focuses on the most frequently monitored condition in the national HMHM programme. The economic evaluation focused on comparing the costs and benefits of typical patient workflows before and after the introduction of HMHM. Only those aspects that were impacted by HMHM were included rather than the whole of hypertension management.

2.1.1 Before and after HMHM workflows

Figure 1 provides a representation of the hypertension HMHM workflow changes. Figure 1 shows that before the use of HMHM the GP or Practice Nurse was responsible for measuring blood pressure (BP) and the patient had to attend four or five times. There was also an impact on practice administration in terms of making initial and return appointments. After HMHM was introduced, patients had the option of signing up to be trained to use home BP monitors and text in their results, thus avoiding most return appointments. Further return appointments would only be needed for a small number of patients since changes to the self-management plan or medication dose could also be agreed remotely. This technology allows health care providers to securely connect to their patients, record the patient reported information and act accordingly.

Figure 1 – Workflows for use of HMHM in blood pressure monitoring in Primary Care



NOTE – The Ayrshire & Arran TEC Hub administer the Florence SMS system on behalf of GPs/Practice Nurses, with the results reported to clinicians for diagnosis and treatment decision-making

2.1.2 Variations in HMHM use by partners

Three partners provided data for the hypertension HMHM workflow; Ayrshire and Arran (A&A), Lanarkshire (Lan) and the Western Isles (WI) NHS Boards. Although a standardised workflow was created (Figure 1), each partner delivered HMHM for hypertension differently. These variations evolved largely in response to the preferences of Primary Care teams involved in the deployment and local TEC organisational structures. Data was provided in a range of formats including anonymised patient data extracts, responses to a customised economic evaluation data collection tool, and follow-up telephone calls.

A&A, Lan and WI provided anonymised data on avoided face to face contacts, A&A and Lan on clinical decision-making and the reasons for stopping monitoring and WI on variations in BP monitoring. This meant there were important differences in the definitions used and assumptions made between the three NHS boards which made comparisons between them difficult. The variables are illustrated in Table 1.

A&A's two protocols meant different members of staff were involved in the face to face patient contacts and a different average number of text messages were sent out for each. They assumed the split of contact time between GPs and Practice Nurses (PNs) was 40:60 for Protocol 1 and 70:30 for Protocol 2.

In Lanarkshire only the initial appointment with the practice nurse (PN) was factored onto the HMHM staff cost. Their rationale for not including staff time for sending out SMS reminders was the amount of local variation across GP surgeries. This also meant a single time split between GP and PN involvement in HMHM could not be assumed, so two splits (40:60 and 10:90) were employed in the economic modelling.

WI is one of Scotland's smallest NHS Boards, so any data provided could only be for a limited number of participants. Although this made comparisons and extrapolations difficult, their data already incorporated before and after HMHM, both with and without any treatment required for hypertension management.

Details of the assumed staff costs are included in Appendix B. They do not include those associated with introducing HMHM as these were drawn from existing resources. The benefits of avoiding 24 hour ambulatory BP monitoring (ABPM) were included since the unit cost of £53.40 (NICE, 2013) could have a big impact. Remote BP monitors can be deployed differently, so detailed projections are included in Appendix C.

Table 1 – Similarities and differences in data provided for the economic evaluation

	A&A	Lan	WI
Avoided face to face contacts counted as full appointment length	X	√	√
Centralised TEC Hub supporting HMHM included in costs	√	X	X
Staff time to send out SMS reminders included in costs	√	X	X
Separate HMHM protocols for hypertension	√*	X	X
Before and after HMHM workflows embedded in data provided	X	X	√
Costs of any treatment required embedded in data provided	X	X	√
Investment and running costs provided	√	√	X
Avoidance of ambulatory 24 hour monitoring costs provided	√	√	√

** Protocol 1 for diagnosis of hypertension, Protocol 2 for those diagnosed with hypertension*

2.2 Blood pressure monitoring results

2.2.1 Ayrshire and Arran

Ayrshire & Arran provided 10 months' worth of data for a total of 474 patients. As described above, there were separate HMHM hypertension protocols for diagnosis and for those diagnosed as having high blood pressure. The protocols required different levels of remote monitoring which meant that the number of face to face contacts avoided for patients (some used both) and the staff were different (Table 2).

Table 2 shows that a total number of 1,094 P1 contacts and 201 P2 contacts were recorded to have been avoided, a total of 1,295. This total was used to determine the monetary value (Table 3).

Table 3 shows that the monetary equivalent of appointment time saved per 100 patients in A&A was between £2.5 and £4.1k, although the inclusion of avoided 24 hour ABPM increased this considerably to £7.9 to £9.5k per 100 patients. In order to calculate Net Present Value, the benefits of using HMHM need to be compared to the running and investment costs (Tables 4 and 5).

A&A were unique in Scotland in setting up a TEC Hub to support people redesigning their services to include digital technologies. It was estimated that 15% of the TEC Hub staff costs should to be allocated to HMHM in A&A.

Table 2 – Number of avoided face to face contacts in A&A (2017/18)

No. face to face contacts	No. patients on protocol 1	No. contacts avoided by protocol 1 patients	No. patients on protocol 2	No. contacts avoided by patients on protocol 2
1 to 3	437	1038	47	96
4 to 10	11	56	20	105
TOTAL	**448**	**1094**	**67**	**201**

Table 3 – Monetary equivalent of face to face contacts avoided in A&A (2017/18)

	No. face to face contacts avoided	Equivalent cost of appointment time saved		Equivalent cost of ABPM avoided	TOTAL MONETARY EQUIVALENT	
		Min*	Max*		Min	Max
All 474 patients	1,295	£8,102	£13,791	£25,312	£33,413	£39,102
Per 100 patients	364	£2,528	£4,140	£5,340	£7,868	£9,480

* *Range based on clinicians spending between 1 and 6 minutes on face to face BP monitoring (split between GPs and PNs according to protocol 1 and 2 requirements)*

Table 4 – Running costs of hypertension HMHM in A&A (2017/18)

	Staff costs		Non-staff costs
	Minimum*	Maximum*	HMHM text bundle apportioned to hypertension†
All 474 patients	£1,289	£3,322	£5,641
Per 100 patients	£282	£759	£1,673

* *Range based on 3 to 7 minutes of TEC admin time, 5 minutes practice administration, and 1 to 6 minutes of clinician time (split between GPs and PNs as described previously)*

† *Cost per text per patient, including annual licence and membership = 20p. Protocol 1 requires 53 texts, 99 texts for protocol 2*

Table 5 – Investment costs of hypertension HMHM in A&A (2017/18)

HMHM text bundle apportioned to hypertension	BP monitors*	BP cuffs*
Initial set up cost = £477	Unit cost = £11.99†	Unit cost = £2.99
	200 units = £2,398††	245 units = £673

* *Assume replacement after 5 years*

† *A lower price for BP monitors was negotiated nationally during the HMHM Programme*

†† *A&A made a batch purchase of 200 monitors and 245 cuffs*

Ayrshire & Arran's TEC Hub

The TEC Hub is a Pan-Ayrshire service hub that is accessible through a Single Point of Contact (SPOC) and is a service function is to support staff across Health and Social Care who choose to utilise digital technologies as part of their assessment, care planning and day to day intervention for patients with long-term conditions. There are a range of digitally enhanced workflows that can be used to support remote clinical monitoring, self-management and alternative virtual services.

The hub is managed through a local partnership operational management structure and as such complies with both strategic and operational risk management and business continuity arrangements. A senior manager provides overall leadership which is delegated operationally to Team leaders and Senior Administration Management. On a day to day basis administration staff provide the service and support TEC in accordance with the standing operating procedures, protocols and guidelines. The administration staff also support the SPOC and have generic job descriptions around the roles. Within the team they have specialised areas, such as TEC, Intermediate Care etc.

Perceived advantages of this model include the ability to ensure quality standards, reduce risk and implement governance arrangements that would not be possible if there were numerous sites attempting to undertake administration monitoring. There are economies of scale as the admin team can support larger numbers of patients, users and protocols. This model has been in operation since 2014.

Net Present Value (NPV)
A range of NPVs is presented from minimum benefit for maximum cost to maximum benefit from minimum cost over a 10 year period (Table 6).

When the results are scaled to 100 patients, all scenarios yield a positive NPV over 10 years (Table 6). Consecutively adding in the benefit of avoided 24hr ABPM and then all investment costs yields even more positive NPVs, mainly due to the large effect of avoided 24 hour ABPM costs. As discussed previously, these benefits are non-cash releasing.

Break-even analysis
Break-even analysis calculates how many patients would need to use the digital technologies to recover the upfront investment costs.

Two of the scenarios for overall benefit per patient (Table 7) in Year 0 are net negative due to the assumptions around averaging per patient cost and the different approach to costs and benefits over a 10 year period in the NPV calculations (Table 6). Again, once the benefit of avoided 24 hour ABPM is added, all scenarios become net positive. With all investments added in as well, between 56 and 76 patients would have to use HMHM to break-even (although this is not cash releasing).

