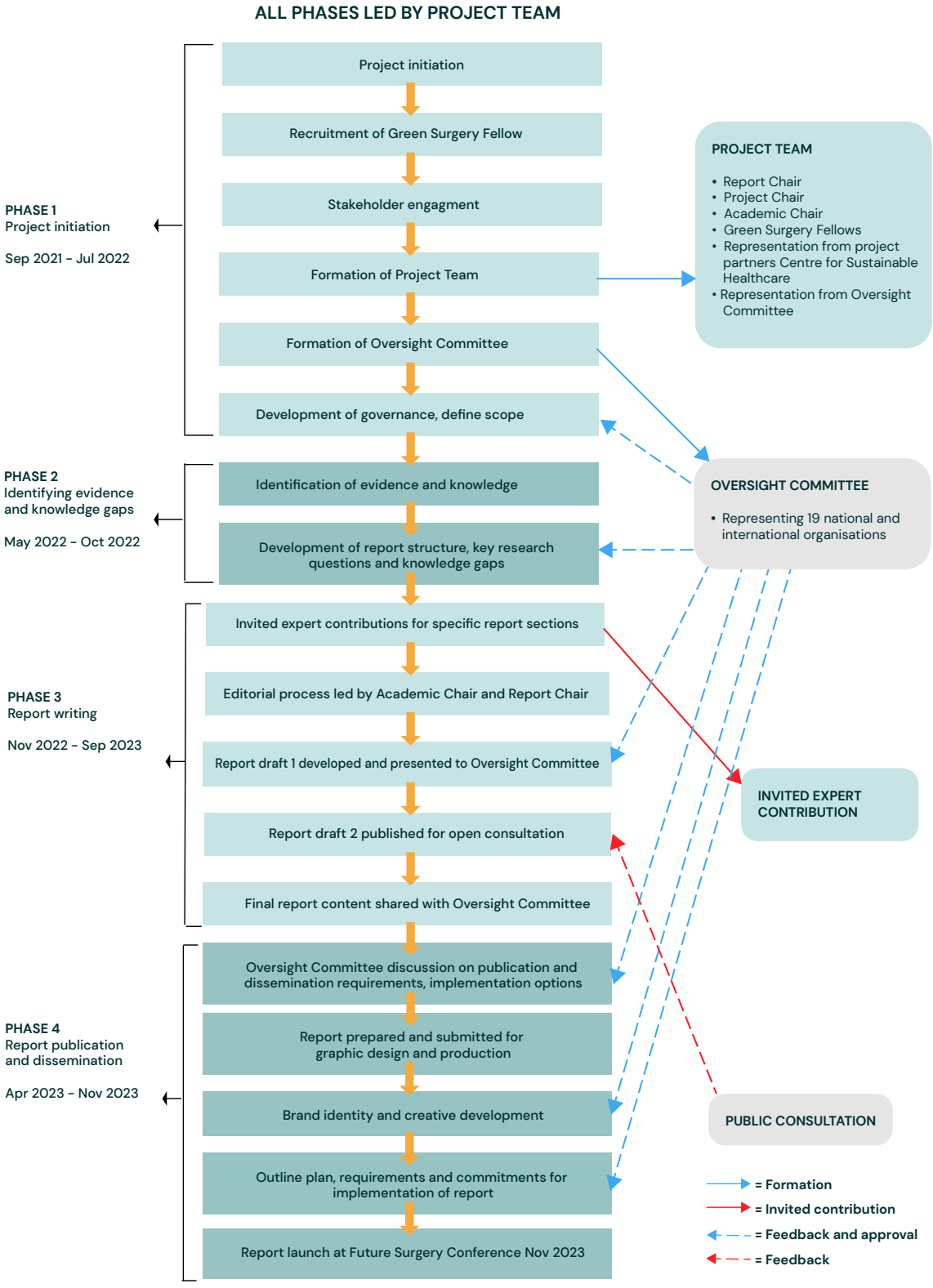
Appendix

Refer to main report for references.

Appendix 1: Process for developing the report

Appendix Figure 1 outlines the process taken for the development of the report. Please see report for full list of contributors.

Appendix Figure 1: Process and timeline for developing the report



Appendix 2: Evaluating the financial spend on surgical care

Analysis was led by Chantelle Rizan. We would like to thank Vimaladipa Tennison and Hasina Begum (NHS England) who assisted in providing data, alongside those who helped code data; Pinky Kotecha, Ardra Rahalakshimi, Gulz Dhanova, Radhika Patel, and William Wilson.
This analysis relates to report Section 1.2.

