Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Assessment
August 2022

Bluetooth Tagging – evaluation of potential for efficiency gains from tracking medical equipment

What were we asked to look at?

The Scottish Health Technologies Group (SHTG) was asked by the medical equipment management group at Glasgow Royal Infirmary (GRI) to evaluate the potential efficiency gains from using Bluetooth tagging to track medical equipment.

Why is this important?

Medical Equipment is often moved between departments or wards without documentation or tracking. This results in staff spending time searching for equipment, which diverts valuable time away from the provision of patient care. The value of lost and missing equipment at the GRI in the last 5 years amounted was in excess of £300,000. The medical equipment management department for NHS Greater Glasgow and Clyde were interested in the use of tracking equipment to reduce this problem.

What was our approach?

Our SHTG Assessment includes a literature review of the tracking of medical equipment in hospital settings, with a view to identifying examples of efficiency gains, in particular from Bluetooth tagging. We conducted a survey on the current use of equipment tagging within NHSScotland and carried out a cost-effectiveness analysis to estimate potential efficiency gains. Information on our SHTG Assessment product can be found on the Scottish Health Technologies Group website.

What next?

This work will be used to inform a business case on the use of Bluetooth tagging at the GRI and more broadly across NHS Greater Glasgow and Clyde. The findings will also be considered by the National Infrastructure Board

Key findings

- Published literature relating to the tagging of medical equipment was limited in quantity and quality, but illustrates the potential time and resource savings that could be gained from equipment tagging compared with no tagging and manual equipment searching.
- A survey of NHSScotland health boards found limited use of medical equipment tagging and no use of Bluetooth tagging beyond recent pilot studies.
- A recent pilot study conducted within the GRI Emergency Department concluded that the use of Bluetooth tagging led to a reduction in staff time spent searching for medical equipment.
- A cost-minimization analysis based on the pilot data concluded that using Bluetooth tagging to track medical equipment was associated with lower costs of in excess of £600,000 over 5 years compared with no tagging system. The results are driven by a reduction in time (and associated resource costs) spent searching for medical equipment and the value of missing assets avoided. The results are sensitive to the base case assumptions.
- There is no off-the-shelf solution available for medical equipment tracking. Boards would need to adapt current technology options to suit their local requirements and environments.

Contents

Introduction

SHTG was approached by the GRI Medical Equipment Management Group at NHS Greater Glasgow and Clyde to provide advice on the use of Bluetooth tagging to track medical equipment.

The group identified £2,617,118 worth of assets from across the health board that have been recorded as unavailable in the last 5 years. In addition to the cost of medical equipment that is lost or missing, misplaced assets often means that healthcare professionals waste time searching for equipment. Time spent searching for equipment represents an opportunity cost as it diverts time away from patient care.

Research question

Does the use of Bluetooth tagging (using the FloKi Health Bluetooth technology) lead to efficiency gains for tracking medical equipment in a hospital setting compared with active Radio Frequency Identification (RFID), WiFi tracking and no tracking?

Methods

The research question was addressed in three ways:

- a literature search was conducted to identify systematic reviews, health technology assessment and other evidence-based reports
- a survey of current use of tagging systems was carried out across all NHSScotland boards, and
- an economic evaluation was conducted based on the results of a pilot study run at NHS Greater Glasgow and Clyde by the GRI Medical Equipment Management Group. This pilot study is discussed in the literature review section.

Literature search

A systematic search of the secondary literature was carried out between 7 December 2021 and 15 December 2021 to identify systematic reviews, health technology assessments and other evidence-based reports. Medline, Medline in Process, Embase and the Cochrane Database of Systematic Reviews were searched.

The primary literature was systematically searched between 7 December 2021 and 15 December 2021 using the following databases: Medline, Medline in Process and Embase.

All search results were limited to the English language and publication after 2015.

Key websites were searched for guidelines, policy documents, clinical summaries, economic studies and ongoing trials.

Concepts used in all searches included: FloKi, Bluetooth, RFID, active RFID. A full list of resources searched and terms used is available on request.

