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The impact of overweight and obesity on hospital resource use (hospital episodes) in Scotland

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Contents

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Abbreviations

BMI	Body mass index
CI	Confidence interval
HE	Hospital episode
IRR	Incidence rate ratio
PAF	Population attributable fraction
SHeS	Scottish Health Survey
SIMD	Scottish Index of Multiple Deprivation
SMR01	Scottish Morbidity Record 01 (general/acute inpatients and day cases)
SMR04	Scottish Morbidity Record 04 (mental health inpatients and day cases)
SMR06	Scottish Morbidity Record 06 (Scottish Cancer Registry)
SPICe	Scottish Parliament Information Centre

Summary

The prevalence of overweight and obesity in Scotland has remained stubbornly high in recent years. In 2016, over 65% of adults aged 16 years and above were overweight or obese (and 29% of adults in Scotland were classified as obese). Reducing obesity in the population remains an important public health priority.

The aim of this study was to estimate the percentage of hospital resource use due to overweight and obesity in 2015/16. This was measured by specialty-level admission to hospital and the direct cost of hospital episodes (HEs) in Scotland.

Scottish Health Survey (SHeS) data for 1995–2013 were linked to Scottish Morbidity Record 01 (SMR01) and Scottish Morbidity Record 04 (SMR04). The risk of admission to 27 specialties by body mass index (BMI) weight category was estimated using negative binomial regression techniques. The percentage of hospitalisations attributable to overweight and obesity was estimated by calculating population attributable fractions (PAFs). These were also applied to the direct hospital admission costs for each specialty in 2015/16 to estimate the hospitalisation cost attributable to overweight and obesity.

A small and uncertain percentage of HEs in Scotland, and associated costs, were attributable to overweight and obesity in the population. Our best estimate is that 2.6% (95% confidence interval [CI] –9.0% to 12.4%) of HEs were attributable to overweight and obesity in 2015/16, equating to an extra 40,506 (95% CI –140,135 to 192,756) episodes. However, the wide CIs around this estimate mean that we cannot conclude that there was a net impact on the overall number of HEs due to overweight and obesity. The estimated cost for HEs attributable to overweight and obesity in 2015/16 was £117 million (95% CI –£411 million to £560 million). This estimate also has a wide degree of uncertainty around it.

Further research is needed to look at alternative means of estimating the direct cost of HEs due to conditions medically related to overweight and obesity, as well as those conditions which may be indirectly aggravated by excess weight, increasing the risk of admission to hospital.

Chapter 1: Background and aim

The prevalence of overweight and obesity in Scotland has remained stubbornly high in recent years. In 2016, over 65% of adults aged 16 years and above were overweight or obese (and 29% of adults in Scotland were classified as obese).[1] With the prevalence of obesity rising steadily between 2003 and 2008, and largely unchanged since this time,[1] reversing the trend remains an important public health priority.

How excess weight increases the risk of many adverse health outcomes, such as type 2 diabetes, osteoarthritis, cardiovascular disease and certain cancers, is well documented.[2,3,4,5,6,7] Excess weight also makes everyday activities harder and may shorten life expectancy.[2,8]

The Scottish Government has a long-term commitment to tackling overweight and obesity in Scotland and published a new diet and healthy weight strategy in 2018 – **A Healthier future: Scotland's Diet & Healthy Weight delivery Plan**.

Obesity has been linked to increased healthcare resource use and a rise in associated costs in several countries.[9] In 2015/16, the total NHS health service operating costs were estimated at £11.2 billion, with 56.9% of this spent on hospital services. This was an increase of 3.9% compared to 2014/15.[10] However, there is less information on the burden of overweight and obesity on hospital sector resource use and the associated direct costs to the NHS in Scotland. It is feasible, for example, that overweight and obesity may impact the overall risk of hospital admission due to the potential for greater medical complexity from managing conditions which may be intensified by overweight and obesity.[11,12]

The aim of this study was to estimate the percentage of hospital resource use explained by overweight and obesity in 2015/16, as measured by specialty-level admission to hospital and the direct cost of HEs in Scotland. This study will not include other associated NHS costs such as prescribing, outpatient costs or GP consultations.

