Healthcare Improvement Scotland | SHTG Advice on health technologies

SHTG Assessment
December 2023

In response to enquiry from the Accelerated National Innovation Adoption (ANIA) Collaborative

Technology-Enabled Theatre Scheduling Systems

What were we asked to look at?

The Scottish Health Technologies Group (SHTG) was asked by the Accelerated National Innovation Adoption (ANIA) collaborative to review the evidence on the use of technology-enabled theatre scheduling systems.

Why is this important?

As set out within the NHSScotland Recovery Plan 2021–26, it is vital that the backlog of care in acute and elective services is addressed in order to minimise risk to patients and reduce pressure on people and services across the health and care system.

The optimisation of theatre capacity is identified within the Recovery Plan. Technology-enabled theatre scheduling systems provide an opportunity to automate and more efficiently schedule theatre time, with a view to increasing patient throughput and minimising 'downtime' associated with staff and theatre resource.

What was our approach?

We reviewed the published evidence on the use of technology-enabled theatre scheduling systems. We conducted a national survey of relevant stakeholders on current theatre scheduling practices, and the benefits and challenges of implementing a national technology-enabled theatre scheduling programme.

An independent evaluation of a technology-enabled theatre scheduling system (Infix®) was conducted in NHS Lothian. The evaluation aimed to explore whether Infix® is able to

increase the efficiency and throughput of operating theatres across four specialties (ear, nose and throat (ENT), maxillofacial, ophthalmology and plastics) over a 24–week period.

More information about SHTG Assessments can be found on our website.

What next?

Our SHTG Assessment will be used by ANIA and the Scottish Government's Digital Health and Care Policy Team, as part of their decision making (that is, a business case) on the purchase and rollout of technology-enabled theatre scheduling systems across Scotland.

Key points from the evidence

- There is limited published evidence investigating the implementation of technology-enabled scheduling systems to optimise theatre scheduling.
- Our NHSScotland survey demonstrates a large variation in theatre scheduling practices across health boards.
- The use of a technology-enabled theatre scheduling system may improve the consistency and efficiency of theatre scheduling. Potential benefits of an automated system include:
    - reduced patient cancellations and waste
    - enhanced data analysis capabilities.
- The challenges of introducing an automated system include:
    - anxiety and resistance to change among staff.
    - concerns about inadequate training, technical skills, and funding
    - potential safety risks arising from data breaches, inadequate training, and support.
    - technical risks.
- Our independent evaluation of the Infix® theatre scheduling technology in NHS Lothian provided some evidence that the technology can increase operating theatre efficiency. Within ophthalmology, throughput of patients per session increased from four to five (an increase of 26%) and throughput per hour increased by 25% after the implementation of Infix®. For ENT, operating session utilisation increased following the implementation of Infix®, though this did not translate into increased patient throughput. In the maxillofacial and plastics specialities, there were no significant changes in theatre efficiency.
- Further data collection must accompany the roll out of a technology-enabled theatre scheduling system within Scotland, aligned to the Infix® evaluation. These data will help ensure that the potential value of the new system is realised.

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Introduction

The increasing demand for healthcare places significant burden on healthcare staff and services. Operating theatres are critical resources within hospitals and their capacity can affect patient flow and waiting lists across the system. Figures from the NHSScotland Efficiency and Productivity Framework show that there are over 300 operating theatres within Scotland, with an average running cost of £1.4m per theatre per annum.[1]

Operating theatres in many hospitals are not used to their full capacity as a result of the complexity of theatre scheduling and the dynamic nature of demand due to large waiting lists, which can adversely affect outcomes for patients, particularly those requiring critical care.[2] The costs associated with running operating theatres are substantial, and inefficiency in the system increases the risk of wasted resource.

The purpose of this SHTG Assessment is to inform decision making on the purchase and rollout of a technology-enabled theatre scheduling system across Scotland.

Health technology description

Technology-enabled theatre scheduling systems are digital tools or applications that use machine learning and optimisation techniques to automatically generate operating theatre lists from electronic patient records (EPRs). The technology uses EPR data to prioritise patients based on urgency of treatment, and schedules procedures based on average operating time data. The system generates a theatre list that can be checked and edited as required.

Demand for operations in Scotland

The total number of planned operations has been rising, and there is a need to make sure that our resources are efficiently used.[3]

We have used data from Public Health Scotland to review patterns in the numbers of planned operations in NHSScotland.