Table 6 – Net Present Value of hypertension HMHM in A&A over 10 years

	Avoided contacts, minus running costs	Avoided contacts plus avoided ABPM, minus running costs	Avoided contacts plus avoided ABPM, minus running and investment costs
Min benefit, max cost	£3,184	£57,770	£51,667
Min benefit, min cost	£24,107	£78,694	£72,591
Max benefit, max cost	£7,631	£62,218	£56,115
Max benefit, min cost	£19,660	£74,246	£68,143

Table 7 – Break-even analysis of hypertension HMHM in A&A over 10 years

	Net benefit per patient at Year 0 for avoided contacts, minus running costs	Net benefit per patient at Year 0 for avoided contacts plus avoided ABPM, minus running costs	No. patients needed to break-even for avoided contacts plus avoided ABPM, minus running and investment costs
Min benefit, max cost	-£7	£46	76 patients
Min benefit, min cost	-£2	£51	69 patients
Max benefit, max cost	£5	£58	60 patients
Max benefit, min cost	£10	£63	56 patients

2.2.2 Lanarkshire

Lanarkshire provided 17 months' worth of data from February 2016 to June 2017. This was for a total of 460 patients and the total number of face to face contacts avoided in shown in Table 8.

A total of 1,966 contacts were avoided in 17 months, which equates to 1,388 (for 325 patients) in one year. This total was used to determine the monetary equivalent value (Table 9).

The Lanarkshire model defines one avoided face to face contact to be a full appointment, does not include TEC team costs and there is no TEC Hub. Table 9 shows that the monetary equivalent value of appointment time saved per 100 patients in Lanarkshire was between £2k and £4.4k, although the inclusion of avoided 24 hour ABPM increased this considerably to £7.4k to £9.8k per 100 patients. To calculate the Net Present Value, these benefits need to be compared to the running and investment costs (Tables 10 and 11).

Table 8 – Number of avoided face to face contacts in Lan (Feb 2016 to June 2018)

No. face to face contacts	No. patients on HMHM protocol	No. contacts avoided by patients on HMHM protocol
0	3	0
1 to 3	251	517
4 to 10	184	1,125
11 to 20	21	324
TOTAL	459*	1,966

* *Data missing for one patient*

Table 9 – Monetary equivalent of face to face contacts avoided in Lan (Feb 2016 to June 2018)

	No. face to face contacts avoided	Equivalent cost of appointment time saved		Equivalent cost of ABPM avoided	TOTAL MONETARY EQUIVALENT	
		Minimum*	Maximum*		Minimum	Maximum
40:60 GP:PN involvement						
All 325 patients	1,388	£8,286	£14,364	£17,339	£25,625	£31,704
Per 100 patients	427	£2,552	£4,424	£5,340	£7,892	£9,764
10:90 GP:PN involvement						
All 325 patients	1,388	£6,552	£12,553	£17,339	£23,892	£29,892
Per 100 patients	427	£2,018	£3,866	£5,340	£7,358	£9,206

* *Minimum time saved = 3 minutes of administration + 10 minutes Practice Nurse + 8 minutes GP time. Maximum time saved = 4 minutes of administration + 20 minutes Practice Nurse + 12 minutes GP time*

Table 10 – Running costs of hypertension HMHM in Lan (Feb 2016 to June 2018)

	Staff costs*	Non-staff costs
		HMHM text bundle apportioned to hypertension†
All 325 patients	£2,460	£1,494
Per 100 patients	£758	£460

* *Based on one PN initial appointment and weekly SMS reminders*
† *Cost per text per patient, including annual licence and membership = 20p. Average of 23 texts per patient*

Table 11 – Investment costs of hypertension HMHM in Lan (Feb 2016 to June 2018)

HMHM text bundle apportioned to hypertension	BP monitors*		BP cuffs*
	Minimum†	Maximum†	
Initial set up cost = £525	Unit cost = £11.99†	Unit cost = £15.00†	Unit cost = £2.99
	200 units = £2,398††	200 units = £3,000††	245 units = £673

* *Assume replacement after 5 years*
† *A lower price for BP monitors was negotiated nationally during the HMHM Programme. Lan initially paid more but was central to ensuring the reduction*
†† *Assume same investment as A&A batch purchases (200 monitors and 245 cuffs)*

Table 12 – Net Present Value of hypertension HMHM in Lan over 10 years

	Avoided contacts, minus running costs	Avoided contacts plus avoided ABPM, minus running costs	Avoided contacts plus avoided ABPM, minus running and investment costs
40:60 GP:PN involvement			
Min benefit, max cost	£14,741	£22,485	£15,195
Max benefit, min cost	£33,877	£41,621	£35,440
10:90 GP:PN involvement			
Min benefit, max cost	£7,456	£57,207	£51,026
Max benefit, min cost	£24,673	£74,424	£67,134

Table 13 – Break-even analysis of hypertension HMHM in Lan over 10 years

	Net benefit per patient at Year 0 for avoided contacts, minus running costs	Net benefit per patient at Year 0 for avoided contacts plus avoided ABPM, minus running costs	No. patients needed to break-even for avoided contacts plus avoided ABPM, minus running and investment costs
40:60 GP:PN involvement			
Min benefit, max cost	£13	£67	63 patients
Min benefit, min cost	£32	£85	42 patients
10:90 GP:PN involvement			
Max benefit, max cost	£8	£61	68 patients
Max benefit, min cost	£26	£80	45 patients

The number of SMS texts for each patient using HMHM is not set by the protocol in Lanarkshire but based on clinical need.

Net Present Value (NPV)
A range of NPVs is presented for 100 patients from minimum benefit for maximum cost to maximum benefit from minimum cost over a 10 year period (Table 12). All of the net benefit approaches are net positive (Table 12), even before adding avoided 24 hour ABPM. This is mainly due to the optimistic assumptions around staff time avoided and new staff time needed for HMHM use.

Break-even analysis
Break-even analysis calculates how many patients would need to use the digital technologies to recover the upfront investment costs.

Again all of the scenarios for overall benefit per patient in Year 0 are net positive (Table 13). With all investments added in as well, between 42 and 68 patients would have to use HMHM to break-even (although this is not cash releasing).

2.2.3 Western Isles

The Western Isles model takes a different approach to those of A&A and Lanarkshire. Four components (non-HMHM with and without hypertension treatment, HMHM with and without treatment) were analysed by their TEC team. If treatment was required, the number of contacts avoided was greater, generating more benefits. The range of avoided times was estimated for the 13 patients, rather than direct data capture at patient level. As previously discussed, the WI population is considerably smaller than the other two hypertension case study areas, so any extrapolations from their sample of 13 patients need to be treated with caution.

Given that the WI model already distinguished between before and after HMHM, staff cost were intrinsic so are not re-considered to avoid double counting. To calculate the Net Present Value, the above benefits need to be compared to the running and investment costs (Tables 15 and 16). The cost of SMS is assumed to be the same as Lanarkshire, the purchasing costs of BP monitors and cuffs as A&A.

Table 14 – Monetary equivalent of face to face contacts avoided in WI (2016/17)

	Equivalent cost of appointment time saved				Equivalent cost of ABPM avoided
	No hypertension treatment		Hypertension treatment required		
	Minimum	Maximum	Minimum	Maximum	
All 13 patients	£142	£337	£193	£437	£694
Per 100 patients	£1,096	£2,590	£1,484	£3,365	£5,340

Table 15 – Running costs of hypertension HMHM in WI (2016/17)

	Staff costs	Non-staff costs
		HMHM text bundle apportioned to hypertension†
All 13 patients	Intrinsic in WI model	£24
Per 100 patients		£185

† *Cost per text per patient, including annual licence and membership = 20p. Average of 23 texts per patient*

Table 16 – Investment costs of hypertension HMHM in WI (2016/17)

HMHM text bundle apportioned to hypertension	BP monitors*	BP cuffs*	Protocol development	Training
Contract cost for 20 users = £450	Unit cost = £15.00†	Unit cost = £2.99	£195	£116
	20 units = £300††	2xboxes of 20 = £60		

* *Assume replacement after 5 years*
† *WI costs relate to the period before the lower price for BP monitors was negotiated nationally*
†† *Assume same investment as A&A batch purchases (200 monitors and 245 cuffs)*

Net Present Value (NPV)
A range of NPVs is presented for 100 patients from minimum benefit for maximum cost to maximum benefit from minimum cost over a 10 year period (Table 17).

Again, all of the net benefit approaches are net positive (Table 17), even before adding 24 hour ABPM. Absolute numbers are smaller, and it is assumed that patient numbers continue to be constant over time.

Break-even analysis
Break-even analysis calculates how many patients would need to use the digital technologies to recover the upfront investment costs.

Again all of the scenarios for overall benefit per patient in Year 0 are net positive (Table 18). With all investments added in as well, between 13 and 18 patients would have to use HMHM to break-even given the relatively low estimated investment cost (although this is not cash releasing).