Methods:

The NHS England national cost collection dataset (financial year 2019/2020) was used as the basis for calculation.[40] This accounts for acute, community, ambulance, and mental health providers (totalling £72.6 billion), but excludes primary care, or 'non-clinical support activities' (relating to organisations not performing clinical activities such as NHS England, Health Education England, NHS Improvement, and NHS Digital). The dataset includes around 4,000 listed activity types, which were assigned to surgical specialties (or as non-surgical) by at least two individuals (PK, AR, GD, RP, WW), based upon NHS main specialty codes.[466] This was cross-referenced by CR against the most commonly treatment specialty code assigned to healthcare resource groups (HRGs; clinically similar treatments), based on all recorded patient episodes in NHS England for financial year 2021/22 (derived from Hospital Episode Statistics data). Any discrepancies in specialty coding were resolved by CR.
To estimate the carbon footprint of surgical care, the proportion of NHS England financial spend (including acute, community, ambulance and mental health providers) relating to surgical specialties was applied to the 16.3 million tonnes of CO_2e previously estimated to be associated with these areas (2019).[22] This estimate was used to determine the average carbon intensity of surgical care per person in the population in England based on 2019 national population data, and applied to population estimates for Northern Ireland, Scotland, and Wales.[467] To determine the amount of woodland creation that would need to be planted to sequester the greenhouse gas emissions associated with surgical care in the UK, we used the UK Environment Agency report on potential carbon offsetting approaches.[468]

Results:

Summary results are presented in section 1.2 of the report, and detailed in Appendix Table 1.

Limitations:

This estimate is limited by the assumption that the proportion of financial spend associated with surgical care is representative of associated greenhouse gas emissions, and at this scale is a reasonable assertion. The surgical specialty financial spend is likely an underestimate, as we were unable to assign imaging, pathology, and high-cost drugs to surgical specialties (a proportion of which will relate to surgical care). It is also limited by hospital coding of specialty for activities, although this was minimised through manual coding of data. The extrapolation of the carbon footprint of surgical care across other UK nations assumed the same average carbon intensity of surgery per person.

Appendix Table 1

Speciallty		First appointment	Follow up appointment	Outpatient procedure	Day case	Elective inpatient	Non-elective long stay inpatient admissions	Non-elective short stay inpatient admissions	Regular day or night admissions	Total for specialty	Proportion of total NHS England spend: £72,548,346,803 (%)
Cardiothoracic surgery	Number of episodes	54,719	123,489	261	2,117	29,635	12,203	4,335	8	226,767	
	Spend (£)	16,631,701	28,924,546	76,860	3,822,824		45,138,241	45,138,241	8,127	£618,403,370	0.85%
Dentistry	Number of episodes	125,667	239,512	382,909	13,713	72	25	1,048		762,946	
	Spend (£)	23,566,670	42,016,312	64,226,091	9,421,282	85,392	25,661	490,199		£139,831,606	0.19%
General surgery	Number of episodes	1,727,975	2,298,944	223,271	1,015,502	236,001	380,658	616,718	8,970	6,508,039	
	Spend (£)	276,531,639	312,146,038	50,016,901	808,031,516	1,004,569,089	1,320,534,168	470,263,636	3,043,787	£4,245,136,774	5.85%
Neurosurgery	Number of episodes	123,992	210,274	10,704	10,320	23,163	12,871	5,403	124	396,851	
	Spend (£)	28,721,825	36,998,995	2,972,158	15,632,512	204,208,841	149,114,222	35,028,342	66,971	£472,743,865	0.65%
Obstetrics and Gynaecology	Number of episodes	1,717,915	3,357,537	2,028,237	195,331	90,146	395,378	823,965	14,795	8,623,304	
	Spend (£)	302,483,650	452,059,891	316,626,904	218,997,263	355,936,250	1,672,451,496	885,180,218	7,320,456	£4,211,056,129	5.80%
Ophthalmology	Number of episodes	1,322,714	3,406,464	2,966,432	525,167	14,810	2,106	12,039	34	8,249,766	
	Spend (£)	168,778,347	339,684,516	376,997,570	516,135,590	44,693,539	12,982,877	20,904,187	39,240	£1,480,215,866	2.04%