The data show that, during March 2023, there were 21,350 planned operations representing an 18.2% increase compared with the 18,069 planned operations during February 2023. When comparing March 2023 with March 2022, there is a 15.2% increase in the number of planned operations.

During March 2023, 8.2% of all planned operations were cancelled the day before or on the day the patient was scheduled to be treated. The percentage of all cancelled planned operations ranged from 4% to 11.6% across NHS boards.

Of all cancelled planned operations during March 2023, 676 (3.2%) were cancelled by the hospital for clinical reasons; 593 (2.8%) were cancelled by the patient; 420 (2%) were cancelled by the hospital because of capacity or for non-clinical reasons; and 70 (0.3%) were cancelled for other reasons.[3]

Review of published literature

Research question

What evidence is available on the implementation of technology-enabled theatre scheduling systems in a real world setting?

Literature search

A systematic search of the primary and secondary literature was carried out between 13 and 17 March 2023 to identify systematic reviews, health technology assessments and other evidence based reports. Medline, Medline in process, Embase, Health Management Information Consortium and Health Business Elite databases were also searched for systematic reviews and meta-analyses. Results were limited to English language papers.

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

Concepts used in all searches included: electronic scheduling, digital scheduling, operating room/theatre scheduling/appointment/planning, theatre optimisation platform. A full list of resources searched, and terms used is available on request.

Research evidence findings

There is limited research investigating the implementation of technology-enabled scheduling systems to optimise theatre efficiency in the real world. Only one study [4] assessed the implementation of a technology-enabled scheduling systems in a real world setting.

This study[4] reviewed a model-based decision support system for the optimisation of theatre use. The decision support system was validated and implemented at a medical centre in the University of California, Los Angeles (UCLA). The system incorporated uncertainty in surgical durations and flexibility in available resources. The results of the study compared before and after implementation of the technology across key operational metrics and costs. After implementation, there was a 6.7% reduction in the average number of anaesthesiologists on call and 3.7% reduction in the average overtime hours for the anaesthesiologists on regular duty. This led to a 3.8% increase in average daily use of operating rooms, an 8.6% decrease in the average number of operating rooms used, and a 2.7% decrease in the average overtime hours for operating room staff. Overall, the implementation of the system resulted

in average daily cost savings of around 7% (estimated to be about $2.2 million per year (approximately £1.8 million per year)) compared with previous practice.[4]

No published evidence was identified that related to user experience, cost effectiveness or the costs of technology-enabled theatre scheduling systems.

National survey

Methodology

To provide information to support decision making, a national survey was conducted on current theatre scheduling practices, and the opportunities and challenges of implementing a national technology-enabled theatre scheduling programme.

A structured questionnaire was sent to people involved in theatre scheduling across Scotland on 14 June 2023. Seventy-seven people, across all NHSScotland regional health boards, were invited via email to complete the questionnaire.

The questionnaire consisted of a series of closed-ended questions, where respondents were provided with predefined response options. Open-ended questions were also included to allow for free-text comments.

The survey was conducted using SmartSurvey. To encourage participation, there was a clear and concise introduction to the survey, explaining the purpose and importance of the survey. Anonymity and confidentiality were assured, and respondents were asked to consent to including anonymised and summarised responses as part of this report.

Respondents

Twenty-two people (29% of the 77 people that received the survey) responded to the survey.

Eleven out of the 14 regional health boards were represented by at least one respondent. Health boards not represented were NHS Shetland, NHS Forth Valley and NHS Orkney.

Roles covered ranged from:

- administration staff (n=1)
- both clinical and non-clinical management (n=14)
- operational/planning support (n=3)
- theatre practitioners (n=2)
- surgeons (n=1), and
- digital services (n=1).

The only predetermined category with no respondents was health care support worker.

Survey results

1. Current state and needs

What type of system do you currently use to schedule theatre sessions?
Most respondents (n=10, 45%) currently use a combination of systems. The most common combination was a mix of paper and an electronic spreadsheet.

There is substantial variation in practice across specialties, even within hospitals. Systems mentioned included outlook diaries, booking sheets, Microsoft Excel spreadsheets and various theatre scheduling technology solutions procured by individual boards.

One hospital in NHS Highland developed their own electronic 'Picking List' which selects patients that have all the data required for surgery. Patients are picked on the basis of clinical criteria, preoperative assessment, consent and readiness for scheduling.