2.3 Avoided travel time

The Scale-up BP study in Lothian (Appendix A) calculated how much travel was avoided by using HMHM. They gave permission to reproduce this below, to augment the case study cost benefit analysis. The Lothian team calculated that in a cohort of 100 patients:

- 48 people would travel by private car, 33 would walk and 19 would use public transport. Based on at least one avoided

Table 17 – Net Present Value of hypertension HMHM in WI over 10 years

	Avoided contacts, minus running costs	Avoided contacts plus avoided ABPM, minus running costs	Avoided contacts plus avoided ABPM, minus running and investment costs
Treatment required			
Min benefit, max cost	£9,481	£64,067	£62,002
Max benefit, min cost	£24,749	£79,335	£77,270
Treatment not required			
Min benefit, max cost	£13,442	£68,028	£65,963
Max benefit, min cost	£32,671	£87,258	£85,193

Table 18 – Break-even analysis of hypertension HMHM in WI over 10 years

	Net benefit per patient at Year 0 for avoided contacts, minus running costs	Net benefit per patient at Year 0 for avoided contacts plus avoided ABPM, minus running costs	No. patients needed to break-even for avoided contacts plus avoided ABPM, minus running and investment costs
Treatment required			
Min benefit, max cost	£9	£63	18 patients
Min benefit, min cost	£24	£77	15 patients
Treatment not required			
Max benefit, max cost	£13	£66	17 patients
Max benefit, min cost	£32	£85	13 patients

appointment for these methods of travel and an average cost of £0.60 for each public transport journey and £1.94 by private car, HMHM for BP monitoring would save £104.57

- A journey was on average 20 to 30 minutes. For 100 people this would equate to between 33.20 and 50 hours saved

2.4 Avoided productivity loss

The Lothian team also calculated that in a cohort of 100 patients:

- 7 people missed work to attend a BP monitoring appointment, an average of 2.3 days for all 100. For one patient this would be a loss of average earnings per day (ONS, 2016) of £110 and the overall costs for seven people missing 2.3 days of work was £1,800

2.5 Key hypertension HMHM findings

The benefits of using HMHM for BP monitoring considered in this analysis are avoided face to face contacts and reduced need for 24 hour Ambulatory Blood Pressure Monitoring. The savings are not cash releasing, but do release staff capacity. Any longer-term benefits such as better BP control leading to reductions in heart disease and strokes have not been included.

Use of **HMHM is cost-effective** for hypertension over a 10 year period. All the scenarios in the modelling are net positive. Comparing costs before and after HMHM shows that:

- Net Present Value over 10 years is between £52k and £73k in Ayrshire & Arran per 100 patients
- Net Present Value over 10 years is between £15k and £67k in Lanarkshire per 100 patients
- Net Present Value over 10 years is between £62k and £85k in the Western Isles per 100 patients

Capacity is released using HMHM for hypertension. Comparing costs and benefits shows:

- Between 56 and 76 patients need to use HMHM for hypertension in Ayrshire & Arran to break-even
- Between 42 and 68 patients need to use HMHM for hypertension in Lanarkshire to break-even
- Between 13 and 18 patients need to use HMHM for hypertension in the Western Isles to break-even

Patient travel time is avoided by using HMHM for hypertension

- The Lothian team estimated that between 33 and 50 hours of travelling time and £105 in travel costs is avoided per 100 patients

Productivity is increased by using HMHM for hypertension

- The Lothian team estimated that £1,800 in loss of earnings is avoided per 100 patients having their BP monitored remotely

Savings can be increased by the use of service models that encourage recycling of the blood pressure monitors for use by other patients. This has not been included in the modelling but is of growing interest.

3. CASE STUDY 2: CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

3.1 Workflows and variations

This case study was chosen because of the potential to avoid both exacerbations of the condition and hospital admissions. Although the numbers using HMHM are smaller than for hypertension, the benefits have the potential to outweigh the costs.

The use of HMHM for COPD was so different across the three partners providing data for the economic evaluation that it was not possible to create a standardised representation of the workflow. Separate workflows were produced for Ayrshire & Arran and Highland (High) to illustrate their different approaches.

No workflow was generated for West Dunbartonshire since their use of HMHM is linked to telecare deployment, and this would have required a hybrid workflow outwith the scope of this economic evaluation.

Ayrshire & Arran's COPD protocol is for patients who are experiencing exacerbations of their COPD. Figure 2 shows that A&A use two different HMHM technologies for COPD, namely Telehealth solutions (HomePod) and Simple Telehealth (Florence) SMS. HomePods are installed in a patient's home and (after they have been trained to use them) enable them to measure a range of symptoms relevant to their condition as well as oxygen saturation levels. This initial phase of

Figure 2 – Workflows for the use of HMHM in COPD in the community in A&A

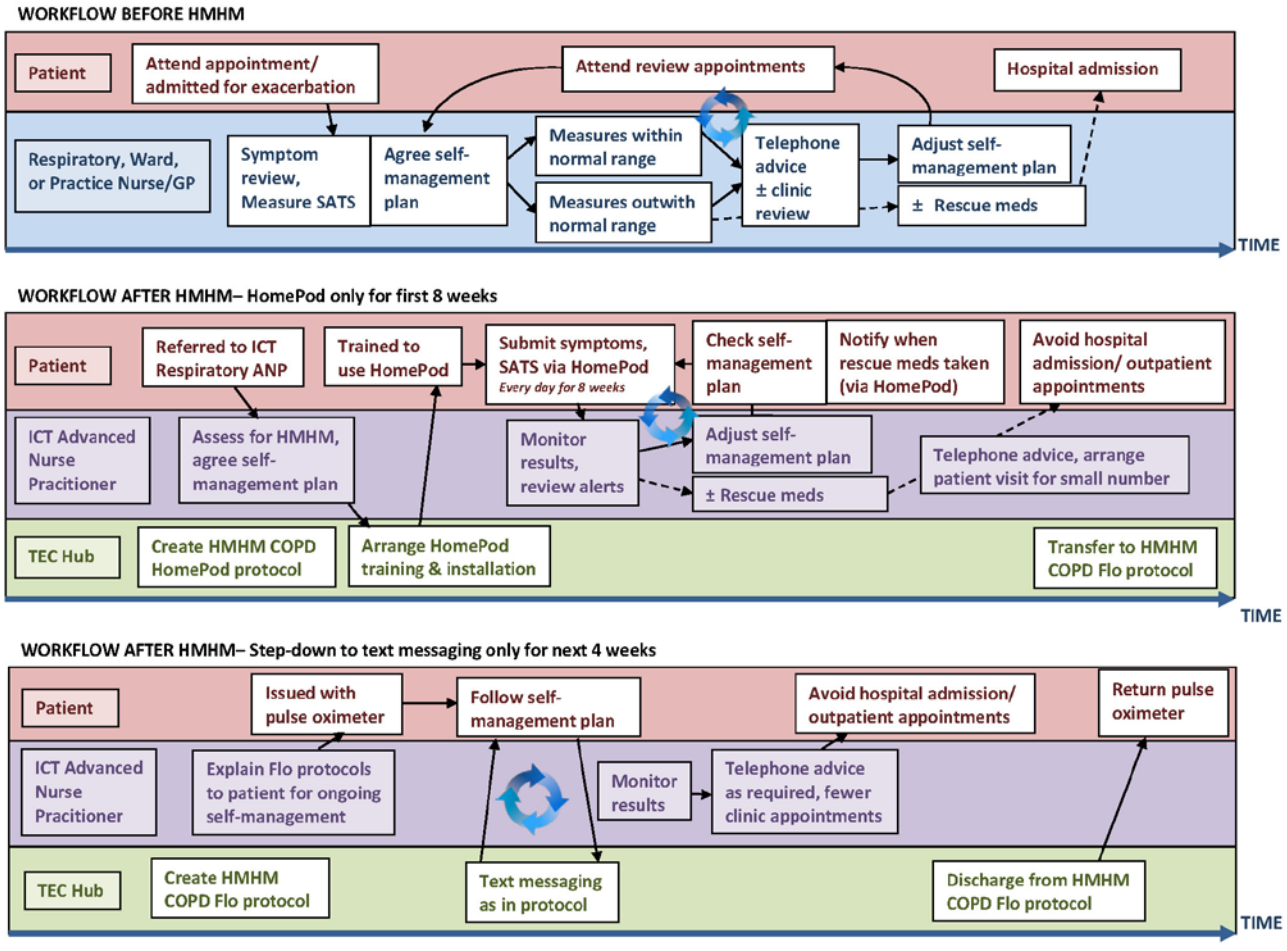
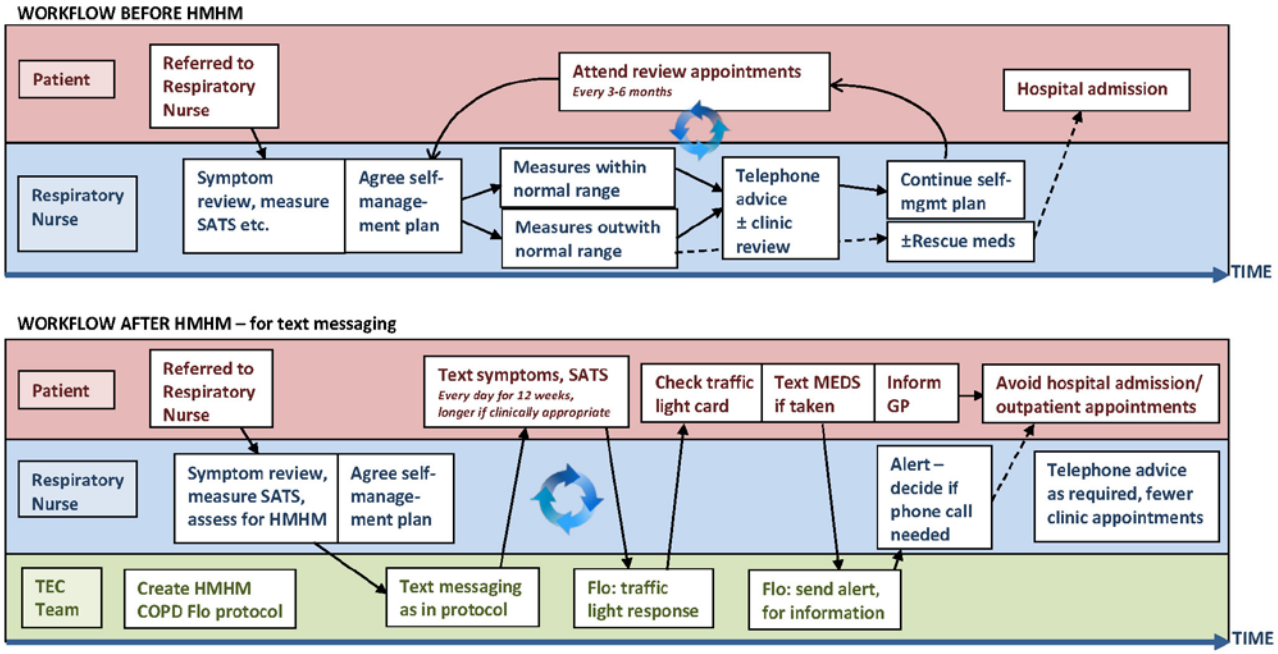