Chapter 2: Methods

Study design

SHeS data for 1995, 1998, 2003, 2008, 2009, 2010, 2011, 2012 were linked to SMR01 and SMR04.[13]

Survey respondents with a cancer diagnosis five years pre or one year post survey (as identified through SMR06: Scottish Cancer Registry) were excluded from the analysis to reduce the possibility of reverse causality. The remaining survey respondents, aged 16 years and over, and who consented to having their health records linked to their survey data, were then followed up for hospital episodes* (HEs) (initial and recurrent) from the date of survey until 31 December 2013 (or until they emigrated or died if sooner). The analysis was based on complete cases only, no multiple imputation was applied.

The survey participants' height and weight (minimally clothed) were objectively measured by the surveyor. A categorical measure of body mass index (BMI), calculated as body weight (kg)/height (m^2), was used to determine the prevalence of overweight and obesity in the Scottish population. BMI was an objectively recorded measure derived from height and weight measurements taken at the time of the survey interview.[14]

Defining HEs

HEs were defined as the number of all initial and recurrent inpatient stays and day cases (combined) in a particular specialty. Twenty-seven specialties had sufficient numbers to facilitate analysis in this study, four were excluded due to small numbers.† Specialty definitions were matched between the cost-book definitions and SMR01 and

* An HE can be either a day case or inpatient admission. An HE is generated when a patient is discharged from hospital. However, an episode is also generated when a patient is transferred between hospitals, significant facilities or to the care of a different consultant. Multiple episodes by the same patient are therefore counted separately.

† The following four specialties were excluded from this study due to small numbers: dermatology, rehabilitation medicine, maxillofacial surgery and medicine and dental.

SMR04 (see Appendix A). A total of nine survey respondents were removed from the sample due to a high number of HEs (> 100 per person).

Modelling the relationship between HEs and BMI

BMI was categorised according to the following definition:

- Healthy weight: 18.5 kg/m^2 to < 25 kg/m^2
- Overweight: 25 kg/m^2 to < 30 kg/m^2
- Obese: $\geq$ 30 kg/m^2

The relationship between BMI and each specialty was modelled using zero-inflated negative binomial regression, adjusting for the following variables recorded at the survey interview: age, sex, Scottish Index of Multiple Deprivation (SIMD) and survey wave. The Akaike information criterion (AIC) and Vuong tests were used to formally assess the zero-inflated negative binomial model fit relative to the negative binomial model.[15,16] Rheumatology was the only specialty where a negative binomial regression model proved a better fit than the zero-inflated alternative.

We estimated the effect size [incidence rate ratio (IRR)] for all (initial and recurrent) HEs, during the entire follow-up period (1995–2013), for overweight and obesity compared to those of healthy weight from the regression models for each of the 27 specialties. Survey respondents with a BMI of < 18.5 kg/m^2 were excluded from the analysis, as our interest was in the role of overweight and obesity rather than low BMI. We also removed a small number of individuals with a BMI > 50 kg/m^2 to avoid the possibility of measurement/recording error.

A Bonferroni adjustment for multiple comparisons (a total of 27) was also applied to offset the chance of a type I error:

Bonferroni-adjusted significance level = α/N
= 0.05/27
= 0.002

Calculating PAFs

The PAF was defined as the proportion of HEs that might have been avoided had the BMI distribution of the Scottish population (SHeS 1995–2013 combined) matched that deemed to minimise risk to health (the counterfactual level).

The counterfactual BMI range deemed optimal for minimising risk to health is termed the theoretical minimum risk level (TMRL) and was defined as 100% of the Scottish population having a BMI within a healthy range (18.5–24.9 kg/m^2). Following regression modelling, PAFs were calculated for each specialty separately using the formula below.