The literature search identified 142 articles. None of the articles pertained solely to Bluetooth tagging technologies. Six articles were deemed to be relevant in that they discussed a form of remote tagging, whether Bluetooth, RFID or WiFi tracking. One further piece of grey literature was identified via the peer review process.

Health technology description

Tracking of equipment can be undertaken using the technologies described below.

Bluetooth tagging

Bluetooth asset tracking, known as Bluetooth Low Energy (BLE) uses wireless technology to create a connection between an object, using a tag on the object or the objects internal Bluetooth facility, and a tracking device.[1] The tracking device is paired with software that can be used to store the data. For location tracking of an object, beacons are required within buildings to monitor BLE emissions.

Radio Frequency Identification

RFID uses electromagnetic fields to transfer data and is mainly used to automatically identify objects and keep track of their location. The technology is comprised of a tag, a reader and middleware (software that acts as a bridge between an operating system or database and applications, especially on a network).

The tag stores information about the item it is attached to (products, assets or individuals). When a tagged object is within the detection range of the reader, the reader identifies the tag information and passes it to the middleware.[2]

An active RFID system consists of a reader, tag and antenna. RFID tags can be active or passive. Active tags use a battery-powered sensor to gather and transmit data to the tag. The reader communicates with the tags continuously and keeps track of real-time information about the location of the tagged objects. Stored data enables real-time monitoring and tracking of individuals and assets, allows for reporting of statistics and analytics forward management.

Passive tags have no battery and rely on radio energy transmitted by a reader to power them. Passive tags are mainly used for identification purposes, while active ones are mostly used to track objects.

WiFi tracking technology

Wifi tracking technology can be used in a similar way to a Global Positioning System (GPS) device. This technology determines where assets are located in relation to the signal strength detected by a 'hotspot.' A hotspot is a physical location which has been set up using a router connected to the internet.

Published research

The literature search identified one cost-benefit analysis, which was based on a systematic review.[3] No guidelines or randomised controlled trials were found which covered any aspect of tagging.

No primary research studies were identified that specifically related to the research question or Bluetooth tagging. One study compared different methods of tracking medical devices, which included Bluetooth tagging as one of the comparators.[4] Another study examined the use of Bluetooth tagging in an educational setting.[5] Four primary studies were found that considered various forms of tagging, primarily RFID, and these are summarised below as the nearest comparative system to Bluetooth tagging.[4-7] One study explored the effects of misplaced equipment on levels of frustration experienced by staff when they could not find equipment in a timely manner.[6]

A 2021 study compared the position measurement accuracy of geomagnetic methods alone, WiFi alone, BLE beacons alone and then combinations of the above.[4] The results showed that the most accurate method of equipment tracking was a combination of geomagnetic and BLE beacons. Combining the two systems reduced the average position error to approximately 1.2 metres (m).

Another study compared the use of BLE tagging with WiFi enabled tagging in educational settings.[5] WiFi enabled tagging tended to be more energy demanding compared with BLE and to have less geographical accuracy. This is partly because BLE beacons can be positioned anywhere, whereas WiFi signals can be more easily blocked. Findings indicated the ideal spacing of BLE beacons and recommended placing of beacons onto ceilings with a spacing distance of 2 m.

The most recent study on RFID conducted a staged asset search exercise, using RFID, to quantify search time.[7] The objective of the study was to assess potential cost savings from reducing time spent locating missing equipment. A survey was conducted to establish a baseline for search frequency within each shift and the amount of time spent searching for equipment. The survey (n=241) showed that staff spent most of their time searching for other staff members, followed by equipment and then patients. Forty clinical staff (nurses, doctors and patient care assistants) were randomly assigned to one of eight clinical

scenarios mimicking real life searches. Post implementation of the RFID, tagged units (pieces of equipment) showed an average 87% reduction in search time across the eight staged asset searches.

One article analysed a conceptual framework to identify benefits and cost attributes of RFID for asset tracking in a hospital facility.[3] It found that using RFID increased utilisation rates of equipment and confidence about the location of equipment, while decreasing annual spending on under utilised assets. These benefits were reported to have been realized through increased staff productivity, quicker patient turnover and cost savings by improved visibility of equipment.

