1. BACKGROUND

Arterial lines are used in operating theatres and Intensive Care Units (ICUs). The arterial sets have opening ports which allow the taking of blood samples and are covered by arterial connectors. There can be several problems with Standard Arterial Connectors (SACs), in that they: can permit infection of the arterial line; can permit blood spillage during sampling that can infect health care workers; permit injections if the arterial line is confused with a venous line, which can result in serious harm, including, in the most serious cases, amputation of a limb.

The Non-Injectable Arterial Connector (NIC) has been engineered to prevent these problems by not permitting accidental administration of medications. This is achieved by means of a one-way valve in an internal chamber, preventing bacterial contamination and preventing blood spillage during sampling. It fits on the arterial line in the same way as a SAC and does not require substantive new skills on the part of users.

The NIC is fully developed and is in use in approximately 30 to 40 trusts across the UK.

This case study presents a Cost Consequence Analysis based on information provided by the NIA Fellow and information in a report from the Eastern Academic Health Sciences Network. The analysis was developed in spring 2017 and was based on the information and evidence available at the time. The limitations of the analysis are as follows:

- The data used in the analysis were taken from one study;
- There were no data available on the incidence of medication errors and infections rates, so adverse events that are potentially avoided could not be valued in the analysis.

2. INPUT COSTS

The NIC is fully developed and tested and it is currently in use. It has a cost of £2 per unit. There is a small difference in the costs of NICs and SACs. The full cost comparison is reported in Table 3.1.

For a hospital to adopt the NIC in its ICU or anaesthetic teams, there will be minimal changeover costs. This is in the form of training time to learn to use the NIC, taking roughly two to three minutes.

3. OUTCOMES

A clinical audit of SACs indicated that there was a 6% bacterial colonisation rate with these devices. Laboratory studies have indicated that the NIC does not become colonised with bacteria or transmit bacteria to the arterial line or the patient.² In clinical settings where the NIC is being used on both the sampling port and the transducer port, the arterial line is transformed into a closed system. Studies are currently being undertaken to determine whether it is possible to extend the lifetime of the arterial line from three days to seven days, potentially introducing further cost saving for the NHS.

The incidence of accidental injection into the arterial line in the literature is reported to be as common as 1:3,440 procedures.³ Attempts were made to calculate the incidence of medication errors that the NIC is designed to prevent (i.e. administering medication into the arterial line rather than into the venous line). A national survey of Consultant Anaesthetists and Consultant Intensivists asking for recall of errors, demonstrated that 28.5% had seen this error occur in their hospital within the previous five years. Furthermore, 10 years’ worth of arterial line data were analysed from the National Reporting and Learning System database. These data show that wrong route drug administration into the arterial line is reported to occur twice per month in the NHS.⁴ However, these figures are understood to be underreported, and it was concluded that it is not possible to estimate the true incidence of errors from these data.

A study was performed to determine the likelihood of the error occurring in the complex ICU environment to determine the need for a safety solution. A forced-error simulation study with junior medical staff showed that the mistake was easy to make, with 66% of candidates making the error and not realising that they had done so.

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² Mariyaselvam M et al. 2015 op. cit. The Non-injectable arterial connector, A cost effectiveness assessment to improve arterial line safety. EAHSN Implementation study, 2015
⁴ Source: NIA Fellow - Unpublished data, under peer review, personal correspondence from the Medical Director, NHS England.
The estimated costs of medication administration errors range from:

- A near miss incident (where injection did not occur), costing £57;
- An incident where the patient suffered no lasting harm, costing £2,230;
- An incident where the patient suffered lasting harm, costing £4,000;
- The most serious case (limb amputation resulting from error), costing £10,174.

A further proposed benefit is that it takes less time to complete a common task using the arterial line, such as withdrawing arterial blood for sampling. The proposed outcome metrics and proxy values are included in Table 3.1.

Table 3.1: Impacts, metrics and proxy values for NIC

<table>
<thead>
<tr>
<th>Impact</th>
<th>Outcome metric</th>
<th>Proxy value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to perform clinical tasks</td>
<td>Time needed to take blood samples for Nurse Band 5/6 of two seconds less per procedure (cost per second = £0.03)⁶</td>
<td>£0.06</td>
</tr>
<tr>
<td>Reduced colonisation of arterial tubes</td>
<td>Arterial line associated infection rates</td>
<td>Difficult to calculate accurately</td>
</tr>
<tr>
<td>Avoided medication errors</td>
<td>Cost of erroneously administering medication via arterial tube instead of venous tube, ranging from near miss incident (£57 per case) to limb amputation (£10,174 per case)⁷</td>
<td>Range from £57 to £10,174 per case</td>
</tr>
</tbody>
</table>

The NIC costs £2 per unit compared to an average cost of £0.18 for a SAC. However, based on observations in the cost effectiveness study, a SAC needs to be replaced each time blood is taken, which can be four times a day, whereas the NIC stays in situ for 72 hours. The average cost of SACs over the same period would therefore be £2.16.