The method used for the calculation of the PAF is shown below:

$$\mathbf{PAF} = \frac{\sum P_i \, RR_i - 1}{\sum P_i \, RR_i}$$

P_i = proportion of population at exposure level i, current exposure
RR = the relative risk at exposure level i

The total number of HEs for each specialty in Scotland in 2015/16 was then multiplied by the respective PAF to give the number of HEs attributable to overweight and obesity in each specialty. An overall PAF was estimated by summing the attributable HEs for all specialties and dividing this value by the total number of HEs to estimate the overall proportion of HEs attributable to overweight and obesity.

Estimating the cost of HEs due to overweight and obesity

We obtained the average gross costs per inpatient and day case for all 27 specialties in 2015/16 from the publication Scottish Health Service Costs 2015/16 [tables R040 (inpatients), R042 (day cases) and R040LS (general psychiatry)].[10] These costs were multiplied by the total inpatient and day case HEs attributable to overweight and obesity (as estimated from the PAFs for HEs) respectively. The two costs were summed giving a total cost for HEs attributable to overweight and obesity for each speciality. These were then aggregated to give overall hospitalisation costs attributable to overweight and obesity in 2015/16.

Chapter 3: Results

Demographics of the SHeS sample (1995–2013)

We followed 45,723 adults of healthy weight or heavier across 360,160 person-years (median 5.1 years; range 1 day through to 19.8 years [7,227 days]). In total, 65% of survey respondents of healthy weight or above had a high BMI (38% overweight and 27% obese) including 70% of men (44% overweight and 26% obese) and 61% of women (34% overweight and 28% obese) (Table 1).

Table 1: Demographics and characteristics of the linked SHeS cohort (1995– 2013)*

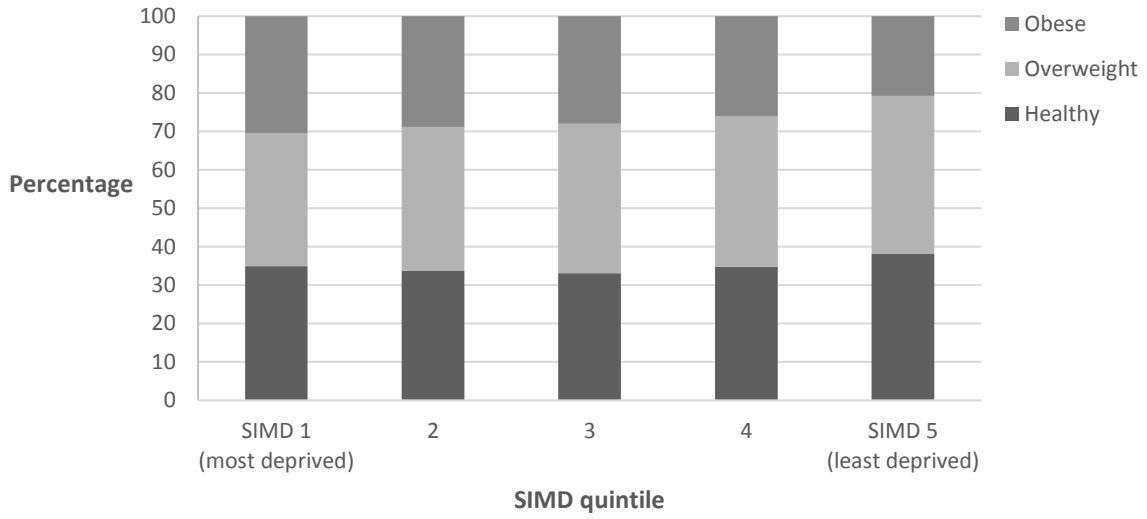
	Healthy weight	**Overweight**	**Obese**	**Total**
Population bases**				
Population at risk, *n* (%)	15,922 (34.8)	17,509 (38.3)	12,292 (26.9)	45,723 (100)
Person-years at risk,	138,217	137,597	84,346	360,160
Sex**				
Male, %	30.1	43.8	26.1	100
Female, %	38.6	33.9	27.5	100
Age at survey (years)**				
Median (IQR***)	40 (29 to 55)	49 (37 to 62)	52 (40 to 63)	47 (34 to 61)
SIMD quintile (%)				
1 (most deprived)	34.9	34.7	30.4	100
2	33.7	37.6	28.8	100
3	33.1	39.0	28.0	100
4	34.8	39.3	26.0	100
5 (least deprived)	38.1	41.2	20.7	100
Survey wave (*n*, %)				
1995	2,966 (45.9)	2,345 (36.3)	1,157 (17.9)	6,468 (100)