Forth Valley Royal Hospital evaluated the use of active RFID in a pilot study in 2014, reported in an NHSScotland assets and facilities annual report in 2017.[9] This paper reported the use of RFID to tag 10,000 mobile medical devices. The evaluation identified the following benefits:

- increased efficiency of planned maintenance as equipment could be located in a much shorter time
- accurate inventory of equipment (including location)
- reduction in staff time spent locating equipment, releasing time for patient care, and
- reduction in replacement costs for missing equipment.

One unpublished report assessed the first 3 months of a pilot study of a Bluetooth tagging system trialed by NHS Greater Glasgow and Clyde.[10] FloKi Health, the creators of the system, generated the report using data gathered during the pilot. The aim of the pilot was to monitor and track asset movements in real time, reducing the time staff spent looking for missing equipment. The ED equipment used in the pilot included infusion pumps, syringe drivers, electrocardiogram (ECG) machines and bladder scanning equipment. Results after 3 months showed that the time spent looking for misplaced items was reduced by a ratio of 3.33 with the tagging system compared with the 3 months prior to the system implementation. Prior to implementation, staff spent 75 hours searching for equipment over a 3 month period, this dropped to 15.5 hours, in the 3 months following implementation. A comparison between using the tagging system to find items and not using the system showed a higher rate of finding lost items and less time spent looking for items. User feedback about the tagging system was positive. It was felt that the system would improve asset management, and this in turn would increase efficiency and improve patient care.

Ongoing studies

In 2021, NHS National Services Scotland (NSS) began discussion with two suppliers, Cylera and Core to Cloud, about how to improve asset inventory, risk analysis and cybersecurity of unmanaged devices across NHSScotland's hospitals. NHS Grampian ran a proof-of-value project entitled "Project Guardian" which started in November 2021. The aim of the project is to improve asset inventory and provide risk analysis and cybersecurity for unmanaged devices (primarily network connected medical devices and systems of inter-related computing devices), via the creation of a National Dashboard for NHSScotland.

Current use of medical equipment tracking technologies

As part of the SHTG Assessment all medical physics departments across NHSScotland health boards were contacted by email to ask about their current use of medical equipment tracking technologies. The following question was asked:

> Are you aware of any medical equipment tracking system in place in your health board? If yes, please could you specify the location and type of technology used?

Responses were received from 10 health boards, representing a spread of rural and urban areas across Scotland. One board responded twice, covering two separate areas within the board.

The 11 responses to the research question are presented in *Table 1*. Points of interest are:

- seven out of the 11 responses (64%) had some experience of using a tagging system
- four respondents (36%) had no experience of using a tagging system
- five boards have used an RFID system.

Table 1: Responses to health board survey around tagging usage

Are you aware of any medical equipment tracking system in place in your Health Board?	
1.	Yes, we currently use RFID tracking for medical equipment within Crosshouse and Ayr hospitals.
2.	We are using RFID tracking on all our mobile medical devices. This includes bed tracking also. We use this technology at one site only. This includes Maternity services and Children's hospital too. We are using Paragon RFID Discovery.
3.	There is only one site within our Board that has any form of equipment tracking system: In Victoria Hospital in Kirkcaldy we have a System Called RFID Discovery, which is supplied and supported by Paragon ID Ltd: ■ if an item leaves this site, it can no longer be tracked

