SUSQI PROJECT REPORT

Project Title: One stent, one visit: a five-year sustainable quality improvement evaluation of biodegradable ERCP stenting at Aberdeen Royal Infirmary

Start date of Project: April 2026

Date of Report: August 2026

Team Members:

Salman Idrees Bhutta

Subita Suparmanian

Akshita Agarwal



The project team, Aberdeen Royal Infirmary.

Background:

Stents are the cornerstone of Endoscopic Retrograde Cholangiopancreatography (ERCP) for benign and malignant pancreaticobiliary disease. Generally, as a rule, plastic stents are used in benign conditions which will require a subsequent procedure for stent removal. As a result, additional investigations and hospital visits are unavoidable. For biliary plastic stents, patients typically require a second ERCP for stent removal. For prophylactic plastic pancreatic stents, follow-up should include an abdominal X-ray to confirm the spontaneous passage. If the stent remains in situ, an Oesophago-Gastro-Duodenoscopy (OGD) should be arranged for stent retrieval using a snare or grasping forceps.

Consequently, each plastic stent results in at least one additional hospital attendance and a second endoscopic procedure. This increases healthcare-related carbon emissions, healthcare costs, pressure on endoscopy services, and exposure of patients to procedure-related risks.

ERCP is a resource-intensive procedure that requires fluoroscopy, sedation, a full endoscopy team, and often an overnight hospital stay. European and UK guidance identifies endoscopy as a priority area for environmental sustainability initiatives [1,2].

Archimedes biodegradable stents (BDS) dissolve in situ, eliminating retrieval procedures, additional hospital visits, and associated risks while maintaining their intended function. BDS have been used routinely for benign biliary and pancreatic indications in Aberdeen for the past five years, with experiences presented at ESGE Days and BSG Live 2026. Published evidence demonstrates high technical and clinical success rates, with post-ERCP pancreatitis rates comparable to standard practice. Cost analyses also suggest that BDS reduces the need for endoscopic retrieval, lowering healthcare utilisation, costs, and environmental impact [3,4,5].

The project supports existing net-zero commitments of NHS Scotland to reach net zero by 2040 for directly controlled emissions and by 2045 for all remaining emissions, with endoscopy specifically identified as a priority area [6]. NHS Grampian reports against the same targets, with clinical

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decarbonisation under way in theatres, procurement and travel [7]. This project extends that approach into endoscopy by taking a whole procedure out of the pathway.

Aberdeen Royal Infirmary, NHS Grampian's tertiary hepato-pancreato-biliary (HPB) and ERCP centre, serves around 626,000 people across Aberdeen City, Aberdeenshire and Moray, much of it rural. In uncomplicated cases, each ERCP involves ward admission the day before, an overnight stay and discharge the next day; avoiding a visit therefore removes the journey, procedure and hospital night.

The team involves endoscopists, endoscopy nurses, the ERCP coordinator, procurement and the NHS Grampian sustainability lead. The BDS pathway is already established, outcome data is available, and the clinicians delivering the service also oversee a yearly audit. Since presenting this work at ESGE and BSG Live 2026, Hammersmith Hospital London, Raigmore Hospital Inverness and Oxford University Hospitals Oxford, have asked about the true pathway cost and carbon footprint of biodegradable stents. This highlights that accurately quantifying the economic and environmental impact of stenting pathways is a shared challenge across UK centres, rather than one unique to Aberdeen.

Using the Centre for Sustainable Healthcare (CSH) sustainable value equation, which balances health outcomes against environmental, social, and financial costs, this project delivers equivalent clinical outcomes at lower overall cost across all three domains [8]. It aligns with key principles of sustainable clinical practice by preventing unnecessary procedures, streamlining care pathways, and replacing retrieval-dependent stents with a low-carbon biodegradable alternative.

Specific Aims:

By August 2026 the project aimed to:

1. Establish the per-case cost (£) and carbon footprint ($kgCO_2e$) of the biodegradable stent pathway compared with conventional plastic stenting, using a bottom-up method that other ERCP units can adopt.
2. Assess whether clinical outcomes and safety were consistent with published biodegradable and plastic stent series.
3. Capture the social value of the pathway through patient and staff perspectives, completing the SusQI triple bottom line.

Success was defined as a net reduction in cost and carbon per patient with a transferable evaluation framework, clinical outcomes comparable to published series, and supportive feedback from those who use and deliver the service.

Methods:

Studying the system

The conventional plastic-stent pathway was mapped against the biodegradable pathway. Each step was annotated with SusQI resource-use circles to show the environmental, social and financial cost involved (Figure 1). Both arms have the same front end: referral and vetting, pre-assessment, ward admission the day before ERCP, consent, sedation, the ERCP itself, and discharge a few hours later in

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uncomplicated cases. The pathways separate only when the stent is chosen. This made the avoidable activity clear: plastic biliary stents require a repeat ERCP for removal, while plastic pancreatic stents require a follow-up X-ray and, if retained, an OGD for retrieval on the same day. A driver diagram or prioritising ideas matrix were not deemed necessary because the map identified one change at one point in the pathway, with no competing options to rank.