What is working well for you?
When asked, on a scale of 1–5 (with 1 being 'poor' to 5 being 'excellent') how well their local scheduling system worked, ten people (45%) selected 3 – a neutral response. Seven (31%) responded negatively (that is, a 1 or 2) and five (23%) responded positively (that is, a 4 or 5).

Respondents were asked to comment on what was working well. Eight (36%) respondents noted the ease and familiarity of using their system and the visibility of it for all staff. One respondent highlighted the Opera[1] system, noting that it was easy to use. For example, Opera provides a clear audit trail of who booked the patient and when, and shows sessions clearly which makes it easy to identify overbookings.

Other comments, each mentioned by one respondent, on what was working well included:

- weekly review processes and multidisciplinary team involvement
- agreed theatre template and agreed theatre operating principles
- good patient selection and efficient identification of patients for surgery, and
- skilled, experienced booking staff.

What does not work so well?
In terms of what does not currently work so well, comments (n=11, 50%) focused on the amount of manual work required to input and check data. Frequent double data entry between systems was noted. The systems were said to be very person dependent.

[1] The Centricity™ Opera system is a commercially available software solution for theatre management

Respondents (n=10, 45%) also noted that conducting data analysis is very difficult with the current systems, and there would be no way to measure the efficiency of current theatre booking.

Other things that do not work well include difficulties managing late cancellations within systems and dealing with variation in practices across specialities. One respondent provided an example of three separate groups being involved in theatre scheduling – nurses, anaesthetists and surgeons. In some health boards, there are three separate systems to organise scheduling that have no direct interface between them.

What improvements could make it better for you?

When asked what would help to improve their current system the following responses were received. There were primarily around the theme of systems related improvements:

- having one system which collates information from other systems to populate one main system (n=9)
- automated reporting, recording of cancelled cases, real time landing page of current capacity - all of which can prevent under or overbooking (n=3)
- a centralised system for NHSScotland (n=1)
- an opportunity for customisation (n=1)
- consistency/standardisation of key metrics (n=1)
- efficiency and flexibility (n=4).

2. Future implementation of national theatre scheduling programme

The second part of the survey explored people's views on the potential for national implementation of a technology-enabled scheduling system. Questions covered the potential benefits, challenges and risks associated with implementing a digital system. People were also asked about the support that would be necessary for successful implementation.

Potential benefits

The majority of responders (n=20, 90%) believed that a technology-enabled theatre scheduling system would bring about a more standardised, streamlined, consistent and automated approach across all Scottish health boards. Responders noted that a digital system would be more modern, user friendly and support seamless integration and links to other waiting list management systems. The two people who couldn't see a benefit noted that their system was currently working well.

Other benefits mentioned by individual respondents included:

- the ability to flag gaps/errors for improvement

- enhance trust from theatre users such as surgeons and anaesthetists
- more sustainable and environmental friendly as a result of using less paper
- improved communication of special instructions (for a procedure).

The potential benefits of a digital-theatre scheduling system were neatly captured by one responder:

> '...reduced clinical time spent on scheduling, reduced wastage in system, improved theatre utilisation, less patient cancellation. Improved data for improvement, improved coding, less paper- more sustainable...'

Three (13%) respondents stated that they did not see any benefits from introducing a new digital programme in their area as they already use a digital system. One respondent noted that their theatre waiting lists have fully recovered post-pandemic and that, because of the size and unique situation of their health board, a new digital programme may potentially impact on their successful collaborative working. Another respondent thought that a new system would end up creating more challenges and barriers to overcome.

Potential challenges

Behaviour change was highlighted as the key challenge by thirteen (59%) respondents. Unless there is substantial and coordinated consultation with staff, asking people to move to new ways of working can lead to anxiety and a risk of resistance within the workforce. Training and support was noted as a way to mitigate these issues, although it was recognised that there is limited spare capacity for training. Training and support were considered a general challenge, especially when it comes to releasing staff for training on new ways of working.

Issues around funding (n=4, 18%) were also described, one respondent suggested that subsidising the programme would be useful. Respondents also mentioned technical difficulties and limited technical skills among staff (n=8, 36%), including already overstretched information technology (IT) staff.

Potential safety risks

Eighteen respondents (81%) noted three main potential safety risks. These were about data; training and support; and technical risks.

Data breaches, inaccuracies and patient misidentification were highlighted as risks with a digital system, especially during the implementation period when people are getting used to new ways of working. It was noted that comprehensive training and support would be needed for successful implementation of a new system. Inadequate user training could potentially result in inefficacy and incorrect allocation.