	■ the system can use both Active and Passive tags, but we currently only make use of the Active tags ■ the Active tags transmit a signal every few seconds which is picked up by dedicated "readers" with aerials attached ■ readers/aerials are placed in ceilings or on walls at regular intervals to achieve adequate coverage and the location is defined as within a 15-metre radius of the closest aerial that has picked up the tag signal ■ the system does not make use of any existing WiFi facility or Bluetooth in any way ■ all readers are however connected to a dedicated on-site system server via the hard-wired hospital network ■ the server presents location information as an interactive web page that can be accessed by anyone in the Board with a network account. Users can search for equipment by various filters or specific item, and ■ passive tags, if we used them, are not picked up by the "readers." They react in response to a handheld device which is used to go round areas and search for passive tags and present results on the handheld screen. I think this can either be downloaded or sent direct to the server for records, but I am not sure. Very useful for doing Asset Audits apparently.
4.	We are currently using RFID technology
5.	We use passive RFID (UHF Gen 2) asset labels for all medical equipment managed by Medical Physics and increasingly for all medical equipment within the board. The board has also auto-cleavable passive tags using the same technology on surgical instrument trays. All tags are encoded in accordance with GS1 standards, implementing a GIAI (internally allocated asset identifiers) numbering sequence. We have a growing fixed reader network, initially covering all locations where surgical instrument trays are used (eg theatres, some clinic and community dental locations) and reprocessed. We also have three RFID reader trolleys that we intend to ask a member of staff to push around each acute site on a periodic basis to update locations of equipment. Asset labels typically cost ~45p each compared to ~20p for a good quality non-RFID label.
6.	We have a few tests of change going on in. Most of it is bespoke.
7.	I have no medical equipment tracking system the expensive always outweighs the benefits with RFID system for us. I think a Bluetooth system would be cheaper more realistic alternative to implement and most likely work through an App that could be installed on the Tech's mobile phones.
8.	The only system we have tried was Aeroscout by Stanley. This was installed as part of a package deal with our infusion pumps. But after 5 years, and a combination of lack of engagement by the supplier and our e-Health department we have de-installed the system.

	It was a WiFi system but could not distinguish between different floors in our tower block. By the time the company came up with a solution, estates had moved some of the Access Points in the ceiling voids, so location was no longer accurate. By this time, the battery in each tag was due for replacement and the investment in time was just not possible with current staffing.
9.	We don't currently have a tracking system for our medical equipment but would be interested in this.
10.	We have no current tracking system and due to the nature of the equipment set up on the Islands can see no benefit to such a system
11.	None currently in use. I have been tracking the technology for over a decade and haven't found a system that meets all the requirements of the organisation.

Cost effectiveness

SHTG conducted a cost-minimization analysis based on the results of the GRI pilot study, in order to evaluate the potential cost savings (optimization improvement) from using Bluetooth tagging to track medical equipment.

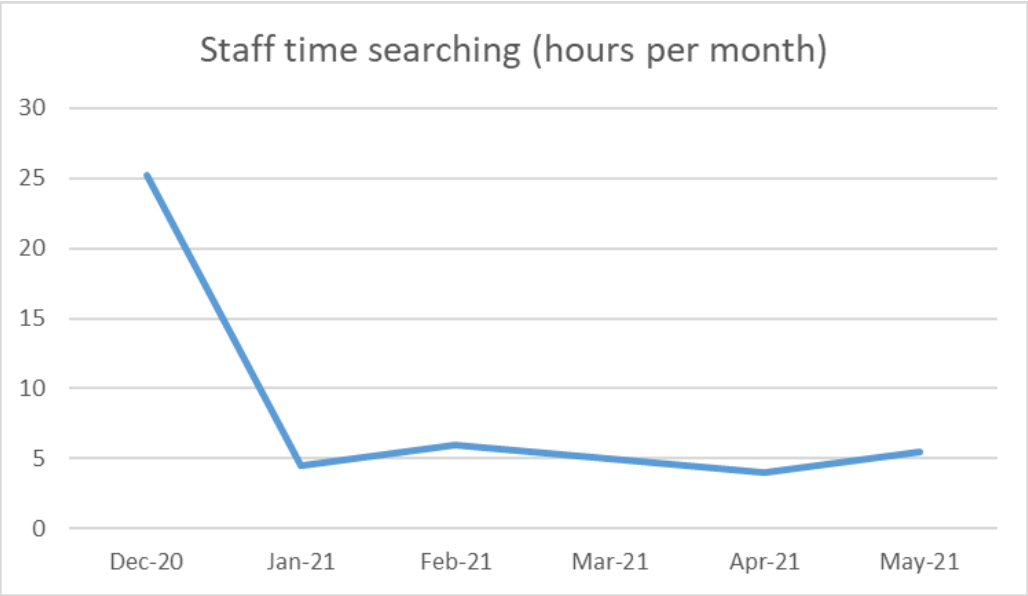
The economic analysis compares the costs associated with no equipment tracking and those associated with the implementation of the FloKi Bluetooth tagging system. Relevant costs include staff cost for hours searching, the cost of the technology and the cost of equipment going missing.