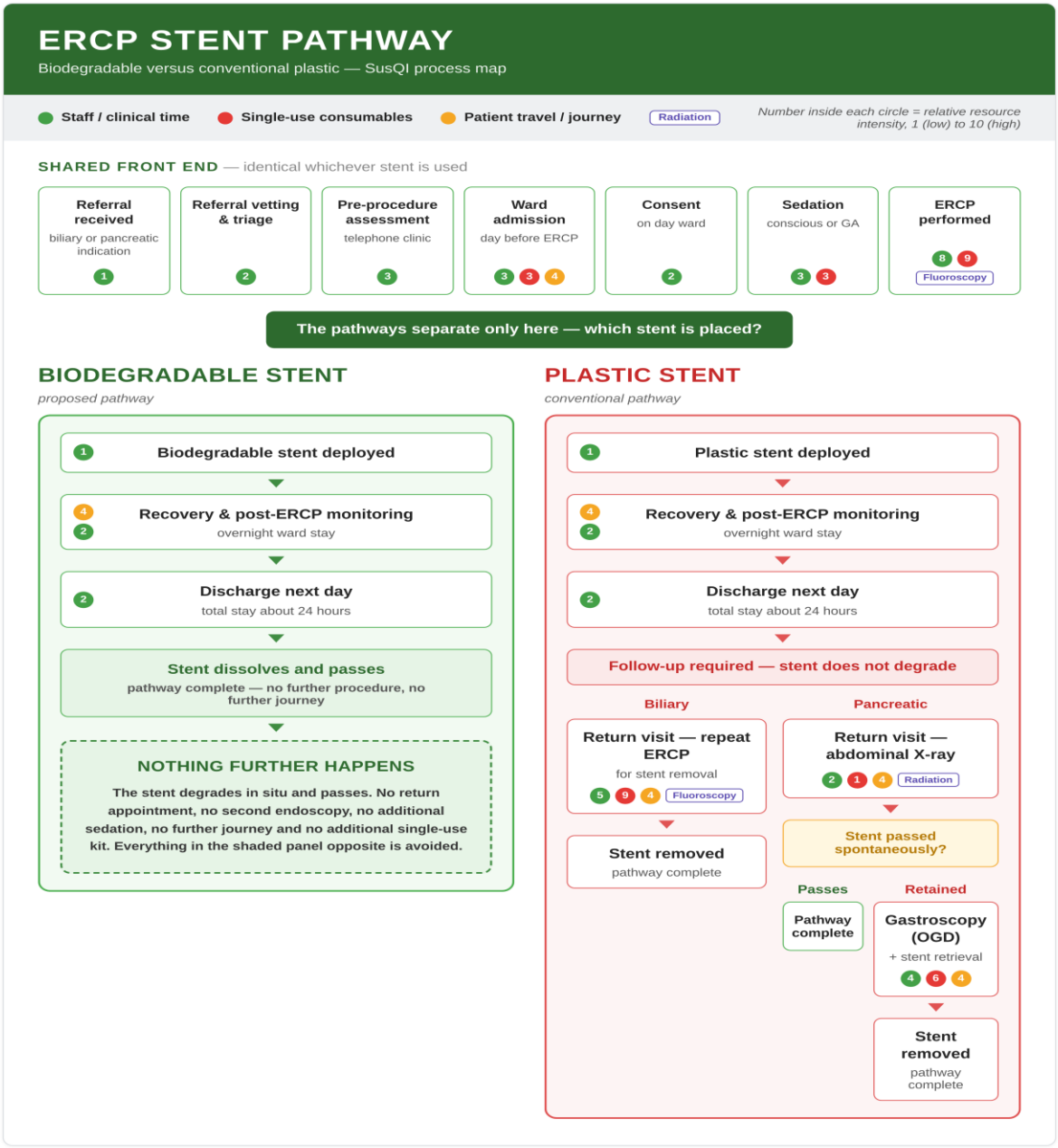


Figure 1. Conventional (plastic) versus biodegradable ERCP stent pathway, mapped with SusQI resource-use intensity. Both arms share an identical front end and separate only at stent choice. Circles show relative intensity from 1 (low) to 10 (high): green = staff and clinical time, red = single-use consumables, amber = patient travel; the violet tag marks a step using ionising radiation. Every step shaded in the plastic panel is avoided by a biodegradable stent.

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Every biodegradable biliary and pancreatic stent placed at Aberdeen Royal Infirmary between October 2020, and October 2025 was reviewed. Cases were identified from the departmental ERCP database and cross-checked against the Endoscopy Management System; none were excluded. Three team members extracted data of indication, technical success, clinical outcome, complications and follow-up. As this was a service evaluation of established practice, ethical approval and research governance registration were not required. One-way road distance from home postcode to Aberdeen Royal Infirmary was taken from the CSH postcode analysis of the 59 stent procedures performed in calendar year 2024 [12]; the mean was applied to every avoided attendance, each counted as a return journey of twice that distance. Because an elective-patient survey showed that most patients travelled by car, the average-car emission factor of 0.339 kgCO_2e per mile was applied [9].

A contemporaneous plastic-stent comparator cohort was not available. Earlier records are archived and not readily retrievable, and biodegradable stents have been the default option for appropriate indications since the CE-certified ARCHIMEDES system (Q3 Medical) was introduced into practice in 2018. Consequently, the plastic-stent pathway was modelled rather than directly observed.

Modelling of biliary stenting was straightforward, as all plastic stents require removal and therefore generate an additional ERCP in every case. For pancreatic stenting, it was assumed that 30% of patients would require endoscopic retrieval following radiographic follow-up, equating to 22 retrieval procedures across the pancreatic cohort. Published retrieval rates for conventional prophylactic pancreatic stents range from approximately 12% to 40% [10,11], placing this assumption toward the upper end of the reported range.

The plastic pathway was modelled on three rules:

Each biliary stent generates one definitive removal ERCP

Each pancreatic stent generates one definitive check abdominal X-ray

Estimated 30% of pancreatic stents will need one retrieval OGD

Key stakeholders were the endoscopists, endoscopy nurses, ERCP coordinator, procurement team, waste management team and the NHS Grampian sustainability lead. They were engaged through emails, and in person meeting, where the pathway map and retrospective findings were discussed in the context of green-endoscopy guidance [1,2]. Data extraction and costing were completed within the department, using consumable prices from local NHS Grampian procurement; informatics, estates and medicines management input was not included. Staff and patient experience did not define the problem but was captured during the project through open-ended surveys of ten nurses, two doctors and ten patients, reported under social sustainability.

Implementing change

The project evaluates substituting a biodegradable stent for a conventional plastic stent in appropriate benign biliary and pancreatic indications. The biodegradable stent degrades in situ, removing the need for a later removal or retrieval procedure. Use increased incrementally, case by case, between October 2020 and October 2025, rather than through a single service-wide switch. Adoption was guided by indication, accumulating published evidence and practical feasibility. There were no PDSA cycles or pilot phase; the stents were introduced as they became available and use

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expanded as confidence grew. Plastic stents remain in use for indications not covered by biodegradable stents. This project adds a retrospective estimate of the pathway's cost and carbon impact, plus a method that other units can apply locally.