The respondents described the need to ensure working interfaces between systems. They identified the risk of running two systems in parallel for a period of time and of system

network issues or system outage, which could result in a delay to booking lists or cancellation of lists.

Support required for successful implementation

When asked what support would be required for successful implementation of a new system, respondents (n=11, 50%) noted a need for an agreed governance structure, which included a clear process for the implementation and routine use of the digital system.

They also described (n=11, 50%) staff engagement as key to success; staff need to have the benefits of the new system promoted and demonstrated in order to gain buy-in. On-site and easily available IT support was seen as a key requirement.

The final question asked respondents if there was anything else that should be taken into account as part of implementing a new digital system. Responses reiterated the need for the correct IT and technical infrastructure, the importance of doing this once for Scotland, integration with other patient record systems, and the challenges relating to people and change management. Other comments included the importance of ongoing funding for new systems, and a recognition that any new system should not adversely affect a patient's journey or outcomes.

Limitations of the survey

Limitations with the survey included:

- a small sample size – only 22 people responded from the 77 people contacted
- respondents were a self-selected group from a targeted population
- responses could have been limited by character limits, that is, the requirement to be succinct within the questionnaire format
- a lack of clarity on the digital-theatre scheduling system that respondents were being asked to imagine; the questions were focused on a concept rather than something respondents would have had experience of
- a survey can inherently result in limited reliability and validity of data as a result of subjective interpretation and researcher bias.

Infix® evaluation

Alongside the literature review and survey, an independent evaluation of a technology-enabled theatre scheduling system (Infix®) was conducted and is described below. Infix® is currently being used in NHS Lothian.

Background

SHTG was asked by the ANIA pathway to provide an independent summary of the data following implementation of Infix® in four operating specialities in NHS Lothian.

A summary of the evaluation conducted by SHTG is provided here. The data were provided to SHTG by NHS Lothian. Acronyms are listed in *Appendix 1*.

What is the value proposition for Infix®?

The company's value proposition for Infix® is that it will improve the theatre booking system, and in doing so, reduce theatre 'downtime'. The following efficiencies are proposed:

- increase insession utilisation by operations only
    - reduce underruns
    - reduce time between operations
- increase patient throughput (number of operations)
- reduce overruns
- reduce cancellations

These efficiencies should result in an increase in the productivity of the operating theatre (productive time) and an increase in the number of operations carried out, while retaining the current major to minor operation ratio.

What are the key outcomes?

SHTG developed three primary outcomes and five secondary outcomes of focus with the study team in NHS Lothian. Definitions and interpretation of the outcomes are detailed in *Table 1*.

Table 1: Primary and secondary outcome definitions and interpretation

Outcome type	Outcome	Definition	Interpretation
	Insession utilisation	Actual used minutes for operations divided by used session minutes for operations, multiplied by 100 to give a percentage figure.	1. Less than 100% = underrun, worse outcome 2. 100% = no under or overrun, planned outcome 3. More than 100% = overrun, worse outcome

Primary		Used sessions minutes is the time booked for operations	
	Throughput per session	Total number of patients seen divided by total number of used sessions	Higher number = better outcome
	Throughput per hour	Total number of patients seen divided by total used session minutes for operations	Higher number = better outcome
Secondary	Number of underruns	An underrun is when the actual used time for an operation is shorter than the booked time for an operation Total number of underruns	Higher number = worse outcome
	Number of overruns	An overrun is when the actual used time for an operation is longer than the booked time for an operation Total number of overruns	Higher number = worse outcome
	Cancellations (Theatre)	Cancellations as a result of lack of theatre time – total number	Higher number = worse outcome
	Cancellations (Other)	Cancellations for all other reasons, excluding lack of theatre time – total number	Higher number = worse outcome
	Number of operations booked onto TrakCare	Total number of operations booked onto TrakCare (excluding cancellations)	Higher number = better outcome

What did we do?

SHTG analysed data collected by NHS Lothian across four specialties (ENT, maxillofacial, ophthalmology and plastics), for primary and secondary outcomes. Outcomes were collected across three data sets for a period of 24 weeks:

- pre-pandemic baseline (before implementation of Infix®; 20 July 2019 to 3 January 2020)
- pre- Infix® baseline (before implementation of Infix®; 17 July 2022 to 21 December 2022)
- post-implementation of Infix® baseline (1 January 2023 to 19 June 2023).