	Healthy weight	Overweight	Obese	Total
1998	2,810 (34.9)	2,724 (38.2)	1,589 (22.3)	7,123 (100)
2003	2,001 (34.2)	2,343 (40.1)	1,498 (25.6)	5,842 (100)
2008	1,380 (30.3)	1,817 (39.9)	1,359 (29.8)	4,556 (100)
2009	1,613 (31.2)	1,999 (38.7)	1,556 (30.1)	5,168 (100)
2010	1,530 (30.9)	1,883 (38.0)	1,546 (31.2)	4,959 (100)
2011	1,585 (31.4)	1,919 (38.0)	1,544 (30.6)	5,048 (100)
2012	1,016 (30.6)	1,278 (38.6)	1,021 (30.8)	3,315 (100)
2013	1,021 (31.5)	1,201 (37.0)	1,022 (31.5)	3,243 (100)

Source: Data from SHeS.
* Demographics by sex, age and SIMD are all weighted for unequal probabilities of address selection and differential non-response.
** Data pooled across survey waves.
*** IQR = interquartile range.

Approximately 45% of the sample were male and 55% were female. BMI increased with age (the average adult of healthy weight was 40 years of age compared with 49 and 52 years of age for overweight and obese respectively). The proportion of adults of healthy weight was broadly similar across quintiles 1 to 4 and highest in quintile 5 (the least deprived). The number of adults who were overweight showed an inverse association with deprivation. The percentage of overweight adults was lowest in the most deprived quintile (34.7%) and highest in the least deprived quintile (41.2%). Conversely, there was a linear association between obesity levels and deprivation. The percentage of obese adults was lowest in the least deprived quintile (20.7%) and highest in the most deprived quintile (30.4%) (see Figure 1 and Table 1).

Figure 1: Percentage of healthy weight, overweight and obese adults by SIMD (1995 –2013)



Source: data from SHeS

The percentage of people with a healthy weight in the SHeS sample decreased between 1995 and 2008 (46% to 30%) and remained relatively constant until 2013. The percentage of the SHeS sample who were overweight increased until the 2003 survey (40%) before subsequently stabilising at around 38%. In contrast, the proportion of the SHeS sample who were obese at baseline increased between 1995 (18%) and 2010 (31%) and then stabilised (Table 1).