Figure 3 – Workflows for the use of HMHM for COPD in the community in Highland



HMHM for COPD lasts for approximately eight weeks, after which the patients step down to four weeks of SMS to text results from a pulse oximeter. The cost of installing and managing HomePods is considerably greater than the SMS solution, but they are useful for those requiring enhanced access and feedback.

Although the team in Highland initially started using home pods for COPD monitoring, they found the cost prohibitive at an early stage and moved to only using Simple Telehealth (Florence) SMS to support self-management in the community. HMHM is offered to patients by the specialist respiratory nurses so tends to be used by people with more severe COPD. These nurses also accept referrals from GPs. Figure 3 shows that Highland's COPD protocol includes an alert that tells the patient to consult their traffic light management plan. Depending on the colour of the traffic light, the advice may be to take medication as prescribed to prevent an exacerbation. HMHM for COPD is used for at least 12 weeks in Highland, with daily texting of symptoms and oxygen saturation levels.

West Dunbartonshire patients also monitor their COPD using only Simple Telehealth (Florence) SMS, but they are also offered a community alarm. Some patients opt to have both but most use only Florence (Flo). Patients are not discharged from Flo but continue to monitor their symptoms and oxygen saturation levels for a long time.

Data for the COPD case studies had to be linked to emergency interventions and prescribing information, which required an application to the Public Benefit & Privacy Panel for health and social care. Approval was given to extract and link data on A&E attendances, NHS24 and ambulance calls, COPD prescribing and emergency hospital admissions for the six month period before the start of HMHM and the six months after the start date i.e. including the monitoring period. The defined follow up period reduced the number of patients included since some had started using HMHM less than six months previously. All patients who died during the six month follow up period were excluded from the analysis (1% of A&A, 3% of Highland, none in W Dunb), although those who died shortly afterwards were not. There was no adjustment for the seasonality of COPD, although the spread of starts across 10 months included those monitoring in the winter and the summer and there was a full year of data for everyone.

3.2 COPD monitoring results

The COPD results are for Net Present Values only since no break-even analyses were conducted. The costs associated with HMHM for COPD are all running costs, rather than implementation costs and therefore rise linearly with the number of patients using the technology. This means there cannot be a break-even point at which implementation costs are recouped.

3.2.1 Ayrshire & Arran (A&A)

Table 19 shows the number of patients using a home pod / Florence for HMHM. Calculating the costs avoided for these 484 patients required linked data on any A&E attendances, calls to NHS24 or the ambulance service, details of prescriptions for their COPD, and any emergency hospital admissions, (Table 20).

Table 20 shows that there were considerable reductions in the number of A&E attendances, calls to NHS24 and emergency hospital admissions after people started using HMHM for COPD. There was a slight reduction in calls to the ambulance service, and an increase in the number of items prescribed for COPD. These changes were used to calculate potential savings (Table 21).

Table 21 shows the potential savings based on the data available before and after remote monitoring for COPD in A&A. Although the cost of prescriptions was the only aspect that rose after HMHM, this was outweighed by savings in healthcare contacts. The actual total saved could be £51k, or nearly £11k per 100 patients, funding that could be deployed elsewhere.

In order to calculate the Net Present Value, the above savings need to be compared to the running and investment costs of HMHM (Table 22).

Net Present Value

Minimum and maximum NPVs are presented (Table 23) showing the present value of benefits for different scenarios, including and excluding emergency hospital admissions. Table 23 shows clearly that the inclusion of avoided emergency hospital admissions in benefits accounting makes a vital difference to the overall NPV, taking it from net negative to considerably positive.

Table 19 – No. patients using HMHM for COPD in A&A

	2014	2015	2016	2017	2018	All patients
Home pod only	6	68	119	131	85	409
Home pod + Flo	-	-	18	48	9	75
All patients	6	68	137	179	94	484

Table 20 – Healthcare contacts for patients using HMHM for COPD in A&A

	No. patients with data	Six months before HMHM			Six months after HMHM			% change
		No. contacts /items	Average per patient	No. bed days	No. contacts /items	Average per patient	No. bed days	
A&E attendance for respiratory (Jan 2014 to 31 Aug 2018)								
434 patients	164	352	2.1	N/A	228	1.4	N/A	-35%
Per 100 patients	38	81			53			
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)								
441 patients	66	108	1.6	N/A	66	1.0	N/A	-39%
Per 100 patients	15	24			15			
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)								
441 patients	77	84	1.1	N/A	78	1.0	N/A	-7%
Per 100 patients	17	19			18			
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)								
434 patients	429	4,578	10.7	N/A	5,244	12.2	N/A	+15%
Per 100 patients	99	1,055			1,208			
Emergency hospital admissions for COPD (Jan 2014 to 31 Dec 2018)								
484 patients	91	59	Av.LoS*	390	32	Av.LoS*	241	-46%
Per 100 patients	19	12	= 6.6	81	7	= 7.5	50	

** Average length of stay in a hospital bed*

Table 21 – Potential savings for patients using HMHM for COPD in A&A

	Cost per contact/item	Costs before HMHM	Costs after HMHM	POTENTIAL SAVING
A&E attendance for respiratory (Jan 2014 to 31 Aug 2018)				
434 patients	£138	£48,576	£31,464	£17,112
Per 100 patients		£11,193	£7,250	£3,943
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)				
441 patients	£40	£4,320	£2,640	£1,680
Per 100 patients		£979	£597	£380
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)				
441 patients	£310	£26,024	£24,165	£1,859
Per 100 patients		£5,901	£5,480	£422
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)				
434 patients	£13	£59,782	£68,479	- £8,697
Per 100 patients		£13,775	£15,779	- £2,004
Emergency hospital admissions for COPD (Jan 2014 to 31 Dec 2018)				
484 patients	£1,453	£85,727	£46,496	£39,231
Per 100 patients		£17,712	£9,607	£8,106
ACTUAL TOTALS		£224,429	£173,244	**£51,185**
PER 100 PATIENT TOTALS		£49,560	£38,713	**£10,847**

Table 22 – Investment and running costs of COPD HMHM in A&A

	Non-staff costs			Staff costs		TOTAL COSTS	
	8 weeks home pod	4 weeks Flo		8 weeks home pod	4 weeks Flo	Min[1]	Max[2]
		Min[1]	Max[2]				
409 home pod patients	£68,123	N/A		£72,556	N/A	£140,679	
75 home pod + Flo patients	£12,492	£2,282	£6,378	£13,306	£116	£28,197	£32,292
All 484 patients	£80,615	£2,282	£6,378	£85,863	£116	£168,876	£172,971
Per 100 patients	£16,656	£472	£1,318	£17,740	£116	£34,892	£35,738

1 *5% Flo licence costs apportioned to COPD + cheapest pulse oximeter* (£18.68, incl. *VAT*)
2 *7% Flo licence costs apportioned to COPD + pulse oximeter cost of £70 (incl. VAT)*

Table 23 – Net Present Value of COPD HMHM in A&A over 10 years per 100 patients

	Excluding avoided emergency admissions	Including avoided emergency admissions
Min benefit, max cost	- £188,658	£28,137,041
Max benefit, min cost	- £221,166	£25,533,747

3.2.2 West Dunbartonshire (WDunb)

West Dunbartonshire patients monitoring their COPD using Simple Telehealth (Florence) SMS are also offered a community alarm. Some patients agree to have both but most use Florence (Flo) without a community alarm. Patients are not discharged from Flo and the absolute numbers are small due to the population size. Table 24 shows the number of patients using Flo for HMHM and a community alarm since their introduction.