Because the pathway was already established, implementation needed little additional infrastructure: no new standard operating procedure or guideline, no further sign-off, no capital equipment, and no loaned or donated consumables. The stents were already procured, in routine use and compatible with the existing ERCP set-up. The only change was the stent itself, which was already in the supply chain and carried a significant unit-price premium over plastic. No financial investment was needed because this was an evaluation of existing practice.

There were no unsuccessful changes to report because the project evaluated an established pathway rather than piloting a new one. Staff education requirements were minimal, as the technique was already part of routine practice; however, two training sessions were delivered.

Measurement:

This section outlines planned measures and data sources; results are reported below. The October 2020 to October 2025 evaluation uses actual clinical and social data from patients and staff, while environmental and economic measures combine cohort activity with published emission factors, local prices and a modelled plastic-stent comparator, as no contemporaneous plastic cohort was available.

Patient outcomes:

Clinical outcomes were measured for the full October 2020 to October 2025 cohort using ERCP reports, follow-up records, the departmental ERCP database and the Endoscopy Management System. Outcomes included technical and indication-specific clinical success, post-ERCP pancreatitis, other adverse events and mortality, benchmarked against published biodegradable-stent series.

The aim is not to prove superior outcomes, but to show that biodegradable stents maintain the same standard of care while making the pathway more patient-centred and efficient. By achieving the same clinical result with one fewer endoscopy, the pathway avoids an additional sedation episode, hospital attendance and procedural risk. No adverse patient impact is expected; instead, the change is intended to reduce environmental harm and financial cost while adding wider social value.

Population outcomes:

No primary population-level data collection was planned because the timeframe and data available to a single endoscopy service were insufficient. Instead, population impact was inferred from cohort activity and service context. NHS Grampian serves a large, dispersed population across North-East Scotland, where every avoided procedure also avoids a return journey. The benefit is greatest for patients least able to travel, including older, rural, low-income and working patients. Potential disadvantage was also considered. Because the change removes an appointment rather than adding a barrier, and requires no digital access, additional literacy or new patient action, no group is expected to lose out.

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Environmental sustainability:

Methodology

A cradle-to-grave carbon footprint analysis was used to estimate the items' greenhouse gas (GHG) emissions. Data was provided on the equipment used to perform ERCPs, OGDs and biliary stent removals and were carbon footprinted using a process-based carbon footprint analysis. Items were weighed by the team and materials identified.

Data was obtained from previous studies by the Centre for Sustainable Healthcare and other references. Where data was not available, calculations were made based on the weight and material of the product. Material weights were converted into GHG emissions using emission conversion factors taken from the Department of Energy Security and Net Zero (DESNZ)'s Greenhouse Gas Reporting Conversion Factors 2026 database, ICE V4.0 database and primary research papers and LCAs. The analysis included GHG emissions associated with primary materials production, transport, and disposal.

Materials

Material emissions were calculated by the weight of the material, emission factor of the material and number of items.

*Total emissions = weight of material * material emission factor*

Waste

Waste emissions were calculated by the amount of waste (tonnes) and the UK emission factor of average emissions by waste stream.

*Total emissions = volume of waste * waste stream emission factor*

The emission factor for clinical waste is 1,074 $kgCO_2e$ per tonne, and 172 $kgCO_2e$ per tonne for both dry mixed recycling and domestic waste.

Travel

Emissions were calculated by the total distance travelled and emissions based on mode of transport. If mode of transport is not known, emissions were based on an average car are used.

*Total emissions = number of miles travelled per patient * emission factor per mode of travel*

The emission factor for an average car is 0.339 $kgCO_2e$ per mile [9].

Activity over the five-year period is summarised in Table 1.

Table 1. Five-year activity data.

Activity, October 2020 to October 2025	Count

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Activity, October 2020 to October 2025	Count
Total procedures	152
Biliary stents	78
Pancreatic stents	74
Procedure Avoided by biodegradable stents	78 stent removals, 22 OGDs, 74 abdominal X-rays

There are four procedures completed during a standard list equating to approximately one hour per procedure. The equipment used to perform the ERCP is used for 30 mins, with the remaining 30mins for the movement of patient and resetting the ERCP procedure room.

The system boundary encompasses the consumables used, associated waste generation, energy consumption of in-room equipment, sedation medications, and the patient's journey. No processes beyond these stages were included in the analysis. Scope decontamination and reprocessing, water use, staff travel, and the manufacture and disposal of the stents themselves were not counted. Water consumption and medication toxicity were considered and judged immaterial to this change, since neither the water used, nor the drugs given differ between the two stents; the difference lies entirely in whether a further procedure takes place. Every exclusion runs the same way, understating the footprint of the pathway a biodegradable stent replaces, so the figure is a conservative floor rather than a full lifecycle account.

Economic sustainability:

Only costs borne by the organisation were included. Patient savings, such as reduced travel and time away from work, were considered social value. Stent and consumable costs were obtained from NHS Grampian procurement records, staff costs from the PSSRU *Unit Costs of Health and Social Care 2024/25* [13], and local tariffs for waste disposal and non-staff bed-days. Abdominal X-rays were costed using a locally agreed figure, as plain radiography is not included in the national NHS tariff.

Unit costs were based on actual prices, while activity data was derived from the five-year biodegradable stent cohort. The plastic-stent pathway was modelled as described in the methods. The analysis focused on costs avoided using biodegradable stents, including repeat ERCPs, retrieval OGDs where required, abdominal X-rays, overnight stays, consumables, staffing, and waste disposal. These savings were offset against the higher acquisition cost of biodegradable stents.

No implementation or maintenance costs were incurred, as the intervention involved substituting one consumable for another within an established clinical pathway. Consequently, no capital investment, break-even point or return-on-investment calculation was required. Results were presented as per-case and projected annual savings.

Each element is derived as follows:

Cost avoided = number of procedures avoided × full per-case cost of procedure.

Additional device cost = number of biodegradable stents placed × unit-price premium over plastic.