Oral and Maxillofacial Surgery	**Number of episodes**	583,376	719,653	527,327	178,432	11,127	3,386	7,574	18	2,030,893	
	Spend (£)	85,853,368	88,999,724	89,282,950	159,540,080	51,364,146	15,342,937	12,449,686	24,644	£502,857,535	0.69%
Otolaryngology	**Number of episodes**	600,911	903,468	1,041,753	147,240	60,043	20,617	64,095	582	2,838,709	
	Spend (£)	73,766,077	99,567,675	132,221,936	228,866,808	258,012,056	61,042,971	39,907,616	121,934	£893,507,073	1.23%
Paediatric surgery	**Number of episodes**	87,396	116,866	143	10,002	3,681	1,261	1,277	1	220,627	
	Spend (£)	14,787,081	16,452,309	41,294	17,950,415	17,745,837	10,768,439	3,847,581	2,009	£81,594,966	0.11%
Plastic surgery	**Number of episodes**	267,748	565,520	1,539,162	244,457	15,266	8,223	71,654	3,515	2,715,545	
	Spend (£)	36,673,985	63,903,200	246,402,170	205,673,317	70,770,271	38,203,625	72,827,820	1,225,186	735,679,573	1.01%
Trauma & orthopaedics	**Number of episodes**	2,253,640	3,847,809	423,288	297,171	204,166	197,666	171,120	3,200	7,398,060	
	Spend (£)	312,223,386	468,631,559	68,066,354	533,339,971	1,329,635,203	1,362,627,652	338,248,922	1,084,147	£4,413,857,194	6.08%
Urology	**Number of episodes**	608,454	1,356,293	629,320	331,033	117,252	77,444	197,054	5,299	3,322,149	
	Spend (£)	77,769,677	145,470,291	105,710,995	293,824,200	446,269,960	214,640,862	135,101,342	1,170,306	£1,419,957,633	1.96%
Vascular surgery	**Number of episodes**	216,017	261,098	2,300	31,779	15,894	7,687	3,155	56	537,986	
	Spend (£)	40,234,371	38,161,496	500,011	45,548,457	111,607,624	78,680,558	18,852,798	67,828	£333,653,143	0.46%

Total surgical	**Number of episodes**	**9,690,524**	**17,406,927**	**9,775,107**	**3,002,264**	**821,256**	**1,119,525**	**1,979,437**	**36,602**	**43,831,642**	
	Spend (£)	1,458,021,778	2,133,016,552	1,453,142,194	3,056,784,234	4,255,675,519	5,099,439,226	2,078,240,589	14,174,636	£19,548,494,727	26.95%
Non-surgical	**Number of episodes**	13,911,504	30,312,273	3,508,809	2,877,035	357,269	2,867,410	4,343,815	294,575	58,472,690	
	Spend (£)	2,214,258,50	3,862,304,571	498,431,949	1,722,775,634	1,179,108,240	8,931,724,466	2,992,711,628	110,914,212	£21,512,229,201	29.65%
Total surgical and non-surgical	**Number of episodes**	23,602,028	47,719,200	13,283,916	5,879,299	1,178,525	3,986,935	6,323,252	331,177	102,304,332	
	Spend (£)	3,672,280,280	5,995,321,123	1,951,574,143	4,779,559,868	5,434,783,759	14,031,163,691	5,070,952,216	125,088,847	£41,060,723,928	56.60%

Appendix 3: Commentary on evidence for higher carbon footprint associated with reusable products when compared with single-use equivalent

	Product	Carbon footprint per case of single-use (X%) relative to reusable (100%)	Source	Comment
Australian energy source assumed	Anaesthetic equipment	97%	McGain et al.(2017)[355]	Australian study, assuming coal-based electricity. Where remodelled processes using US and UK/European energy sources, reusables lower carbon footprint compared with single-use (48-84% reduction respectively)
	Central venous catheter insertion	34%	McGain et al. (2012)[356]	Australian study, assuming coal-based electricity. Assuming US or European electricity (higher proportion of renewables) reduced carbon footprint of re-processing of reusables by 33-50%
	Ureteroscope	99%	Davis et al.(2018)[357]	Australian study (likely to have assumed coal-based electricity)
	Cystoscope	57%	Hogan et al.(2022)[358]	Methodological flaws highlighted in letter to editor including over-estimates of carbon footprint associated with energy consumption.[361] Subsequent response from authors indicates Australian electricity modelled (despite predominantly Irish author group) and decontamination washer- disinfector machine duration assumed to be 1 hour[469] (despite Olympus ETD-Double cycle modelled reported elsewhere at 35 minutes)[470] If UK energy assumed at 35 minutes, (assuming other study parameters correct),358 carbon footprint of reusables would be 55% that of single-use.
Questionable methodological assumptions		67%	Baboudjian et al.(2022)[360]	Lack of transparency • No inventory data (unable to determine material or energy flows assumed) • Characterisation factors not listed (e.g. unable to determine energy source assumed) • No breakdown of results (e.g. unable to determine contribution of PPE and transportation versus cleaning chemicals) • Appears to have assumed PPE changed for re-processing of every scope (listing 4 pairs nitrile gloves, 1 pair neoprene glove, apron), and that reprocessing unit 500km away

Questionable methodological assumptions	Bronchoscope	55%	Sørensen et al.(2018)[471]	Assumed scopes re-processed individually and that PPE changed for every scope (listing 2 face shields, 2 gowns, 3 pairs latex gloves and 2 shoe covers per bronchoscope). Where modelled ≥2 reusable bronchoscopes re-processed together, carbon footprint of reusables less than single-use equivalents
	Spinal fusion set	15%	Leiden et al. (2020)[360]	Compared multiple reusable instruments (45kg) to heavily consolidated single-use set (2kg). Likely that if similarly consolidated reusable set developed this would have lower carbon footprint