Calculating the costs avoided for these 76 patients required linked data on any calls to NHS24 or the ambulance service, details of prescriptions for COPD, and any emergency hospital admissions (Table 25). A&E attendance data was not available as it could not be disaggregated from others in the NHS Board area (Greater Glasgow & Clyde).

Table 25 shows a considerable reduction in calls to NHS24 and the ambulance service and an even bigger reduction in emergency hospital admissions following HMHM for COPD. These were used to calculate potential savings (Table 26).

Table 26 shows the potential savings based on the data available before and after remote monitoring for COPD in West Dunbartonshire. Although the cost of prescriptions was the only aspect that rose after HMHM, this was outweighed by savings in healthcare contacts. The actual total saved could be £11k, or £15k per 100 patients, funding that could be deployed elsewhere.

In order to calculate the Net Present Value, the above savings need to be compared to the running and investment costs of HMHM (Table 27).

Table 24 – No. patients using HMHM for COPD in WDunb

	2016	2017	2018	All patients
Flo	2	26	39	67
Flo + alarm	1	4	4	9
All patients	3	30	43	76

Table 25 – Healthcare contacts for patients using HMHM for COPD in WDunb

	No. patients with data	Six months before HMHM			Six months after HMHM			% change
		No. contacts /items	Average per patient	No. bed days	No. contacts /items	Average per patient	No. bed days	
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)								
57 patients	6	15	2.5	N/A	6	1.0	N/A	- 60%
Per 100 patients	11	26			11			
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)								
57 patients	11	13	1.2	N/A	9	0.8	N/A	- 31%
Per 100 patients	19	23			16			
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)								
50 patients	50	522	10.4	N/A	565	11.3	N/A	+ 8%
Per 100 patients	100	1044			1130			
Emergency hospital admissions for COPD (Jan 2014 to 31 Dec 2018)								
76 patients	9	9	Av.LoS*	31	2	Av.LoS*	9	- 78%
Per 100 patients	11	12	= 3.4	41	3	= 4.5	12	

** Average length of stay in a hospital bed*

Table 26 – Potential savings for patients using HMHM for COPD in WDunb

	Cost per contact/item	Costs before HMHM	Costs after HMHM	POTENTIAL SAVING
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)				
57 patients	£40	£600	£240	£360
Per 100 patients		£1,053	£421	£632
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)				
57 patients	£310	£4,027	£2,788	£1,239
Per 100 patients		£7,066	£4,892	£2,174
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)				
50 patients	£13	£6,817	£7,378	- £562
Per 100 patients		£13,633	£14,756	- £1,123
Emergency hospital admissions for COPD (Jan 2014 to 31 Dec 2018)				
76 patients	£1,453	£13,077	£2,906	£10,171
Per 100 patients		£17,207	£3,824	£13,383
ACTUAL TOTALS		**£24,521**	**£13,312**	**£11,209**
PER 100 PATIENT TOTALS		**£38,959**	**£23,893**	**£15,066**

Table 27 – Investment and running costs of COPD HMHM in WDunb

	Non-staff costs				Staff costs		TOTAL COSTS	
	Alarm yr 1	Alarm yr 2	Flo	Pulse oximeter	Min[1]	Max[2]	Minimum[1]	Maximum[2]
67 Flo patients	N/A	N/A	£619	£3,618	£578	£656	£4,815	£4,893
9 Flo + alarm	£2,628	£1,411	£83	£486	£1,112	£1,122	£3,092	£4,320
All 76 patients	£2,628	£1,411	£702	£4,104	£1,690	£1,778	£7,907	£9,213
Per 100 patients	£3,458	£1,857	£923	£5,400	£2,224	£2,339	£10,404	£12,121

1 *Minimum = 5 minutes of Band 3 administration time + Band 5 nurse time*
2 *Maximum = 10 minutes of Band 4 administration time + Band 6 nurse time*

Table 28 – Net Present Value of COPD HMHM in WDunb over 10 years per 100 patients

	Excluding avoided emergency admissions	Including avoided emergency admissions
Min benefit, max cost	- £618,290	£495,672
Max benefit, min cost	£176,168	£1,364,395

Net Present Values (NPV)
Minimum and maximum NPVs are presented (Table 28) showing the present value of benefits for different scenarios, including and excluding emergency hospital admissions.

Table 28 shows clearly that the inclusion of avoided emergency hospital admissions in benefits accounting makes a vital difference to the overall NPV, taking it from net negative to positive, even when minimum benefit and maximum cost is assumed.

3.2.3 Highland

In NHS Highland, Simple Telehealth (Florence) SMS is used to support self-management for COPD patients, primarily outside primary care. It is offered by the specialist respiratory nurses who see the people with more severe COPD. They also receive referrals from GPs. Table 29 shows the number of people using HMHM for COPD in Highland.

Calculating the costs avoided for these 76 patients required linked data on A&E attendance, calls to the ambulance service or NHS24, details of prescriptions for their COPD, and any hospital admissions (Table 30).

Table 30 shows a sizeable reduction in calls to NHS24 and a greater reduction to the ambulance service, attendances at A&E and in emergency hospital admissions following HMHM for COPD. These changes were used to calculate potential savings (Table 31).

Table 31 shows the potential savings based on the data available before and after remote monitoring for COPD in Highland. The cost of prescriptions was the only aspect that rose after HMHM, and this was outweighed by savings in healthcare contacts. The actual total saved could be £15k, or over £23k per 100 patients, funding that could be deployed elsewhere.

In order to calculate the Net Present Value, the above savings need to be compared to the running and investment costs of HMHM (Table 32).

Table 29 – No. patients using HMHM for COPD in Highland

	2017	2018	All patients
All patients	31	44	76

Table 30 – Healthcare contacts for patients using HMHM for COPD in Highland

	No. patients with data	Six months before HMHM			Six months after HMHM			% change
		No. contacts /items	Average per patient	No. bed days	No. contacts /items	Average per patient	No. bed days	
A&E attendances for respiratory (Jan 2014 to 31 May 2019)								
76 patients	30	42	1.4	N/A	21	0.7	N/A	- 50%
Per 100 patients	39	55			28			
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)								
51 patients	6	12	2.0	N/A	9	1.5	N/A	- 25%
Per 100 patients	12	24			18			
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)								
51 patients	17	18	1.1	N/A	2	0.1	N/A	- 89%
Per 100 patients	33	35			4			
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)								
46 patients	44	630	14.3	N/A	647	14.7	N/A	+ 3%
Per 100 patients	96	1,370			1,407			
Emergency hospital admissions for COPD (Jan 2014 to 31 Aug 2018)								
72 patients	11	8	Av.LoS*	43	3	Av.LoS*	22	- 63%
Per 100 patients	15	11	= 5.4	60	4	= 7.3	31	

** Average length of stay in a hospital bed*

Table 31 – Potential savings for patients using HMHM for COPD in Highland

	Cost per contact/item	Costs before HMHM	Costs after HMHM	POTENTIAL SAVING
A&E attendances for respiratory (Jan 2014 to 31 May 2019)				
76 patients	£138	£5,796	£2,898	£2,898
Per 100 patients		£7,626	£3,813	£3,813
NHS24 calls for respiratory (Jan 2014 to 9 Sept 2018)				
51 patients	£40	£480	£360	£120
Per 100 patients		£941	£706	£235
Scottish Ambulance Service (SAS) calls for respiratory (Jan 2014 to 9 Sept 2018)				
51 patients	£310	£5,577	£620	£4,957
Per 100 patients		£10,934	£1,215	£9,719
No. items prescribed for COPD (Jan 2014 to 31 Aug 2018)				
46 patients	£13	£8,277	£8,449	- £222
Per 100 patients		£17,885	£18,367	- £483
Emergency hospital admissions for COPD (Jan 2014 to 31 Dec 2018)				
72 patients	£1,453	£11,624	£4,359	£7,265
Per 100 patients		£16,144	£6,054	£10,090
ACTUAL TOTALS		**£31,704**	**£16,686**	**£15,018**
PER 100 PATIENT TOTALS		**£53,530**	**£30,155**	**£23,375**

Table 32 – Investment and running costs of COPD HMHM in Highland

	Non-staff costs			Staff costs		TOTAL COSTS	
	Flo min[1]	Flo max[2]	Pulse oximeter	Min[1]	Max[2]	Min[3]	Max[4]
76 Flo patients	£3,384	£4,104	£1,733	£347	£2,418	£5,465	£6,522

1 *Licence cost plus text bundle = £21.72 per patient*
2 *Text bundle = £27 per three months*
3 *Band 6 staff taking 10 minutes per patient*
4 *Band 7 staff taking 60 minutes per patient*

Table 33 – Net Present Value of COPD HMHM in Highland over 10 years per 100 patients

	Excluding avoided emergency admissions	Including avoided emergency admissions
Min benefit, max cost	£332,140	£23,023,970
Max benefit, min cost	£366,362	£23,058,192

Net Present Values (NPV)
Minimum and maximum NPVs are presented (Table 33) showing the present value of benefits for different scenarios, including and excluding emergency hospital admissions.

Table 33 shows that, in the case of NHS Highland, the NPV for all Flo pathways is positive, independent of inclusion or exclusion of avoided admissions in the benefits accounting.

3.3 Key COPD HMHM findings

It should be remembered that the HMHM benefits of avoided A&E attendances, NHS24/SAS calls or hospital admissions are not cash releasing, but release staff capacity.