Net saving = cost avoided − additional device cost.

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Some real-world costs were deliberately excluded because reliable unit prices could not be identified. These included sedation drugs, consumables without procurement catalogue prices, complications related to retained plastic stents, additional bed-days and readmissions, imaging capital and estate costs, and patient travel or time off work. Consequently, these costs were not included in the analysis.

The full boundary of the model, item by item, is tabulated in Appendix Table A1.

Social sustainability:

Social value was captured through open-ended surveys rather than fixed questions, allowing patients and staff to identify what mattered to them. Patients undergoing ERCP were first introduced to biodegradable stents, including how they compare with plastic stents and when each is used, and were then asked for their views in their own words. Endoscopy staff were surveyed in the same open-ended way. Patients were expected to describe avoided journeys, time off work and travel costs, which are reported here as social rather than financial value, valued at HMRC mileage and National Living Wage rates. Staff were expected to highlight the simpler pathway and the value of delivering more sustainable care.

Results:

Patient outcomes:

Across the five-year cohort of 152 patients; 78 biliary and 74 pancreatic, biodegradable stents were placed with 100% technical success and full fluoroscopic visibility. Bile-leak resolution was 96.5% (55/57), cholangitis prophylaxis was effective in 75% (3/4), and all other biliary indications resolved (16/16, with one additional case lacking follow-up). In the pancreatic arm, post-ERCP pancreatitis occurred in 16 of 71 prophylaxis cases (22.5%), pancreatic duct disruptions resolved in 100% (2/2), and the single pancreatic duct stricture resolved without recurrence (1/1). Two deaths occurred (2/71, 2.8%), both from severe pancreatitis in a high-risk group and neither attributable to the stent; there were no stent-related serious adverse events.

These findings align with the published biodegradable-stent experience [4,14,15], showing high technical and clinical success across biliary and pancreatic indications, maintained safety, and no need for a removal procedure. Each clinical result was achieved with one procedure fewer.

Table 2. Clinical outcomes across the five-year cohort (152 patients: 78 biliary, 74 pancreatic). One further biliary case had no follow-up.

Arm	Outcome	Result	Rate
Overall	Technical success	152/152	100%
Biliary	Bile-leak resolution	55/57	96.5%
Biliary	Cholangitis prophylaxis	3/4	75%
Biliary	Other indications resolved	16/16	100%
Pancreatic	Post-ERCP pancreatitis (prophylaxis group)	16/71	22.5%
Pancreatic	Duct disruption resolved	2/2	100%
Pancreatic	Duct stricture resolved	1/1	100%
Safety	Mortality (not stent-related)	2/71	2.8%

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Population outcomes:

No primary population-level data was collected, so these findings are inferred from the cohort and service context. Over five years, the pathway removed 78 repeat ERCPs, 22 retrieval gastroscopies and 74 follow-up X-rays, totalling 152 returning hospital appointments, with a yearly average of 30 appointments avoided. Annual placements were 10, 12, 20, 53 and 57 in successive October-to-October years, so at the current rate of about 55 a year, the pathway now avoids around 55 attendances and 1,850 kg CO_2e annually, with a procedure-cost saving of about £4,100 a year if the case mix is unchanged. One hundred of the avoided appointments (78 ERCPs and 22 OGDs) were endoscopy slots, potentially shortening waits for the wider population served by a stretched service. The avoided visits, and the associated 5,111 kg CO_2e, particularly benefit older, rural and lower-income patients, who often travel furthest. Because the intervention removes an appointment rather than adding a barrier, and asks nothing new of patients, no group is expected to be disadvantaged.

Environmental sustainability:

ERCP emissions

The emissions associated with stent insertion includes from the consumables (production, raw materials, manufacturing), waste disposal and energy used by electronic equipment. Weights and material composition of the equipment used were identified and supplied by the team and are shown in appendix table A2 along with the emissions for the raw materials and production.

Total emissions for the consumable items used in the ERCP were 4.86 kgCO_2e per procedure.

Waste

Waste disposal emissions are calculated by weight of waste and waste stream. It is assumed all the above items are disposed of in clinical waste apart from the cardboard packaging for the orange and blue bins and any sharps.

Total emissions from waste disposal are 1.74 kgCO_2e per procedure.

Electronic equipment

Emissions per procedure (assuming 1 hour procedure).

Estimated energy use for each piece of electrical equipment listed is shown in appendix table A3. This is taken from product information sheet and is an average rather than being directly measured using an energy meter. Actual power draw varies due to multiple factors including LED illumination level, connected peripherals, image processing load, standby versus active use, lamp intensity setting, cooling fan operation, IR/NBI mode usage, and age of the xenon lamp etc.

Average UK Grid emissions for 2025/26 are 0.144 kgCO_2e/kWh. If the equipment uses 2.5kWh for a one-hour procedure, the emissions are 0.36 kgCO_2e. The ERCP tower and obs monitoring is used for 30mins, the room cooling and computers are used for the hour per procedure. Total energy use per procedure is 1.875 kWh or 0.270 kgCO_2e

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Medication

Medication may be used to sedate patients. The emissions associated with the product including the Active Pharmaceutical Ingredient are shown in appendix table A4.

There is likely additional equipment such as needles and syringes to draw up and deliver the medication to the patient.

Emissions from medication are 78.6 gCO_2e (0.0786 $kgCO_2e$).

ERCP Summary

Total emissions per ERCP procedure for consumable equipment and waste is 6.60 $kgCO_2e$, with a further 0.27 $kgCO_2e$ for energy and 0.079 $kgCO_2e$ from medication, resulting in a total of 6.95 $kgCO_2e$ per procedure.

OGD emissions

The emissions associated with an OGD includes those from the equipment (production, raw materials, manufacturing), waste disposal and energy used by electronic equipment. Weights and material composition of the equipment used were identified on the OGD checklist and supplied by the team (appendix table A5) along with the emissions for the raw materials and production.

Estimated energy use for each piece of electrical equipment listed is shown in appendix table A5. This is taken from product information sheet and is an average rather than has been directly measured using an energy meter.