The comparisons of interest were Infix® compared to pre-Infix® baseline and Infix® compared to pre-pandemic, with analyses conducted using R© software (version 4.2.2).

What did we find?

Post-implementation of Infix® compared with the pre-Infix® baseline

Ophthalmology

An average of five people per session are now receiving operations, compared to four per session during the pre-Infix® baseline. The difference represents a 26% increase in throughput per session. An average of 1.28 people per hour are receiving operations, compared to 1.02 during the pre-Infix® baseline. The difference represents a 25% increase in throughput per hour. Both the number of operations booked onto TrakCare and the number of cancellations (other, excluding theatre scheduling issues) increased during post-implementation of Infix®, compared to the pre-Infix® baseline. For TrakCare, the difference represents a 42% increase in the number of operations booked post-implementation of Infix. For number of cancellations (other, excluding theatre scheduling issues), the difference represents a 46% increase in the number of cancellations post-implementation of Infix. The reason for the increase in the number of operations booked onto TrakCare and cancellations (other reasons, excluding theatre scheduling) does not have an obvious explanation.

ENT

Average insession utilisation increased from 66% at pre-Infix® baseline to 75% post-implementation of Infix®, indicating that underruns have been reduced but not eliminated (100% would equal no under or overruns). In addition, the average number of underruns reduced from 6.92 during the pre-Infix® baseline to 3.54 post-implementation of Infix® a decrease of 49%. The increase in efficiency of using the operating theatre did not result in more people having operations per session or per hour. Throughput per session or per hour for ENT may not have increased during our evaluation due to the longer length of operations typical in this specialty, as well as the increasing length of operations seen across the datasets (*see Figure 1*). Longer operation lengths may mean that less time is available to increase the number of people receiving operations (compared to shorter operation times

seen in ophthalmology). We would need more information about how operating theatres were being used to understand relationship between operation lengths and throughput per session and hour. Despite throughput per session or per hour not increasing for ENT, there was an increase in efficiency through reduced theatre 'fallow time.'.

Maxillofacial and plastics

No significant comparisons for primary and secondary outcomes were observed for the maxillofacial speciality and no consistent pattern of results were observed for the plastics speciality.

Post-implementation of Infix® compared to pre-pandemic baseline

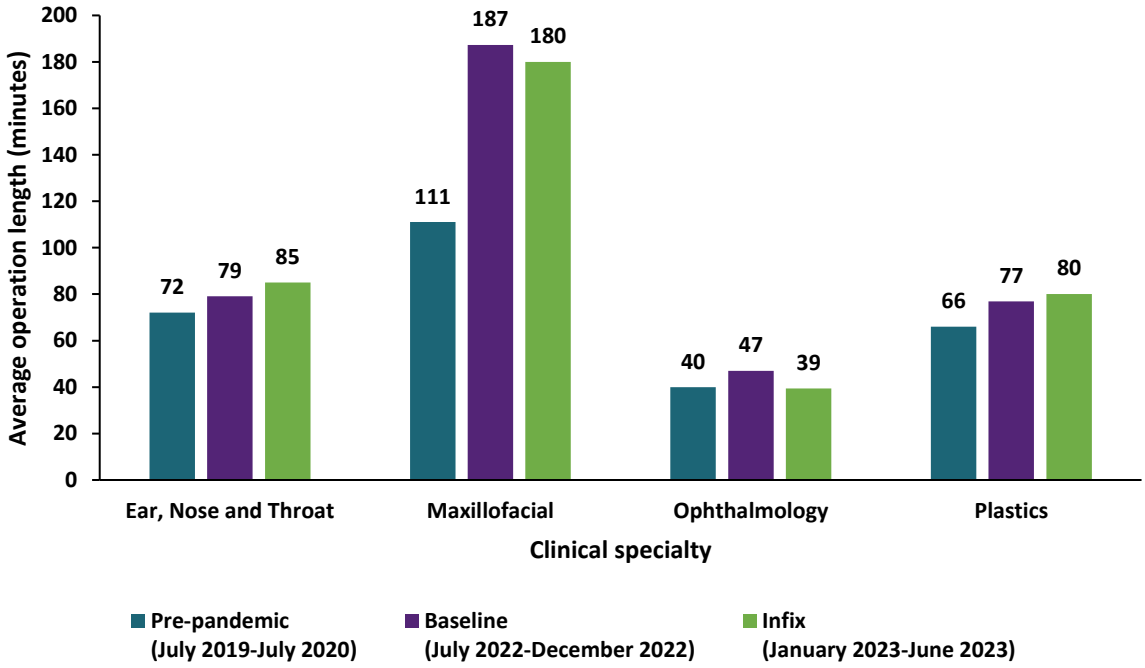
No consistent pattern of significant results within the specialities was observed for the primary and secondary outcomes (*see Appendix 2, Tables 6 to 7*). Any result for this comparison should be interpreted with caution because of the length of time and service provision changes since the pandemic to implementation of Infix® (4 years). In addition, there is reduced data available for a comparison (10 to 11 weeks) compared to the pre-Infix® baseline (24 weeks).