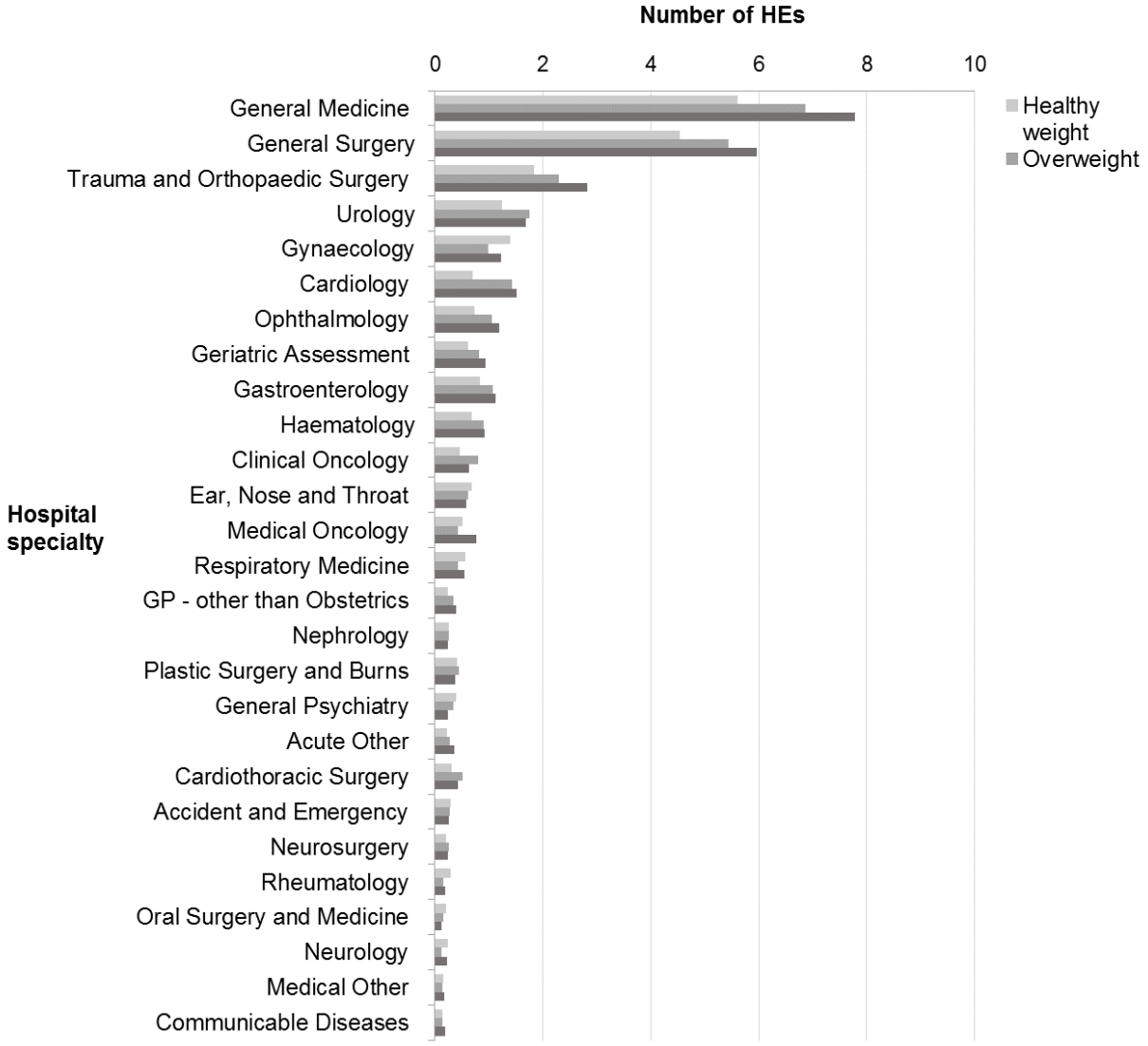
HE descriptive statistics

Almost half (46.7%; 21,372) of the survey respondents who were a healthy weight or above were hospitalised at least once during follow up, equating to 98,776 initial and recurrent HEs across 27 specialties. In total, 45% of HEs occurred in men (44,199) and 55% in women (54,577). Figure 2 shows the number of HEs for each specialty (inpatients and day cases combined) during the entire follow-up period (estimates weighted for non-response) per 100 person-years at risk.

Out of the 27 specialties analysed, 17 showed an increase in the number of HEs per 100 person-years at risk in overweight and obese respondents compared with those of healthy weight (General Surgery, Trauma and Orthopaedic Surgery, Urology,

Cardiology, Ophthalmology, Gastroenterology, Clinical Oncology, Medical Oncology, and Acute Other) (Figure 2).