Emissions from Table A5 are 2.17 $kgCO_2e$.

Waste

One yellow bin is disposed of every 10 OGD procedures. It has a maximum filling weight of 8 kg of waste SHARPSGUARD® eco orange theatre+ - Daniels Healthcare

One blue bin (medically contaminated sharps) is disposed of every 10 OGD procedures. It has a maximum filling weight of 5kg (SHARPSGUARD® eco sharps pharmi 24 xa - Daniels Healthcare).

In total 13kg of waste is disposed of via the clinical incineration route every 10 procedures. This equates to 1.3kg per procedure.

*Total emissions = volume of waste * waste stream emission factor*

The emission factor for clinical waste is 1074 $kgCO_2e$.

Emissions from waste are 1.40 $kgCO_2e$ per procedure.

Summary

Total emissions for the OGD checklist are 2.17 $kgCO_2e$ and with an additional 1.40 $kgCO_2e$ from waste, total emissions per OGD are 3.57 $kgCO_2e$. No sedation is used for retrieval gastroscopy; topical lidocaine throat spray only, for which no emission factor was available.

Emissions per procedure

Based on the checklists provided, the emissions for each procedure are set out in Table 3.

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Table 3. Carbon footprint per procedure, excluding patient travel, calculated with the Centre for Sustainable Healthcare [12]. A biliary stent removal is footprinted as a full ERCP because the same room, team and equipment are used. Equipment energy is included within the consumables figure. The abdominal X-ray uses a published general-radiography value. Components are rounded to two decimal places and may not sum exactly to the totals.

Procedure	Consumables and equipment	Waste	Medication	Total ($kgCO_2e$)
Carbon Footprint per ERCP	5.13	1.74	0.08	6.95
Carbon Footprint Retrieval OGD	2.17	1.40	n/a	3.57
Carbon Footprint Abdominal X-ray	n/a	n/a	n/a	0.80

Patient travel

Patient journeys for the 59 ERCP stent procedures performed in calendar year 2024 (January to December, used as the sampling year) totalled 2,538 one-way miles. This equates to a mean one-way distance of 43 miles (median 19 miles) and mean return journey of 86 miles.

The average emissions per mile travelled by car is 0.339 $kgCO_2e$.

*Emissions are calculated as number of miles travelled per patient * emission factor*

Each avoided hospital attendance removed 29.15 $kgCO_2e$ (return trip of 86 miles multiplied by 0.339 $kgCO_2e$). The new pathway removed 152 return patient journeys over the five-year period, avoiding 4,430.8 $kgCO_2e$ (the 22 retrieval OGD's were conducted whilst the patient was already onsite for the x-ray, therefore, had no additional associated travel.) This equates to avoided yearly travel emissions of 886.16 $kgCO_2e$.

Carbon avoided across the cohort

Use of biodegradable stents avoided 78 follow-up ERCPs, 74 abdominal X-rays and approximately 22 OGDs between October 2020 and October 2025, giving the totals in Table 4. With an average return journey of 86 miles per avoided attendance, this equated to 13,072 road miles over the five-year period (average 2,614 miles per year).

The carbon saving per avoided procedure, including consumables, medication, energy and patient travel, is:

Follow-up ERCP (stent removal): 36.10 $kgCO_2e$.

Retrieval OGD: 3.57 $kgCO_2e$ (no additional travel; the patient is already on site for the X-ray).

Abdominal X-ray: 29.95 $kgCO_2e$.

Table 4 demonstrates the per procedure avoided emissions over the five-year cohort using the new pathway. **This averages a yearly carbon saving of 1,022.1 $kgCO_2e$** across the avoided procedures and journeys.

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Table 4. Avoided five-year activity and associated carbon savings (including consumables, medication, energy and patient travel).

Avoided activity	Number	Per unit ($kgCO_2e$)	5-year total ($kgCO_2e$)
Follow-up ERCP (stent removal)	78	36.10	2,815.8
Retrieval OGD	22	3.57	78.5
Abdominal X-ray	74	29.95	2,216.3
Total			**5,110.6**

Economic sustainability:

Each avoided procedure was costed in full: £1,212.87 for a repeat ERCP including the overnight ward stay, £162.97 for a retrieval OGD, and £74 for an abdominal X-ray. A biodegradable stent costs £635 against £27.30 for a plastic double-pigtail stent, a premium of £607.70 per patient.

In the biliary arm, each of the 78 patients avoids a repeat ERCP worth £1,212.87 against the £607.70 premium, a net saving of £605 per case and £47,203 across the arm.

In the pancreatic arm, each of the 74 patients avoids an abdominal X-ray and, under the base assumption that 30% of plastic pancreatic stents are retained, 22 patients avoid a retrieval OGD; the avoided care is worth on average £122 per patient, about £485 short of the premium, so this arm is cost-additive by £35,909 across the cohort.

Taken together, avoided procedures across the 152 patients were worth £103,665 against £92,370 in additional stent costs, giving a net procedure-cost saving of £11,295 over five years, **or a net procedure-cost saving of £2,259 a year** or £74 per patient.

Because the changes require no set-up or maintenance spending, there is no payback period; savings begin with the first stent placed.

Itemised per-case costs for each avoided procedure are tabulated in Appendix Tables A6 and A7.

Table 5. Cost per case, built from local NHS Grampian procurement and PSSRU 2024/25 staffing [13]. Abdominal X-ray £74 (local); biodegradable stent £635 vs plastic £27.30, a premium of £607.70 per patient.

Component	ERCP (£)	OGD (£)
Consumables	308.90	28.47
Staffing (PSSRU 2024/25)	803.72	134.45
Waste disposal	0.25	0.05
Overnight bed-day	100.00	n/a
Total per case	**1,212.87**	**162.97**

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Table 6. Net procedure-cost saving across the 152-patient cohort over five years (about £2,259 per year): +£605 per biliary case, −£485 per pancreatic patient, +£74 per patient overall. Rounded components may not sum exactly to the totals shown.