The range of costs for the SAC is £0.04 to £0.79. The cheapest versions would be less costly to use than the NIC over time (£0.48 over 72 hours with four blood samples/day), whilst the more expensive alternatives would reveal an even greater saving for the NIC (£9.48 over 72 hours).

4. ECONOMIC ANALYSIS

The annual savings reported for a hospital using NIC rather than SAC are presented in table 4.1. This represents a hospital trust with 16 critical care beds, assuming the patient in each bed has four blood withdrawals / day. All costs are taken from the report previously cited.⁸
Table 4.1: Cost savings over one year using NIC compared to SAC for hospital with 16 ICU beds

<table>
<thead>
<tr>
<th>Item</th>
<th>Calculation</th>
<th>Annual savings using NIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to perform procedure</td>
<td>Average two seconds less time to use NIC; four blood withdrawals per day. Ten hours of nursing staff Band 5/6 time per hospital per year is saved under NIC.</td>
<td>£1,091</td>
</tr>
<tr>
<td>Consumables</td>
<td>Cost of one NIC is £2 over 72 hours. Cost of SAC is £2.16 over 72 hours (4 per day x 3 days). i.e. net saving per bed of £0.16 for 72 hours; net saving per bed of £0.37 per week; net saving per 16 beds of £5.92 per week; annual savings per 16 beds of £308.</td>
<td>£308</td>
</tr>
<tr>
<td>Reduced infections</td>
<td>Infection rates of 0.68% reported in the East of England Region. Infection rates may be reduced by 25% but not tested.</td>
<td>Not estimated</td>
</tr>
<tr>
<td>Avoided medication errors</td>
<td>Cost of inadvertent arterial line injection ranges from £57 (near miss), to £10,174 (amputation resulting from error). However incidence is too low to calculate.</td>
<td>Not estimated</td>
</tr>
<tr>
<td>Total (excluding avoided infections and medication errors)</td>
<td></td>
<td>£1,376</td>
</tr>
</tbody>
</table>

There would be minimal changeover costs when a hospital changed from using SAC to using NIC. This is in training time to learn to use the NIC, taking roughly two to three minutes. However, this would be a one-off cost and no substantive new skills are required to implement the NIC in practice. The health economics study included in the Eastern Academic Health Science Network Patient Safety Study reported that this innovation is likely to be dominant in health economics terms, in that it delivers improved outcomes at lower overall costs. This evaluation did not include the changeover costs or the option of using the cheaper types of SAC available, which do not prevent the error from occurring. Given that the incidence of the adverse events that the NIC prevents are not calculated, it is not possible to estimate the return on investment. However, even at the lowest cost of an inadvertent arterial line injection (£57), a threshold analysis is likely to show that the NIC would need to prevent few such events to be cost saving. Also, by using a safety innovation that ensures this error cannot occur, there is the potential for avoiding future reputational damage and/or claims for clinical negligence, although the cost of these consequences are difficult to quantify.

5. IMPACT ON EMPLOYMENT

The manufacturer and distributor of the NIC has employed two more people in order to produce and sell the device.

There will be no change to health care staff costs as the same staff will be using the device for the same procedure.

There will be wider societal benefits from the prevention of adverse events, particularly in the most serious cases. For patients, this could result in a more economically productive life for those who would have otherwise come to harm.
6. CONCLUSION

The information on costs and outcomes has been used to carry out a cost-consequence analysis. The evidence presented is of good quality on the measurements used and is open about the elements that cannot be measured. There are major consequences (incidence of errors and infection rates) that have not been quantified and hence able to be valued, although these events are, fortunately rare. This plus the small margin of cost reduction in using the NIC mean that the economic case for NIC is not able to be confirmed at this time, but it has potential to be cost saving from an NHS perspective, as demonstrated in the AHSN patient safety study. The cost savings for individual uses of the NIC are modest but, given the extensive use of arterial lines, it has been estimated to potentially save £20,500 in staff costs (due to quicker procedures) and £26,000 in consumables (due to lower overall cost of the NIC) in the East of England NHS region over one year.\(^9\) One must also consider the consequences of not implementing a safety innovation that has been validated and recommended for use by the NHS.

As previously mentioned, the analysis was limited by the fact that data used were taken from one study, plus there were no data available on the incidence of medication errors and infections rates, in order to include these in the analysis.

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\(^9\) Mariyaselvam et al. 2015 op. cit.