Other

Length of operations

SHTG requested additional information regarding average length of operations in NHS Lothian because of the pattern of results that was emerging during the evaluation. As evidenced in *Figure 1*, average length of operations differed per specialty and across the data sets collected. The average operations lengths for ophthalmology are shortest, while those for maxillofacial are the longest. There is an increase in operation length for ENT and plastics across all data sets. For the maxillofacial specialty, the pre-Infix® and post-implementation of Infix® operations lengths are longer than pre-pandemic and for ophthalmology, operation lengths have remained relatively consistent across the data sets.

Figure 1: Average length of operations (in minutes) in NHS Lothian, per specialty, for each data set (pre-pandemic, pre-Infix® baseline, and post-implementation of Infix®



Implementation issues

The results observed in the SHTG evaluation may have been influenced by low statistical power (that is, not enough data), variations in practice across specialties and challenges in Infix® implementation across the specialties in NHS Lothian, or a combination. Unfortunately, qualitative data exploring staff experiences is not available to explore any implementation challenges. Lack of statistical power and the lack of data on staff experiences of implementation may be considered limitations of this evaluation. No further data on equality and diversity, patient and public involvement, or safety was available for inclusion within the SHTG evaluation.

Conclusion

There is very limited published evidence on the effectiveness of technology-enabled scheduling systems in a real world setting.

Based on our survey of experts across NHSScotland, there is large variation in practice when it comes to theatre scheduling, and substantial opportunities for improvement using a proposed digital system. The feedback identified the potential benefits of adopting a digital-theatre scheduling system as achieving a standardised, efficient, and automated method for theatre scheduling across Scotland. Additional benefits suggested included reduced patient cancellations, waste and clinical time spent on scheduling, as well as improved coding and data for performance analysis.

The key challenges of implementing a national system, as described in the survey, were mostly associated with behaviours such as anxiety and resistance to change among staff, and issues around training, technical capability, and funding. These should be taken into account when implementing a new system.

The SHTG evaluation found evidence that Infix® can increase operating theatre efficiency. In the ENT specialty, the operating theatre is being used more efficiently, with underruns reduced but not eliminated. The increase in efficiency did not result in more people receiving operations in this specialty, which may be because of longer operations compared to other specialties, as well as an increase in operation length across the data sets (see *Figure 1*). For ophthalmology, one additional person per session is having an operation. The shorter average length of operations in ophthalmology compared to other specialties (see *Figure 1*), may have meant that the increase in efficiency freed up enough operating theatre time to carry out an additional operation per session.

Research gaps and recommendations for future work

There is a need to gather robust data to demonstrate the effectiveness of technology-enabled theatre scheduling systems in the UK health and social care system. The implementation of a new system in Scotland should be accompanied by an agreed evaluation framework to ensure data are collected to inform decision making on the continued roll out of the technology.

There was a lack of conclusive evidence across all outcomes and comparisons for the Infix® evaluation. Further data collection and a full Health Technology Assessment (HTA) at a later date should be considered to develop the evidence base further.

The views of professional experts should be gathered on the practicalities of a digital system (following use in Scotland).

Future work should also include an economic evaluation of the system, to weigh up the costs of the digital platform against the potential benefits and resource savings.