Arm	Procedures avoided	Value avoided (£)	Stent premium (£)	Net saving (£)
Biliary (78)	78 repeat ERCPs	94,604	47,401	+47,203
Pancreatic (74)	74 X-rays + 22 OGDs	9,061	44,970	−35,909
Total (152)	78 ERCPs + 22 OGDs + 74 X-rays	103,665	92,370	+11,295
Yearly average	**15.6 ERCPs + 4.4 OGDs + 14.8 X-rays**	**20,733**	**18,474**	**+2,259**

Social sustainability:

Open-ended surveys showed consistent support. All ten patients supported biodegradable stents after the difference from plastic stents and relevant indications were explained; two had direct experience of a biodegradable biliary stent. All ten endoscopy nurses and both doctors were also supportive, citing the simpler pathway and more sustainable care. Although small and qualitative, the sample showed clear agreement that avoiding a second procedure and choosing the more sustainable option added social value alongside clinical and carbon benefits.

Using the HMRC approved mileage rate for 2026/27 of 55 pence per mile, an average return journey of 86 miles equates to a patient travel cost saving of £47.30 per avoided attendance, £1,438 per year and £7,190 over the five years. Counting one lost working day of 7.5 hours per attendance at the 2026/27 National Living Wage of £12.71 per hour adds £95.33 per patient, £2,898 per year and £14,489 over five years. Hospital car parking is free at Aberdeen Royal Infirmary, as across NHS Scotland, so no parking saving is claimed. These figures exclude the time and travel of accompanying relatives and are therefore conservative estimates of the financial benefit returned to patients.

Discussion:

Over five years of routine use, biodegradable stents maintained the clinical outcomes expected from conventional stenting while avoiding one downstream procedure for every patient. In total, the over the five-year period, the pathway released 152 hospital appointments, reduced emissions by 5,111 $kgCO_2e$ and generated a net procedure-cost saving of £11,295, **equivalent to yearly savings of 30 appointments, 1,022 $kgCO_2e$ and £2,259, and returned about £4,300 a year to patients** in avoided travel and lost wages. Patient and staff feedback was consistently supportive.

The clinical outcomes align with published experience. Technical success was complete, matching Anderloni et al. [14] and slightly exceeding the 98% reported in a recent Australasian cohort [16]. At 152 patients, this is among the largest reported series, comparable with 132 patients from King's College Hospital [15]. Post-ERCP pancreatitis occurred in 16/71 prophylaxis cases (22.5%), compared with 11% in the Australasian cohort [16]; both involved high-risk patients, and neither of the two deaths was stent related. Unit performance has since improved, with the latest departmental audit showing an overall post-ERCP pancreatitis rate of 2.1%.

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Comparing local costs with national prices supports the approach. The 2025/26 NHS Payment Scheme lists elective intermediate therapeutic ERCP at £1,124 to £1,360, so the bottom-up estimate of £1,212.87 sits within the national range despite excluding estates, equipment and overheads [17]. The retrieval OGD estimate is lower (£162.97 versus £653 for therapeutic gastroscopy [17]) because the model counts only consumables, staff time and waste, as Scotland has not published per-case tariff, and overheads cannot be reliably assigned to a single unit-level procedure. Because national prices include overheads that the model deliberately excludes, applying English tariff values to the avoided care would roughly double the estimated net saving. The figures reported here should therefore be interpreted as a conservative floor.

The environmental analysis, completed with the Centre for Sustainable Healthcare [12], found that avoided patient travel was the main source of carbon saving. Procedural emissions were 6.95 $kgCO_2e$ for a repeat ERCP, 3.57 $kgCO_2e$ for a retrieval gastroscopy and 0.80 $kgCO_2e$ for an abdominal X-ray. Each avoided attendance also saved 29.15 $kgCO_2e$ from travel, based on a mean 86-mile return journey (43 miles each way). Overall, travel accounted for 87% of the carbon avoided and removed 13,072 road miles from the pathway.

Published centre-wide studies show the same pattern: travel was the largest emission source at 45% in a French unit [18] and 83% in an Indian centre [19], whose per-procedure emissions excluding travel, 6.50 $kgCO_2e$, are close to the present figures. Both report whole-centre averages across all endoscopies; these are among the first procedure-specific figures for ERCP. For gastroscopy, Elli and colleagues reported a procedure-specific footprint of 5.43 $kgCO_2e$ [20]. The lower estimate of 3.57 $kgCO_2e$ reported here mainly reflects the exclusion of scope reprocessing and a leaner procedure without sedation, vascular access or biopsy sampling.

All 22 patients and staff surveyed supported the pathway, and because the avoided journeys fall mainly on older, rural and lower income patients, the social benefit concentrates where the burden of travel is greatest.

The main limitations are the single-centre retrospective design and the absence of a contemporaneous plastic-stent cohort, which meant the comparator had to be modelled. The costing counts only what the department demonstrably stops spending, so overheads, capital and the downstream costs of retained stents go uncounted. The carbon inventory stops at the same line: scope decontamination, stent manufacture and staff travel sit outside it, and a few small items carried no emission factor. Each simplification trims the benefit rather than inflating it, so the figures reported are floors.

Conclusions:

Routine biodegradable stenting delivered the intended clinical outcomes, with universal technical success and biliary results consistent with published series, while removing a downstream procedure for every patient, at a modest net saving of about £2,259 a year and a carbon reduction of about 1,022 $kgCO_2e$ a year, dominated by avoided travel. The key output is the reproducible bottom-up model, built in the absence of a Scottish tariff and adjustable to any unit's prices and follow-up practice.

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Next steps are to develop a practical framework that helps interested services reproduce the greener, more sustainable pathway, and to re-audit outcomes as adoption expands. NHS Grampian intends to build on the work within its green-endoscopy and net-zero commitments. This project has helped embed sustainability as a routine quality domain. It also shows that green endoscopy can reduce environmental impact while supporting patient-centred care.

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Appendices. The completed SusQI process map for both stent pathways is reproduced as Figure 1. The itemised per-case costing workbook and the open-ended survey prompts used with patients and staff are available on request. The cost model boundary, the carbon footprint inventories supplied by the Centre for Sustainable Healthcare and the itemised cost inventories are reproduced below.