GRI Pilot study results

The staff search time for equipment before and after implementing FloKi Bluetooth tagging is presented in *Figure 1*. Search times were recorded manually prior to the pilot, and the data for December 2020 represents an average time per month over the preceding 3 months.

The data show a fall in search time from an average of 25 hours per month to approximately 5 hours per month, as a result of the use of Bluetooth tagging.

Figure 1: Staff search time



Note: the red line represents the implementation of FloKi Bluetooth tagging.

Staff resource savings for the pilot period have been calculated based on the reduction in staff time spent searching for equipment (approximately 20 hours less per month). The reduction in time equates to an efficiency gain of £1,562 (based on band 5 staff costs) over the course of the pilot.

Economic analysis methods

Data on time saved searching for medical equipment during the pilot was based on the tracking of 66 assets over the course of 3 months. Colleagues at GRI had identified 2,500 assets they wish to tag for tracking, both within the hospital setting and in the community. These consists of 1,500 tagged assets within ED departments and 1,000 ambulatory infusion pump tags. In the economic analysis, the time saved searching for equipment has been extrapolated from the 66 assets in the pilot to estimate the total search time per month associated with 2,500 assets, in order to illustrate the potential impact of implementing the Bluetooth tracking system. The time horizon for the analysis was 5 years.

WiFi tagging has also been included in the analysis as an alternative option for equipment tracking. A key assumption is that WiFi tagging is at least as effective as Bluetooth tagging in terms of tracking medical equipment, but the costs of the two systems are different.

Parameters and sources

Table 2 presents the key parameters used in the model. Staff resource costs were based on pay rates for staff at NHSScotland agenda for change (AfC) band 5. This is a conservative estimate, as feedback from the pilot suggested that senior nurses and potentially F1 spend time searching for equipment. The AfC band level has been explored in sensitivity analyses.

The costs of the FloKi Bluetooth tagging system and the WiFi tagging system were provided by the team at GRI. Costs included quotes for 2,500 tags, and installation and ongoing maintenance costs. For the year one cost of the tracking technology, the tagging and installation costs in addition to one year of support cost were included. After year one, only the annual maintenance costs were applied. These costs vary depending on the complexity of the installation, the number of tags and the area to be tracked. The cost of missing assets included the cost of the type of assets which would have been tagged if FloKi was available (for example, T34 infusion pumps) but were identified as missing in the last 5 years at GRI.

Table 2: Parameters included in the analysis

Parameter	Base case input	Source	Scenario analysis
Search time per month (in hours)			
Before tagging (66 assets)	25.2	Pilot testing data	
After tagging (66 assets)	5		
Before tagging (2,500 assets)	954.5	Extrapolation based on pilot testing data	
After tagging (2,500 assets)	189.4		
Costs			
Band 5 hourly wage	£15.5	NHS Scotland AfC	Band 4 hourly wage
			Band 6 hourly wage
Bluetooth tags and installation	£136,000	GRI	
FloKi yearly support cost	£48,000		
Wifi tags and installation	£241,812		
Wifi yearly support cost	£31,164		
Cost of missing assets per year	£58,940		
Assets searched monthly	2500		208
Number of years	5		1

Abbreviations NHS National Health Service; AfC = Agenda for change;

Results

Using Bluetooth tagging to track medical equipment was associated with lower costs over 5 years compared with no tagging system and compared with a WiFi tagging system (*Table 3).* The results compared with no tracking are driven by a reduction in time (and associated resource costs) spent searching for medical equipment, but also the avoidance of missing assets.