HMHM is cost-effective for COPD over a 10 year period. When the cost of emergency hospital admissions avoided is included, a comparison of costs with and without HMHM shows:

- NPV over 10 years is between £26m and £28m in Ayrshire & Arran per 100 patients
- NPV over 10 years is between £496k and £1.4m in West Dunbartonshire per 100 patients
- NPV over 10 years is approximately £23m in Highland per 100 patients

People using HMHM for COPD had **fewer NHS24 and ambulance service call-outs** and used fewer emergency admission bed days for their COPD in the six months after starting monitoring compared to the six months before.

- In Ayrshire & Arran and Highland they also had fewer A&E attendances in the six months after starting HMHM than before. (This data was not available for West Dunbartonshire)

People using HMHM for COPD had an **increased number of items prescribed** for their condition in the six months after starting monitoring compared to the six months before.

No break-even analyses could be conducted for the COPD case studies. Costs associated with the workflows were determined to be running costs (which rise linearly with the number of patients monitoring) rather than implementation costs.

4. DISCUSSION AND IMPLICATIONS FROM THESE CASE STUDIES

The case studies included in this economic evaluation represent two of the conditions currently of most interest for Home and Mobile Health Monitoring (HMHM). Hypertension has the highest number of remote monitoring users in Scotland and as such is the closest to a tipping point to become business as usual for services diagnosing and managing high blood pressure. The need to be aware of the potential costs and savings of hypertension HMHM is hugely relevant at present with the national funding of 'Scale Up BP'. COPD is also of interest, but for a different reason; anything that has the potential to improve its management and avoid hospital admissions can considerably improve patients' circumstances and outcomes, at a vastly reduced cost to the NHS.

Despite considerable local variation between the partners providing data for these case studies, all of the scenarios modelled were shown to be cost effective over a 10 year period. Although most of the benefits are non-cash releasing, aspects such as avoided appointments do create additional capacity for staff working across primary and secondary care, many of whom work under considerable pressure.

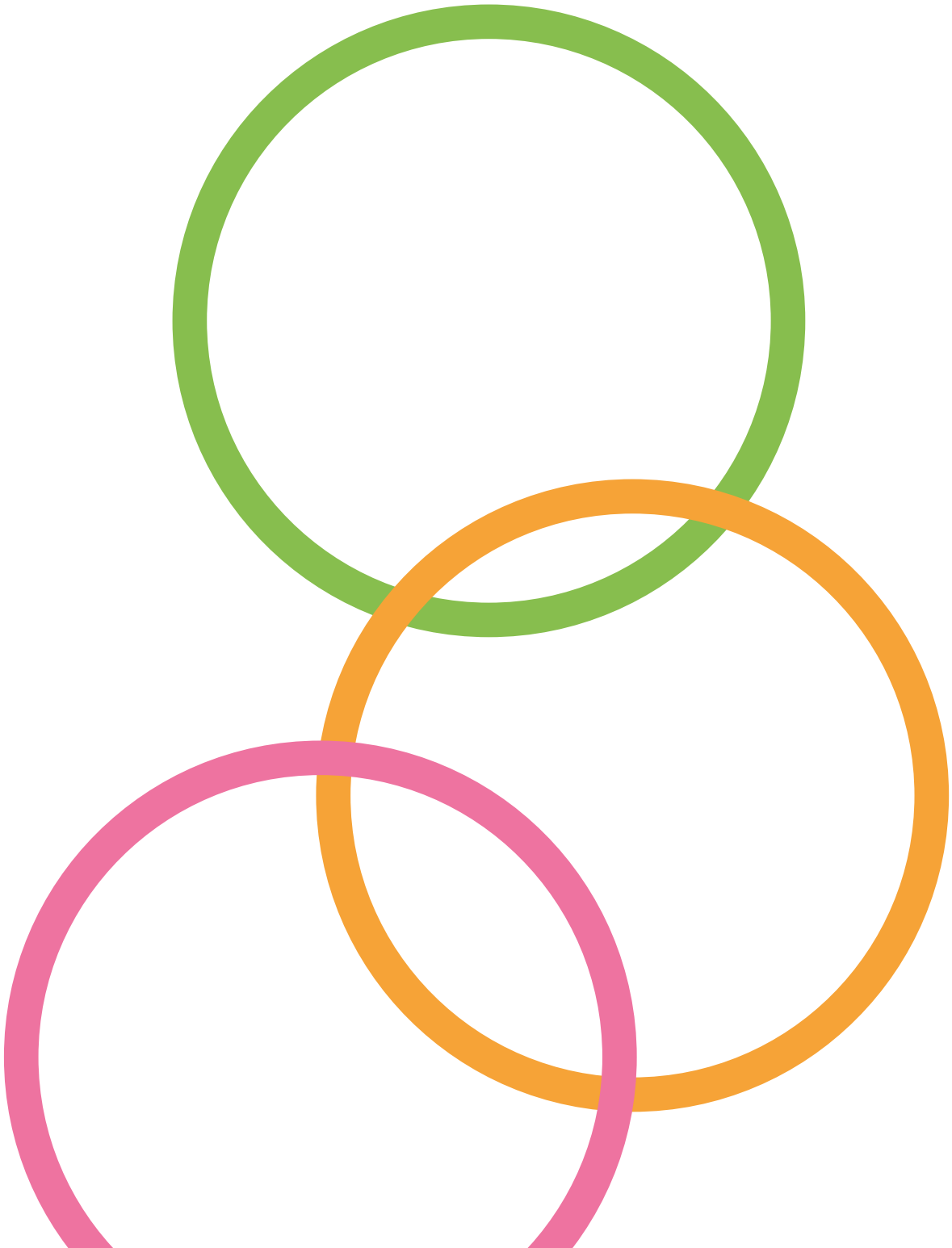
The return on investment is net positive over 10 years for hypertension and the return is greater for the larger populations studied in this report. The return is also positive for smaller populations, and is likely to be in proportion to the overall system budget. Capacity is released for hypertension HMHM and only 40 to 70 patients need to use it in larger populations to break-even between the cost of introducing the technology and realising savings. Other important benefits include patients avoiding travelling time and increasing productivity by not being absent from work to have their blood pressure monitored face to face.

Similar positive results were also generated for COPD, with all three case study areas showing net positive gains over a 10 year period. The return on investment was an order of magnitude larger than for hypertension, being up to £28 million per 100 patients in the larger case study populations. In general, people using HMHM for COPD self-management had fewer A&E attendances, NHS24 and ambulance call-outs and fewer emergency admissions to hospital in the six months after HMHM than the six before. Although the three case study areas had different models of HMHM implementation, notably Ayrshire & Arran using relatively expensive HomePods, the net present values were still positive when the cost of avoided hospital admissions was included in the modelling. It may be possible to cite this result in negotiations with national procurement to drive down the cost of the monitoring technologies.

HMHM improves other outcomes for hypertension and COPD, including self-management, condition control and access to services (Alexander, 2018). The savings from this have not been included in this economic modelling. Neither have the savings from recycling blood pressure monitors since there is no identified proportion of all monitors that are generally returned. Different areas use the remote monitors for their own combination of diagnosis/medication titration/ongoing management, so the proportion recycled (after diagnosis/medication titration) varies from place to place.

Given the variation in use of HMHM for hypertension and COPD across the different partners, future economic evaluations would benefit from any moves to standardise delivery models. Ideally, definitions and assumptions

would be agreed at the outset by all partners. This economic evaluation tried to tease out the incremental return on investment, which was difficult when each of the partners took a different approach to HMHM implementation. In order to calculate the full return on investment for COPD, access to linked data for all three partner populations was needed, which required an application to the Public Benefit & Privacy Panel for Health and Social Care. This caused a delay in the economic evaluation, but full permission was granted. That said, patients could only be included when a full six months post-HMHM had elapsed, and the data supplied was complete for the full six month period. Some partners supplied patient level data where the reason for A&E attendance was recorded by free text, so it is possible that some respiratory patients were not identified and missed from the economic evaluation.