Figure 2: Unadjusted number of HEs in each specialty per 100 person-years at risk‡ adults (16 years and over) by BMI category (weighted)§,**



‡ Nine individuals with more than 100 admissions over the time period were removed due to influence as outliers.

§ The following specialties were excluded from further analysis due to small numbers: Dermatology; Rehabilitation Medicine; Maxillofacial Surgery; Dental.

** Source: SHeS 1995–2013 linked to SMR01 and SMR04.

What was the risk of hospital admission by BMI?

The IRR of having an HE (all 27 specialties combined) was no different between healthy weight and overweight adults (IRR 0.98, 95% CI 0.92 to 1.06) or for obese adults compared to those of healthy weight (IRR 1.02, 95% CI 0.95 to 1.10) after adjustment for age at baseline (survey), sex, SIMD and survey wave.

Overall, approximately 17 out of 27 specialties showed an increased risk of admission for either adults who were overweight or obese after adjustment for age, sex, SIMD and survey wave. Seven specialties suggested an inverse relationship between admission and BMI. Of these, only two specialties had a statistically significant increased risk of admission for adults who were either overweight or obese after Bonferroni adjustment: General Surgery (both overweight and obese) and Rheumatology (obese only), and one specialty had a statistically significant inverse relationship with weight: Respiratory Medicine (obese only) (see Appendix B).

The percentage of HEs caused by overweight and obesity

By calculating the PAFs based on the adjusted IRRs, it was estimated that 2.6% (95% CI –9.0% to 12.4%) of HEs in Scotland in 2015/16, across all 27 specialties combined, were due to overweight and obesity. However, this estimate is uncertain.

The direction of the effect of overweight and obesity was split among the 27 specialties, with 17 specialties estimated to have an increased number of HEs attributable to overweight and obesity and 10 specialties estimated to have an inverse relationship with overweight and obesity. Of the 17 specialties with a proportion of HEs attributable to overweight and obesity, Rheumatology was estimated to have the highest PAF but also a wide level of uncertainty (PAF 22.9%, 95% CI –26.2% to 52.9%). Of the 10 specialties with an inverse relationship with weight, Medical Oncology had the largest inverse relationship and also a wide degree of uncertainty (PAF – 30.9%, 95% CI –69.6% to –1.1%). With the CIs showing wide levels of uncertainty around the estimates for individual specialties and given the number of specialties and the broadly even spread around the mean estimate it is likely that this

represents substantial random variation rather than real differences in PAFs by specialty (see Figure 3). The number of HEs attributable to overweight and obesity are shown in Table 2.

Figure 3: Percentage of HEs (PAFs) attributable to overweight and obesity, by specialty