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Appendix 1: Abbreviations

ANIA	Accelerated National Innovation Adoption pathway
CfSD	Centre for Sustainable Development
COVID-19	Coronavirus Disease 2019
df	Degrees of freedom
ENT	Ear, Nose and Throat
EPRs	Electronic patient records
HTA	Health Technology Assessment
M	Mean
ND	No difference
SD	Standard Deviation
SHTG	Scottish Health Technologies Group
UCLA	University of California, Los Angeles

Appendix 2: Infix® evaluation results

Table 2: Results from primary outcome comparison between post-implementation of Infix® compared with pre-Infix® baseline, presented per specialty

Post-implementation of Infix® vs. pre-Infix® baseline					
Primary outcome	**Specialism**	**Statistic (df)**	**d or r**	**Direction**	**M(SD)**
Insession utilisation	**ENT**	**$t_{(23)}$=2.59***	**0.53**	**Infix® > baseline**	Infix® : 75.18(9.93) baseline: 66.17(10.40)
	Maxillofacial	$t_{(23)}$=0.64	0.13	ND	-
	Ophthalmology	$t_{(23)}$=0.82	0.17	ND	-
	Plastics	Z= - 0.46	0.09	ND	-
Throughput per session	ENT	Z= - 0.17	0.03	ND	-
	Maxillofacial	Z=1.09	0.22	ND	-
	Ophthalmology	**$t_{(23)}$=7.90*** **	**1.61**	**Infix® > baseline**	Infix® : 5.13(0.30) baseline: 4.06(0.62)
	Plastics	$t_{(23)}$=0.44	0.09	ND	-
Throughput per hour	ENT	Z= - 0.28	0.06	ND	-
	Maxillofacial	$t_{(23)}$=0.40	0.08	ND	-
	Ophthalmology	**$t_{(23)}$=7.91*** **	**1.62**	**Infix® > baseline**	Infix® : 1.28(0.07) baseline: 1.02(0.15)
	Plastics	**$t_{(23)}$= - 2.10***	**- 0.43**	**baseline > Infix®**	baseline: 0.67(0.16) Infix® : 0.59(0.11)

*Note: df = degrees of freedom; d = Cohens d; r = Pearson's r; M = Mean; SD = Standard Deviation; ENT = Ear, Nose and Throat; t = t-statistic for paired t-tests; Z = Z statistic for Wilcoxon Signed-Ranks; ND = No difference; *p < 0.05, **p<0.01, ***p<0.001*

Table 3: Results from primary outcome comparison between post-implementation of Infix® compared with pre-pandemic baseline, presented per specialty

Post-implementation of Infix® vs. pre-pandemic baseline					
Primary outcome	**Specialism**	**Statistic (df)**	**d or r**	**Direction**	**M(SD)**
Insession utilisation	ENT	$t_{(11)}$=0.24	- 0.03	ND	-
	Maxillofacial	$t_{(11)}$=1.67	0.21	ND	-
	Ophthalmology	$t_{(11)}$=1.34	0.48	ND	-
	Plastics	$t_{(11)}$=0.22	- 0.29	ND	-
Throughput per session	ENT	$t_{(11)}$= - 1.59	- 0.52	ND	-
	Maxillofacial	**$t_{(11)}$= - 3.46****	**- 1.16**	**PP > Infix®**	PP: 1.69(0.56) Infix® : 1.14(0.19)
	Ophthalmology	$t_{(11)}$=2.11	0.76	ND	-
	Plastics	**$t_{(11)}$= - 4.56*****	**- 1.42**	**PP > Infix®**	PP: 2.42(0.20) Infix® : 2.05(0.36)
Throughput per hour	ENT	$t_{(11)}$= - 1.51	- 0.38	ND	-
	Maxillofacial	**$t_{(11)}$= - 3.66*****	**- 1.15**	**PP > Infix®**	PP: 0.48(0.16) Infix® : 0.31(0.06)
	Ophthalmology	$t_{(11)}$=2.08	0.74	ND	-
	Plastics	**$t_{(11)}$= -2.43***	**- 0.87**	**PP > Infix®**	PP: 0.69(0.06) Infix® : 0.61(0.15)

*Note: df = degrees of freedom; d = Cohens d; r = Pearson's r; M = Mean; SD = Standard Deviation; ENT = Ear, Nose and Throat; t = t-statistic for paired t-tests; Z = Z statistic for Wilcoxon Signed-Ranks; ND = No difference; *p < 0.05, **p<0.01, ***p<0.001; PP = pre-pandemic.*

Table 4: Results from secondary outcome comparison between post-implementation of Infix® compared with pre-Infix® baseline, presented per specialty