5. RECOMMENDATIONS FROM THIS ECONOMIC EVALUATION

This economic evaluation has shown that Home and Mobile Health Monitoring (HMHM) for both hypertension and COPD have net positive returns on investment. Capacity is released for hypertension HMHM and a break-even point reached for a relatively small number of patients (around 40 to 70 in the more densely populated areas). However, the processes required to reach these conclusions proved more difficult than expected when this evaluation was being planned. Lessons learned for any future economic evaluation of HMHM include:

- It should be possible for other partners using HMHM to apply their own data to the economic modelling described in this report. This may require some expert support, but would augment any other evaluation results. A standardised approach to outcomes could include the development of a bank of indicators and values to enable measurement and evaluation to be undertaken more easily by multiple stakeholders and across different studies
- It would be useful to have centralised access to baseline NHS cost data for current service delivery models. This would support future economic modelling of digitally enabled models of care and make it easier to aggregate and compare results, or as a minimum, read across different evaluations
- It would be very helpful if partners implementing HMHM for the same condition were able to agree some standard and systematic approaches to the implementation and measurement of outcomes. Whilst it is unlikely that they could disregard local circumstances to implement the same model, any similarities would considerably aid the calculations required to determine return on investment
- It took a considerable amount of time to fully collate and analyse the wealth of data that has been included in this economic evaluation. This was underestimated at the outset of the work, so dedicated capacity for any future economic work should be agreed at an early stage

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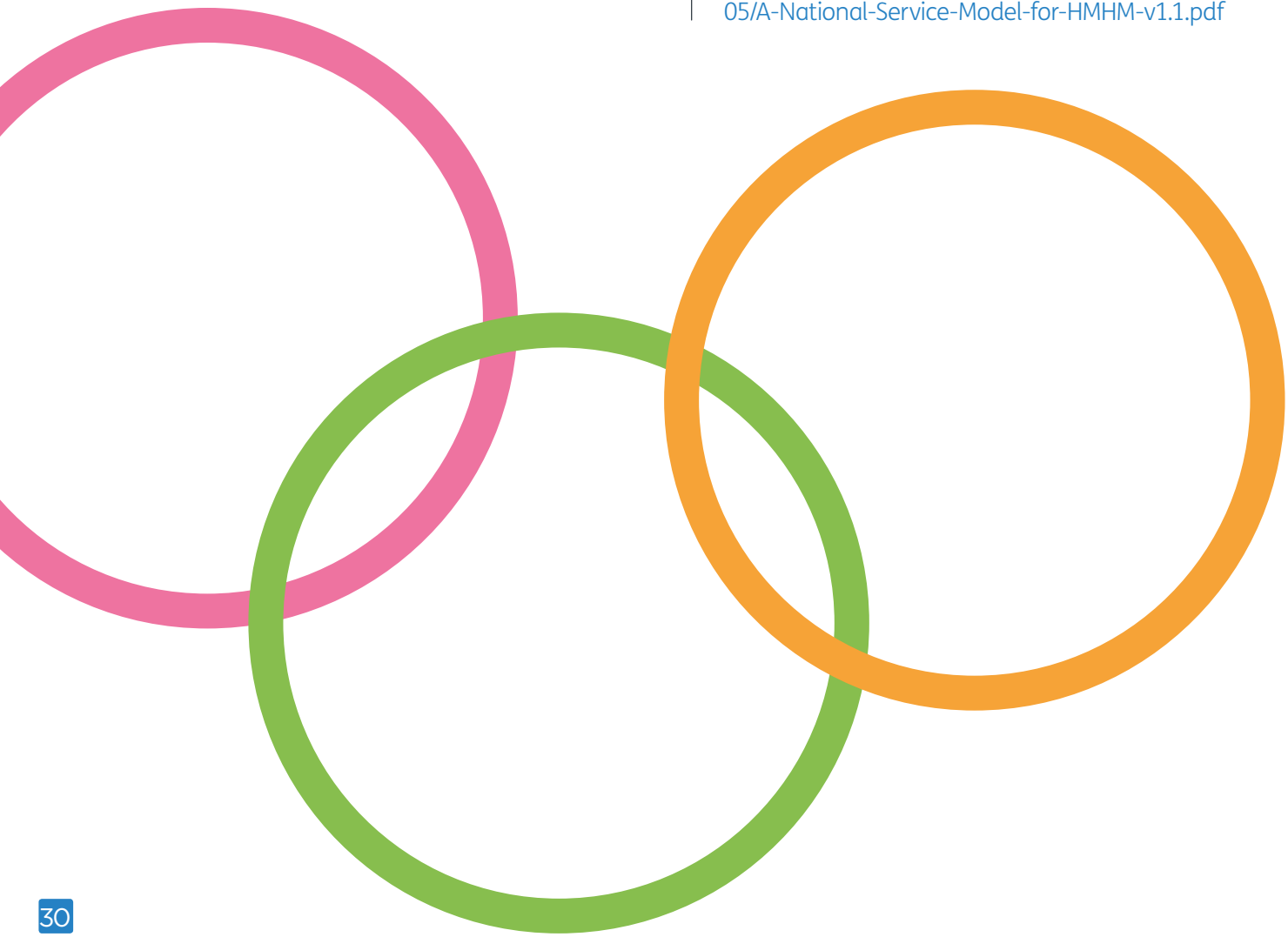


APPENDIX A – OVERVIEW OF LOTHIAN SCALE UP BLOOD PRESSURE STUDY

Scale-Up-BP is a telemonitoring service based on text-messaging of blood pressures (BP) by patients to a centrally held third-party client service called Florence(T). Patients receive automatic feedback either confirming BP control or advising them to contact their practice if the level is very high. A novel element to the service in Lothian is that NHS IT is able to interrogate the Florence server and generate a patient-level summary which can be sent through the routine document handling service Docman(T) to clinicians at a frequency determined by clinical need and which can be reviewed along with laboratory results and letters.

Our research team collected data on patients from 8 practices during the early stages of rollout of the Scale Up BP program in Lothian with a view to investigating the feasibility of a definitive trial of such a service. This report details a small component of the outcomes from this study, namely a calculation of the direct intervention costs of the service. It is based on data from 776 patients recruited to the study, of which 167 had been enrolled in the study for 12 months at time of data upload.

While the study did observe an improvement in the proportion of patients achieving BP control relative to their baseline measurements, caution should be taken in interpreting these results as the study was not designed to estimate effectiveness (or cost-effectiveness) and did not have a randomised control arm. Further caution should be observed as the earliest practices recruited to the study (and therefore those which the bulk of the data are derived from) were predominantly from affluent areas. A further download of data is anticipated in the future with longer follow up of practices from more deprived areas which is hoped will allow us to validate some of these findings.

The following sections offer a breakdown of the methods used to estimate the direct intervention costs of the study. Please take care to note that these do not account for any impact the intervention has on wider NHS service use, such as changes in patterns of primary care consultation or long term impacts on secondary care utilisation due to reductions in cardiovascular events, such as stroke, should BP control have been achieved.

Annual overheads

Table A1 – Breakdown of annual overhead cost components

Cost component	Cost, £ per annum	Notes/source
Florence licence fee	12,600.00	Study invoicing
DocMan support	1,500.00	Study invoicing
Help/support line	16,723.80	Based on Lothian rollout, 60% FTE of a grade 4 (100%FTE = £27,873 p/a)
Total	**£30,823.80**	

Though the help/support line is more reasonably thought of as a variable cost, it is difficult to attribute a specific proportion of FTE needed per patient. Figures are given to allow readers to calculate different FTE if required.

Per patient set up costs

Table A2 – Breakdown of per patient setup costs

Cost Component	Mean Cost, £ per patient	Notes
Patient training in use of BP monitor	14.33	Assumes 20 mins per patient of practice nurse time (£43 per hour, patient facing time*) for monitoring based on anecdotal evidence
BP monitor	21.00	Study invoicing
Cuffs	3.24	Study invoicing (£10.80 per set). Assumes 30% of patients require large cuffs, based on anecdotal evidence from participating practices
Total	**38.57**	

** Curtis, L.et al (2016) Unit costs of health and social care. Kent: Personal Social Services Research Unit*

Training times per patient were not recorded, hence the 20 minute assumption. Anecdotally the true average is expected to be lower, with some patients who are already familiar with home monitoring only needing a few minutes, though this represents a conservative assumption. As the study progressed, this task was also delegated to lower grade staff in some practices suggesting that it may be possible to further reduce this.

Variable running costs

These factors are more nuanced than those above.

Table A3 – Per utilisation price estimates and calculations for variable running cost components