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Appendix 1. Cost model boundary

Table A1. Boundary of the cost model. Items on the left are priced in the model; items on the right are excluded, and each exclusion understates the cost of the plastic-stent pathway that biodegradable stents replace.

Included in the model	Not included
Stents, the priced comparator: plastic double-pigtail £27.30; biodegradable £635.00	Drugs: sedation medication (midazolam, fentanyl)
Devices and accessories: guidewire (Jagwire); extraction / trawl balloon; cold snare (Exacto); sphincterotome (Autotome RX); locking device and biopsy cap	Unpriced ward and trolley items: suction tubing; scope water bottle; wipes; gauze swabs; lubricant gel; cytology or cleaning brush; Neutraflush sachet; domestic and recycling bin liners
Airway, IV and sedation kit: bite block and mouthguard; Yankauer suction; IV cannula; syringes; saline flushes; Tegaderm; nasal oxygen cannula	Staffing gap: OGD scope decontamination and portering
Imaging contrast: iodinated contrast for the fluoroscopy run, £10.00	Downstream clinical costs: complications of retained plastic stents (pancreatitis, migration, stricture, infection, surgery); extra bed-days and readmissions
Insufflation and irrigation: CO_2 connecting tubing; CO_2 gas cylinder and rental; irrigation and water-pump tubing	Capital, estates and social value: imaging capital and estates (C-arm, building); patient travel and lost work time (reported under social sustainability)
PPE, wipes and handling: disposable aprons; alcohol wipe sachets; glide and slide sheet	
Waste containers and disposal: yellow clinical bin; sharps bins; disposal charged by weight	
Staff time, PSSRU 2024/25: consultant endoscopist; specialty registrar; endoscopy, radiology, recovery and ward nurses including the 24 hour stay; radiographer; decontamination technician	
Facility and imaging: overnight ward stay, non-staff bed-day; abdominal X-ray, £74.00 per examination	

Appendix 2. Carbon footprint inventories, Centre for Sustainable Healthcare

Table A2. Inventory for consumables, weights, emission factors and carbon footprint for an ERCP.

ERCP equipment	Number of items used	Carbon emission factor per item (kg CO_2e /item use)	Carbon emissions per procedure (kg CO_2e)
Drawing-up needle 23G	2	0.003	0.006
5 mL syringe	2	0.033	0.066
One Blue canula PVC	1	0.046	0.046
Saline flush (10 mL pre-filled)	2	0.047	0.093
Transparent IV dressing	1	(*)	
Alcohol wipe (single sachet)	4	0.033	0.131

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ERCP equipment	Number of items used	Carbon emission factor per item (kg CO_2e /item use)	Carbon emissions per procedure (kg CO_2e)
Lubricant sachet Optilube 5 gram/sachet	2	0.030	0.060
Gauze swab (single)	3	0.034	0.103
Yankauer sucker	1	0.071	0.071
Irrigation tubing (water pump set)	1	0.368	0.368
Patient drape (cotton-reusable)		Excluded	
CO_2 connecting tubing	1	0.368	0.368
Suction tubing	1	0.368	0.368
Scope water bottle	1	0.044	0.044
Scope cleaning brush (disposable per ERCP)	1	0.026	0.026
Bite block - con-med scope save	1	0.039	0.039
Nasal cannula (O_2)	1	0.368	0.368
IV giving set	1	0.091	0.091
Disposable plastic apron	1	0.065	0.065
Contrast syringe 5ml	1	0.033	0.033
Scope cleaning with Neutraflush 2 sachet	1	(*)	
CO2 tube for 24 hours	1	0.368	0.368
Orange Bin with weight 32l	1	0.580	0.580
Packaging per orange bin - cardboard	1	0.027	0.027
Sphincterotome (Autotome RX)	1	0.248	0.248
Cold snare (Exacto)	1	0.032	0.032
Blue bin for medically contaminated sharps	1	0.350	0.350
Packaging per blue bin	1	0.092	0.092
Non-sterile gloves, nurses (5 pairs, counted per glove)	10	0.026	0.260
Apron - nurses	5	0.065	0.325
Gloves, doctors (2 pairs, counted per glove)	4	0.026	0.104
Aprons - doctors	2	0.065	0.130
Total			4.862

(emission factor not known; item not included in the total)*

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Table A3. Estimated energy use for electronic equipment used during ERCP.

Standard equipment		Energy use per hour kWh
ERCP endoscopy stack / tower	Olympus CV-1500 video processor	0.6
ERCP endoscopy stack / tower	Olympus CLV-S200 light source	0.5
Obs monitor	Patient obs monitor	0.15
Room cooling	Wall AC unit (procedure room)	1
2 Desktop	Desktop PC and monitor *2	0.2
One laptop	Laptop	0.05
Total energy use per procedure (kWh)		**2.5**

Table A4. Carbon footprint for sedation medication, midazolam and fentanyl.

Medication	Emissions per item (kg CO_2e)
Midazolam 5mg/5ml solution for injection ampoules	0.0360
Midazolam 5mg/5ml solution for injection pre-filled syringes	0.0533
Fentanyl 100micrograms/2ml solution for injection ampoules	0.0253

Table A5. Inventory for equipment, weights, emission factors and carbon footprint for OGD consumables and electronic equipment.