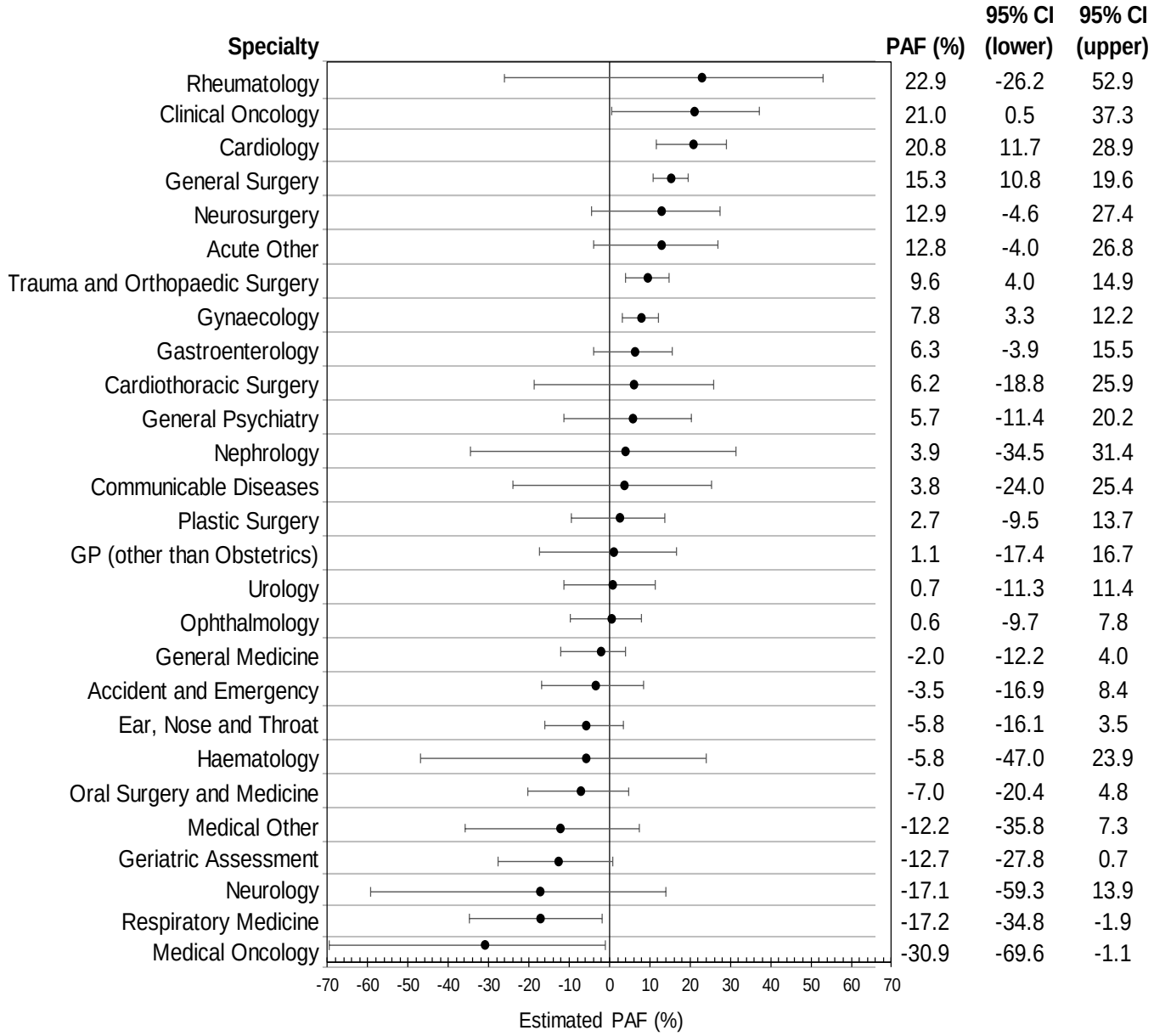


Table 2: HEs attributable to overweight and obesity in 2015/16

Specialty	All HEs	HEs attributable to overweight and obesity	95% CI HEs (lower)	95% CI HEs (upper)
Rheumatology	7,233	1,656	–1,895	3,826
Clinical Oncology	34,523	7,250	173	12,877
Cardiology	69,292	14,413	8,107	20,025
General Surgery	261,740	40,046	28,268	51,301
Neurosurgery	12,849	1,658	–591	3,521
Acute Other	17,179	2,199	–687	4,604
Trauma and Orthopaedic Surgery	104,273	10,010	4,171	15,537
Gynaecology	48,521	3,785	1,601	5,920
Gastroenterology	59,005	3,717	–2,301	9,146
Cardiothoracic Surgery	16,385	1,016	–3,080	4,244
General Psychiatry	17,269	984	–1,969	3,488
Nephrology	12,011	468	–4,144	3,771
Communicable Diseases	8,982	341	–2,156	2,281
Plastic Surgery and Burns	24,156	652	–2,295	3,309
GP (other than Obstetrics)	17,629	194	–3,067	2,944
Urology	73,036	511	–8,253	8,326
Ophthalmology	51,849	311	–5,029	4,044
General Medicine	436,781	–8,736	–53,287	17,471
Accident and Emergency	20,911	–732	–3,534	1,757