Post-implementation of Infix® vs. pre-Infix® baseline					
Secondary outcome	**Specialism**	**Statistic (df)**	**d or r**	**Direction**	**M(SD)**
Number of underruns	**ENT**	**$t_{(23)}$= -4.42*** **	**- 0.90**	**baseline > Infix®**	baseline: 6.92(1.91) Infix® : 3.54(3.13)
	Maxillofacial	$t_{(23)}$=1.13	0.23	ND	-
	Ophthalmology	$t_{(23)}$=1.00	0.20	ND	-
	Plastics	$t_{(23)}$= - 0.62	- 0.13	ND	-
Number of overruns	ENT	Z= - 0.38	0.08	ND	-
	Maxillofacial	Z=0.53	0.11	ND	-
	Ophthalmology	$t_{(23)}$=1.20	0.25	ND	-
	Plastics	Z=0.76	0.16	ND	-
Cancellations: All other reasons	ENT	Z=0.38	0.08	ND	-
	Maxillofacial	$t_{(23)}$= - 0.64	- 0.13	ND	-
	Ophthalmology	**Z= - 1.20****	**0.24**	**Infix® > baseline**	Infix® : 15.46(4.06) baseline: 10.58(6.47)
	Plastics	Z= - 0.55	0.11	ND	-
Number operations TrakCare	ENT	$t_{(11)}$=0.42	0.15	ND	-
	Maxillofacial	$t_{(11)}$= - 1.18	- 0.07	ND	-
	Ophthalmology	**$t_{(23)}$=4.08*****	**1.53**	**Infix® > baseline**	Infix® : 95.08(23.33) baseline: 66.75(17.00)
	Plastics	$t_{(11)}$=1.02	0.22	ND	-

*Note: df = degrees of freedom; d = Cohens d; r = Pearson's r; M = Mean; SD = Standard Deviation; ENT = Ear, Nose and Throat; t = t-statistic for paired t-tests; Z = Z statistic for Wilcoxon Signed-Ranks; ND = No difference; *p < 0.05, **p<0.01, ***p<0.001.*

Table 5: Count of Cancellations (Theatre) between post-implementation of Infix® compared with pre-Infix® baseline, presented per specialty

Secondary outcome	Specialism	Baseline	Infix®
Cancellations (Theatre)	ENT	1	2
	Maxillofacial	0	1
	Ophthalmology	2	2
	Plastics	2	2

Note: ENT = Ear, Nose and Throat.

Table 6: Results from secondary outcome comparison between post-implementation of Infix® compared with pre-pandemic baseline, presented per specialty

Post-implementation of Infix® vs. pre-pandemic baseline					
Secondary outcome	**Specialism**	**Statistic (df)**	**d or r**	**Direction**	**M(SD)**
Number of underruns	**ENT**	**$t_{(11)}$= -4.74*** **	**-0.67**	**PP > Infix®**	PP: 5.50(2.36) Infix® : 1.50(0.91)
	Maxillofacial	$t_{(11)}$= -1.03	- 0.25	ND	-
	Ophthalmology	$t_{(11)}$=1.73	0.25	ND	-
	Plastics	**$t_{(11)}$= -2.22***	**- 0.39**	**PP > Infix®**	PP: 10.08(2.94) Infix® : 7.83(2.79)
Number of overruns	ENT	Z= - 0.36	0.10	ND	-
	Maxillofacial	Z=0.74	0.21	ND	-
	Ophthalmology	$t_{(11)}$=0.65	0.38	ND	-
	Plastics	**Z= - 1.37*** **	**0.39**	**PP > Infix®**	PP: 10.08(2.94) Infix® : 1.50(1.31)
Cancellations: All other reasons	ENT	$t_{(11)}$=0	- 0.22	ND	-
	Maxillofacial	Z= - 0.65	0.19	ND	-
	Ophthalmology	$t_{(11)}$=0.57	0.11	ND	-
	Plastics	$t_{(11)}$= - 0.33	- 0.06	ND	-

*Note: df = degrees of freedom; d = Cohens d; r = Pearson's r; M = Mean; SD = Standard Deviation; ENT = Ear, Nose and Throat; t = t-statistic for paired t-tests; Z = Z statistic for Wilcoxon Signed-Ranks; ND = No difference; *p < 0.05, **p<0.01, ***p<0.001; PP = pre-pandemic.*

Table 7: Count of Cancellations (Theatre) between post-implementation of Infix® compared with pre-pandemic baseline, presented per specialty

Secondary outcome	Specialism	PP	Infix®
Cancellations (Theatre)	ENT	2	2
	Maxillofacial	0	1
	Ophthalmology	2	2
	Plastics	2	2

Note: ENT = Ear, Nose and Throat; PP = pre-pandemic.