OGD checklist	Number	Unit	Emissions per unit (kg CO_2e)	Total emissions (kg CO_2e)
PPE and computers				
Gloves 5 pairs	10	Per glove	0.026	0.26
Aprons	3	Per apron	0.065	0.195
Nursing Computer (laptop) kWh of energy used (*)	0.05	Per 1 hr use	0.144	0.0072
One Desktop kWh of energy used (*)	0.1	Per 1 hour use	0.144	0.0144
Waste Management & Sharp				
Yellow bin		Per 500g disposed	0.285	**
Black bin		Per 500g disposed	0.086	**
Recycling bin		Per 500g disposed	0.033	**
Endoscopy Equipment Stack				
Main Olympus procedural tower. kWh of energy used (*)	1.1	Per 30 mins use	0.144	0.0792
Suction / vacuum container		(**)		

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OGD checklist	Number	Unit	Emissions per unit (kg CO_2e)	Total emissions (kg CO_2e)
4K monitor & EVIS X1 processor kWh of energy used (*)	0.15	Per hour use	0.144	0.0108
Diathermy unit & accessories kWh of energy used (*)	0.1	Per hour use	0.144	0.0072
Hand Washing Station	5	Per hand wash using liquid soap	0.012	0.06
Post-Procedure Scope Tray		(**)		
Secondary Monitoring Setup				
- Obs monitor kWh of energy used (*)	0.15		0.144	0.0216
Patient Labelling System				
- Zebra ZD411 thermal printer producing patient ID labels	1		0.005	0.005
Daily use Equipment trolley		(**)		
Procedural consumables				
Yankauer sucker	1	Per item use	0.071	0.071
Suction tubing	1	Per item use	0.368	0.368
Alcohol wipe (single sachet)	4	Per item use	0.033	0.131
Lubricant sachet Optilube 5g	2	Per item use	0.030	0.060
Gauze swab (single)	3	Per item use	0.034	0.103
Bite block, con-med scope save	1	Per item use	0.039	0.039
Irrigation tubing (water pump set)	1	Per item use	0.368	0.368
CO2 connecting tubing	1	Per item use	0.368	0.368
Scope cleaning with Neutraflush, 2 sachets	1		(*)	
Lidocaine throat spray	1		(*)	

(emissions from energy use = energy used (kWh) * emissions per kWh. Emissions are 0.144 kg CO_2e/kWh)*

*(** no further details supplied)*

Appendix 3. Cost model inventories

Table A6. Itemised per-case cost of a repeat ERCP, from NHS Grampian procurement and PSSRU 2024/25 staffing [13]. Components are rounded and may not sum exactly to the totals shown.

Item	£
Consumables and accessories	**308.90**
Sphincterotome (Autotome RX)	94.56
Extraction / trawl balloon *	76.70

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Item	£
Guidewire (Jagwire 0.035/260)	73.55
Cold snare (Exacto)	17.86
Iodinated contrast 10 mL	10.00
Sharps bin, yellow / orange (1 per 10)	5.40
Sharps bin, blue medication (1 per 10)	5.40
Glide / slide sheet	5.09
Locking device + biopsy cap	4.73
CO2 connecting tubing (1 per 4)	3.68
Irrigation / pump tubing (1 per 4)	3.61
Clinical waste bin, yellow container (1 per 4)	2.57
CO2 cylinder, gas + rental (1 per 20)	2.00
Disposable aprons × 7	1.38
Bite block / mouthguard	0.55
IV cannula 22G	0.44
Yankauer suction	0.43
Nasal cannula, O2	0.31
Tegaderm dressing	0.31
Saline flush 10 mL × 2	0.26
Syringe 5 mL × 2	0.06
Alcohol wipe sachet	0.01
Ten further tray items, no catalogue price held	*0.00*
Staff time, PSSRU 2024/25	**803.72**
Ward nurse, Band 5 (1:5, overnight)	225.60
Endoscopy nurses × 3, Band 5	141.00
ERCP consultant	140.00
Radiology nurses × 2, Band 5	94.00
Senior ward nurse, Band 7	69.00
Specialty registrar	66.00
Radiographer, Band 6	59.00
Decontamination technician, Band 3	9.12
Waste disposal, by weight at local tonne rates	0.25
Overnight ward stay, non-staff bed-day	100.00
Total per case	**1,212.87**

Table A7. Itemised per-case cost of a retrieval OGD, from NHS Grampian procurement and PSSRU 2024/25 staffing [13]. The abdominal X-ray is costed at a locally agreed £74 per examination, taken whole rather than itemised.

Item	£

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Item	£
Consumables and accessories	**28.47**
Cold snare (Exacto)	17.86
Sharps bin, yellow / orange (1 per 20)	2.70
CO2 cylinder, gas + rental (1 per 20)	2.00
Clinical waste bin, yellow container (1 per 8)	1.29
Disposable aprons × 4	0.79
CO2 connecting tubing (1 per 20)	0.74
Irrigation / pump tubing (1 per 20)	0.72
Bite block / mouthguard	0.55
IV cannula 22G	0.44
Yankauer suction	0.43
Nasal cannula, O2	0.31
Tegaderm dressing	0.31
Saline flush 10 mL × 2	0.26
Syringe 5 mL × 2	0.06
Alcohol wipe sachet	0.01
Ten further tray items, no catalogue price held	*0.00*
Staff time, PSSRU 2024/25	**134.45**
Endoscopy nurses × 3, Band 6 (20 min room)	59.00
Consultant endoscopist (20 min room)	46.67
Recovery, same Band 6 team (1:3, 60 min)	19.67
Decontamination technician, Band 3	9.12
Waste disposal, by weight at local tonne rates	0.05
Total per case	**162.97**

Critical success factors			
People	**Process**	**Resources**	**Context**

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Critical success factors			
People	**Process**	**Resources**	**Context**
☒ Patient involvement and/or appropriate information for patients - to raise awareness and understanding of intervention ☒ Staff engagement ☒ MDT / Cross-department communication ☒ Skills and capability of staff ☒ Team/service agreement that there is a problem and changes are suitable to trial (Knowledge and understanding of the issue) ☒ Support from senior organisational or system leaders	☒ clear guidance / evidence / policy to support the intervention. ☐ Incentivisation of the strategy – e.g., QOF in general practice ☒ systematic and coordinated approach ☒ clear, measurable targets ☒ long-term strategy for sustaining and embedding change developed in planning phase ☒ integrating the intervention into the natural workflow, team functions, technology systems, and incentive structures of the team/service/organisation	☐ Dedicated time ☒ QI training / information resources and organisation process / support ☒ Infrastructure capable of providing teams with information, data and equipment needed ☒ Research / evidence of change successfully implemented elsewhere ☒ Financial investment	☒ aims aligned with wider service, organisational or system goals. ☒ Links to patient benefits / clinical outcomes ☒ Links to staff benefits ☒ 'Permission' given through the organisational context, capacity and positive change culture.

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