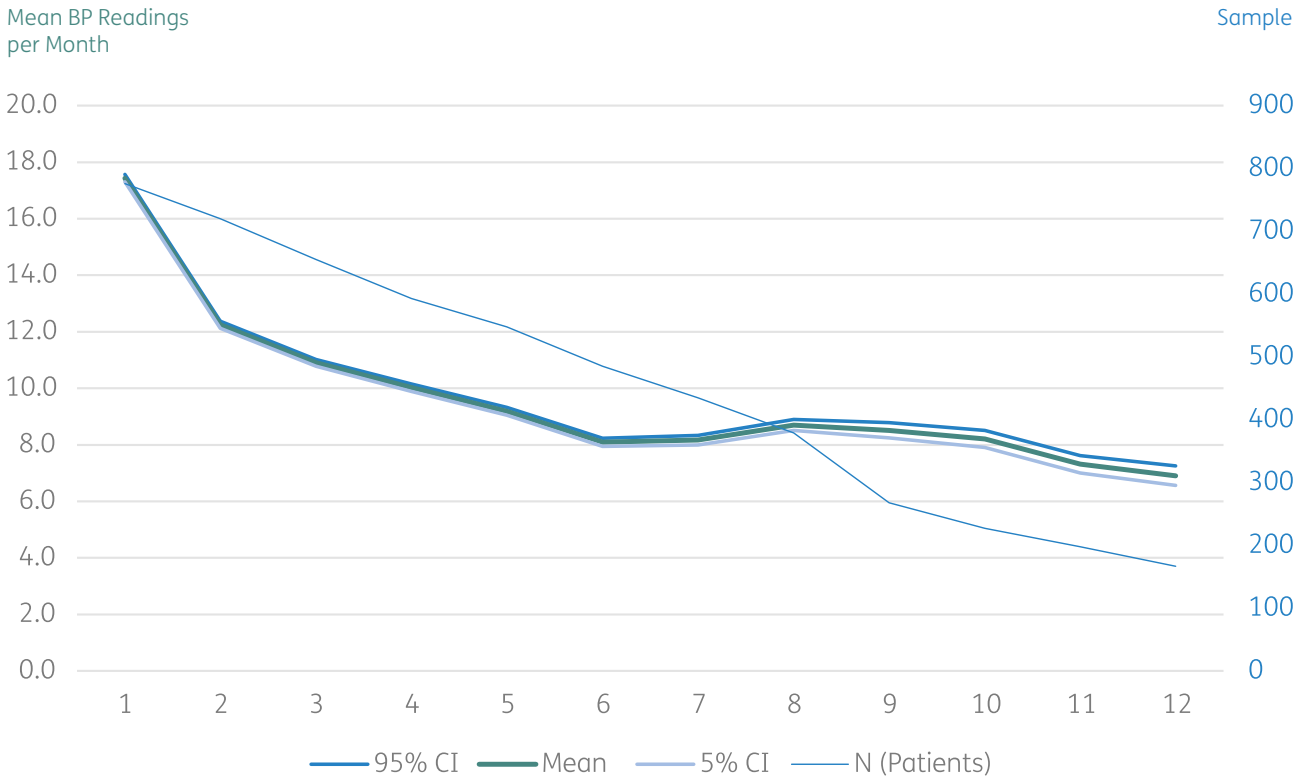
Cost Component	Cost, £	Notes
Home BP reading	0.08	Per text message
DocMan report reviewing		Per 3 months
Controlled (SBP <150)	0.60	Assumes 1 min of practice nurse time (£36/hr non patient facing*), anecdotal evidence from clinicians
Uncontrolled (SBP 150+)	1.80	Assumes 1 min of practice nurse time (£36/hr non patient facing*), anecdotal evidence from clinicians

* *Curtis, L.et al (2016) Unit costs of health and social care. Kent: Personal Social Services Research Unit*

Cost of BP reading transmission (text messages)

Starting with the costs of BP readings, Figure 1 shows the mean number of readings per patient enrolled in the study over their first 12 months of use. Note that the sample size gradually diminishes as at time of data upload, some patients had been using the device for longer than others. The gradual widening of the confidence interval around the mean number of transmissions represents the additional uncertainty generated from having this lower sample as time goes on. The awaited second data upload should increase the sample sizes for later months and provide similar early data for the following year for those who were recruited early.

Figure A1: Mean Florence readings per patient per month with confidence intervals



Rates of transmissions dropped over the first 12 months from 17.4 to 6.9 BP reading per patient per month. Summing over the mean readings per month would imply approximately an average of 115.7 texts sent per patient over the first 12 months. Note however that the higher utilisation in the first month includes both a more intense period of monitoring to establish a clinical baseline, and several transmissions from testing the equipment and training patients in its use. These have been included in the calculations as they would nevertheless still incur cost, but they are unlikely to be present in future years, hence any extrapolation over a longer period would be upwardly biased.

DocMan Report Monitoring

It is important to note that this section is referring only to the time spent checking the report when it is received and does not capture any time spent in follow up patient contacting/appointments, as these risked double counting with other data.

No data were recorded for the duration of practice staff time required checking DocMan reports, or the frequency of reporting per patient, which can be: monthly, 3 monthly or 6 monthly. Instead discussions were held with clinicians to determine a reasonable method to model these costs, from which it emerged that patients showing warning indicators (ie uncontrolled) would require deeper investigation. As a result a 1 vs 3 minute split was introduced based on the whether the patient was controlled or not. For simplicity, and due to the limitations of available data, estimates of the proportion of patients reporting controlled BP (defined as systolic BP below 150mmHg) at recruitment and 12 month follow-up were used assuming 3 monthly reporting (the most common frequency). Reports at month 3, 6 and 9, have been based on a temporary assumption that the proportion achieving control was spread evenly over the 12 months observed. While this is unrealistic, the cost difference associated with this is negligible, and plans are in place to generate parameters to populate this assumption at next data download.

Table A4 – Estimated cost of BP transmission (text message) and DocMan report reading time over the first 12 months of home monitoring

Month	Transmissions (texts)		DocMan monitoring time	
	Activity	Cost	Controlled £	Uncontrolled £
1	17.44	1.39	-	-
2	12.25	0.98	-	-
3	10.90	0.87	0.51	0.28
4	10.02	0.80	-	-
5	9.19	0.73	-	-
6	8.09	0.65	0.52	0.23
7	8.17	0.65	-	-
8	8.70	0.70	-	-
9	8.51	0.68	0.55	0.16
10	8.21	0.66	-	-
11	7.31	0.59	-	-
12	6.91	0.55	0.58	0.07
Total	**115.71**	£ 9.26	£ 2.15	£ 0.74

Calculating total Costs

Subject to all the assumptions outlined above, and the important caveat that the initial sample is taken from an affluent population, the below table breaks down the identified components of the direct intervention costs over the first 12 months of a patient's care.

Table A5 – Summary of cost components total by type

Cost component	£	Notes
Annual overhead	30,823.80	Licence fees and 60% FTE of a grade 4 staff operating the helpline
Per patient setup costs	38.57	Equipment costs and initial patient training in use of devices
Variable running costs (first 12 months only)	12.15	Text messages, and time spent reviewing DocMan reports

So for example, for 500 patients, these estimates would suggest a direct intervention cost of:

£30,823.80 + ([£38.57 + £12.15] x 500) = £56,183.80

APPENDIX B – ASSUMPTIONS FOR STAFF COSTINGS

The following tables provide an overview of the general staffing and WTE assumptions made across all partner sites.

Table B1 – WTE assumptions

WTE factor	
Days/year	220
Hours/day	7.5
Hours/year	1,650
Minutes/year	99,000

Source: Scottish Government HSCA standard assumptions

Table B2 – Staff cost underlying assumptions

	Admin/ TEC Admin	Practice Nurse	General Practitioner
	Band 3 AfC, incl on-costs	Band 5 AfC, incl on-costs	Av WTE, partners and salaried, incl on-costs
Cost per WTE	£25,600	£37,500	£98,400
Cost per minute	£0.26	£0.38	£0.99

Source: HSCA health workforce statistics team, SWIS 2016/17 and 2017/18 extracts

Table B3 – Assumed staff time ranges per contact

	Admin		Practice Nurse		General Practitioner	
	Min	Max	Min	Max	Min	Max
Appointment/ regular interaction	2	4	10	20	8	12
Monitoring appointment	N/A	N/A	5	10	N/A	N/A
Admin./review/ data entry	2	4	2.5	5	3	8

Source: Scottish Government HSCA standard assumptions

APPENDIX C – VARIATION IN USE OF BLOOD PRESSURE MONITORS

In all three sites, the up-front investment in BPM and cuffs covered the cohort under consideration over the period of analysis (including recycling). Additionally, there were different regional models of BPM usage and a range of possible scenarios impacting on investment cost, including the purchase price, the total number of BPM purchased and the turnover cycle (number of weeks before a BPM can be reused). It therefore proved difficult to introduce these local variations into the costing model and only the upfront investment cost and an assumed replacement cost after 5 years was included. However, the following provides a break-out model with scenarios of what different BPM usage protocols would translate to in terms of investment cost.

Unit cost estimates provided by partners ranged from £12 to £15. The initial test of change purchases (Ayrshire & Arran and Lanarkshire) were at a higher price of £75 for monitors with additional capabilities, however, this would not be an accurate reflection of purchases and implantation cost going forward. At one extreme, there could be no recycling of monitors (model employed in Lothian) and patients would retain the BPM they were given.

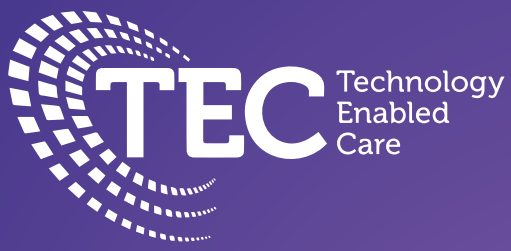
The estimated total investment cost in this model based on these parameters for a cohort of 100 patients range from £120 to £1,500. If bought in batch, the marginal cost of each monitor would decline with the size of the patient cohort, but also depend on the recycling rotation assumptions described above.

Table C1 provides an overview of some the cost implications of a variety of scenarios.

Table C1 – Investment costs of blood pressure monitor usage

Scenarios	Assumptions	No. monitors purchased	Weeks required to clear cohort of 100 patients	Total investment cost	
				Low unit cost (£11.99)	High unit cost (£15.00)
No recycling	Patient retains individual monitor	1 per patient for 100 patients	N/A	£1,199	£1,500
Partial recycling	Split 60% retain monitor, 40% recycle monitor	80	4	£959	£1,200
Full recycling	2 week rotation	10	20	£120	£150
		20	10	£240	£300
		50	4	£600	£750
		100	2	£1,199	£1,500
	3 week rotation	10	30	£120	£150
		20	15	£240	£300
		50	6	£600	£750
		100	3	£1,199	£1,500

Source: Calculations based on data provided by Ayrshire & Arran, Lanarkshire and Western Isles



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