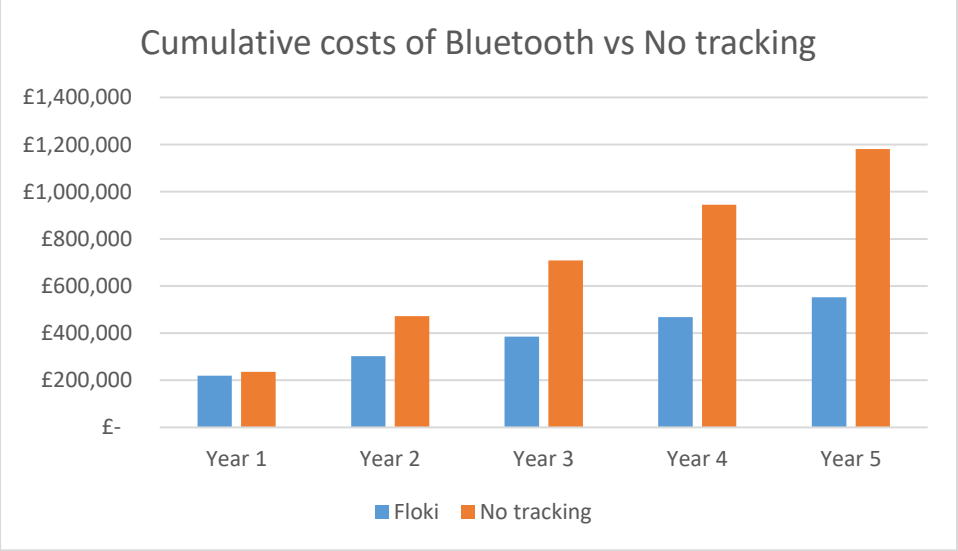
While the benefits of Bluetooth and WiFi tagging were assumed to be equal, the FloKi Bluetooth system was less costly.

Table 3: Results of base case analysis

Outcome	FloKi	Wifi	No tracking
Cost of search time	£175,785	£175,785	£885,954
Cost of missing assets	£-	£-	£294,700
Cost of tracking system	£ 376,000	£ 397,632	£ -
Total costs	£551,785	£573,417	£1,180,654
Total savings vs no tracking	**£ 628,869**	**£ 607,237**	£ -
Total savings vs WiFi tags	**£ 21,632**		

The cumulative costs of Bluetooth versus no tracking have been presented in *Figure 2* below. Even though Bluetooth tagging is shown to have a similar cost to 'no tracking' in year 1 due to the cost of initial investment, over time resource savings increase, making the tracking system increasingly cost effective when viewed as a long-term investment. This is due to the cumulative effect of the relatively large difference between the fixed annual maintenance cost from year 2 onwards for FloKi and the annual cost of searching 2,500 assets if no tracking system is available.

Figure 2: Cumulative costs of Bluetooth v no tracking over five years



Sensitivity analysis and limitations

Scenario analyses were performed to explore the uncertainty surrounding the model. Alternative values for various parameters were explored, including the frequency of asset searches per year, the time horizon of the model and the pay scales of the staff spending time searching for equipment. Results are presented in *Table 4* below.

Table 4 Scenario analyses – savings vs no tracking

Scenario number	Scenario	Base case	Bluetooth	Wifi
0	**Base case**	**-**	**£ 628,869**	**£607,237**
1	Search time across 2,500 assets annually	Search time across 2,500 assets monthly	-£22,119	-£43,751
2	1 year time horizon	5 years	£16,974	-£72,002
3	AfC band 4	AfC band 5	£563,713	£542,081
4	AfC band 6	AfC band 5	£818,437	£796,805

As shown in table 4, results are sensitive to assumptions around the frequency of medical equipment searches completed. The base case analysis assumes a search time per month across the tagged 2,500 assets. . If the frequency of searches drops to once a year per asset, both the Bluetooth and WiFi tagging systems are more costly than the 'no tracking' system. Results are also sensitive to the time horizon of the model with Bluetooth tagging being £16,974 cheaper than no tracking but the Wifi tagging system being more expensive in the first year post implementation. This is due to the higher implementation cost of the Wifi tagging system when compared with the FloKi Bluetooth system. Results are less sensitive to the pay grade of staff who do the searching for assets.

There are a number of limitations which may affect the robustness of the analysis:

- time spent searching for equipment was not recorded in the same way before and during the pilot. Estimates for time spent searching before the pilot were based on staff recalling the time spent and may not be as accurate as the pilot data
- the pilot period only covered 66 assets which is substantially lower than the planned implementation. The reductions in search time used in this analysis have been calculated as search time per asset before being extrapolated. The real effect of the search time for 2,500 assets has not been observed
- the cost for missing assets were not taken from the trial, but was sourced separately. It was applied in the assessment as a likely cost saving given the nature of the technology and its purpose, and
- it was not possible to obtain a quote for the RFID tracking technology and so RFID could not be included as a comparator.

Other important considerations are as follows:

- there is no off-the-shelf solution available. Boards need to adapt available solutions to suit their own requirements and environments. As a result of the tailored implementation of the technology in each medical site, it is not feasible to conduct a budget impact analysis for NHSScotland, and
- the savings calculated based on the reduced time staff spent searching for assets is 'resource-releasing' rather than 'cash-releasing'.

Conclusion

Based on the limited available published literature, and the results of a pilot study and cost-effectiveness analysis, medical equipment tracking technology has the potential to generate efficiency gains by reducing staff time searching for equipment and avoiding costs of replacing missing equipment.

Extrapolations based on the NHS Greater Glasgow and Clyde pilot show that the GRI ED department could benefit from potential resource savings in excess of £600,000 £ over 5 years in the base case analysis.

Beyond the monetary value of staff time, freeing up valuable resources means that staff can dedicate more of their time to patient care, which will help to minimise pressures on the health and care system.

As part of our engagement with users of tracking technologies in the boards, the experience and outcomes were always spoken about positively. There is no central oversight or understanding of the current use of medical tracking technology in NHSScotland.

Identified research gaps

Robust comparative data collection and evaluation would establish the perceived benefits of equipment tagging systems.

Acknowledgements

Healthcare Improvement Scotland development team

- Ms Jenny Harbour, Health Services Researcher
- Ms Meryl Heggeland, Health Economist
- Dr Dawn Mahal, Health Services Researcher
- Ms Mary Michael, Project Officer
- Ms Charis Miller, Health Information Scientist

SHTG Executive would like to thank the following individuals who provided peer review comments on the draft review which were considered by the authors:

- Mr Steve Brown, Head of Electro medical Equipment Services, Medical Physics, Raigmore Hospital, NHS Highland
- Dr Paul Campbell, Clinical Director, Clinical Informatics, NHS National Service Scotland
- Mr Peter Cook, Head of Medical Physics and Bio-engineering, NHS Highland
- Mr Iain Forrest, Medical Physics Manager, NHS Fife
- Dr Sulisti Holmes, Head Of Decontamination and Incident Reporting Investigation Centre, National Services Scotland
- Mr Adrian McNairn, Medical Engineering Technician Specialist, NHS Dumfries and Galloway
- Ms Laura Metcalfe, Interim Head of Service, Medical Equipment Management, NHS Greater Glasgow and Clyde
- Mr Paul Mortimer, Head of NHS Strategic Capital Investment, Scottish Government
- Dr Edward Mullen, Clinical Engineering Professional Advisor, Medical Devices and Legislation Team, Scottish Government
- Dr Malcolm Phillips, Head of Medical Equipment Management, NHS Lothian
- Dr Donald Reece, Programme Manager, NHS National Services Scotland
- Ms Lesley Sneddon, Technical Manager, Glasgow North, Medical Equipment Management, NHS Greater Glasgow and Clyde

Declarations of interest were received from all peer reviewers. All contributions from peer reviewers were considered by the author. The peer reviewers had no role in authorship or editorial control and the views expressed are those of Healthcare Improvement Scotland.

Published August 2022

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Appendix 1: abbreviations

A&E	Accident and Emergency
AfC	Agenda for Change
BLE	Bluetooth low energy
ECG	Electrocardiogram
GIAI	Global Individual Asset Identifier
GPS	Global Positioning System
GRI	Glasgow Royal Infirmary
GS1	Global Standards 1
Ltd	Limited
NHS	National Health Services
NHS GGC	NHS Greater Glasgow and Clyde
NSS	National Services Scotland
QEUH	Queen Elizabeth University Hospital
RAH	Royal Alexandra Hospital
RFID	Radio Frequency Identification devices
RHC	Royal Hospital for Children
SAS	Scottish Ambulance Service
SHTG	Scottish Health Technologies Group
UHF	Ultra High Frequency
WiFi	Wireless Fidelity