Specialty	All HEs	HEs attributable to overweight and obesity	95% CI HEs (lower)	95% CI HEs (upper)
Ear, Nose and Throat	35,055	–2,033	–5,644	1,227
Haematology	61,048	–3,541	–28,693	14,590
Oral Surgery and Medicine	3,396	–238	–693	163
Medical Other	10,035	–1,224	–3,593	733
Geriatric Assessment	91,520	–11,623	–25,443	641
Neurology	10,747	–1,838	–6,373	1,494
Respiratory Medicine	38,203	–6,571	–13,295	–726
Medical Oncology	38,192	–11,801	–26,582	–420
All specialties combined	**1,581,820**	**40,876 (2.6%)***	**–160,283 (–9.1%)***	**196,094 (12.4%)***

* Total may not sum precisely due to rounding of individual specialty estimates.

The cost of hospitalisation due to overweight and obesity

The cost of hospitalisation across all 27 specialties in 2015/16 attributable to overweight and obesity was estimated at 2.9% (95% CI –9.1% to 13.8%) of the roughly £4 billion total cost of hospitalisations per year in Scotland. Thus, the estimated cost of hospitalisations in 2015/16 due to overweight and obesity was £117 million (95% CI – £411 million to £560 million), but this estimate was very uncertain and could have been zero or even positive.

As shown in Table 3, of all the specialties, General Surgery was estimated to have the highest total HE costs attributable to overweight and obesity of approximately £86 million (95% CI £61 million to £111 million) followed by Cardiology (£42 million, 95% CI £23.5 million to £58 million), and Trauma and Orthopaedic Surgery (£41 million, 95% CI £17 million to £64 million). However, the increased costs for these specialties need to be seen in the context of potential decreased costs for other specialties and the overall net cost being close to zero and uncertain.

Table 3: Estimated total HE costs and costs attributable to overweight and obesity, 2015/16

Speciality	**Total HE costs**	**Total HE costs due to overweight and obesity**	**Total HE costs due to overweight and obesity 95% CI (lower)**	**Total HE costs due to overweight and obesity 95% CI (upper)**
Rheumatology	£16,854,575	£3,859,698	–£4,415,899	£8,916,070
Clinical Oncology	£71,461,959	£15,007,011	£357,310	£26,655,311
Cardiology	£200,901,141	£41,787,437	£23,505,433	£58,060,430
General Surgery	£564,453,988	£86,361,460	£60,961,031	£110,632,982
Neurosurgery	£83,778,894	£10,807,477	–£3,853,829	£22,955,417
Acute Other	£23,604,868	£3,021,423	–£944,195	£6,326,105

Speciality	Total HE costs	Total HE costs due to overweight and obesity	Total HE costs due to overweight and obesity 95% CI (lower)	Total HE costs due to overweight and obesity 95% CI (upper)
Trauma and Orthopaedic Surgery	£431,921,955	£41,464,508	£17,276,878	£64,356,371
Gynaecology	£92,287,623	£7,198,435	£3,045,492	£11,259,090
Gastroenterology	£94,455,017	£5,950,666	–£3,683,746	£14,640,528
Cardiothoracic Surgery	£111,922,595	£6,939,201	–£21,041,448	£28,987,952
General Psychiatry	£352,822,939	£20,110,908	–£40,221,815	£71,270,234
Nephrology	£59,072,321	£2,303,821	–£20,379,951	£18,548,709
Communicable Diseases	£24,061,097	£914,322	–£5,774,663	£6,111,519
Plastic Surgery	£72,389,913	£1,954,528	–£6,877,042	£9,917,418
GP (other than Obstetrics)	£94,666,471	£1,041,331	–£16,471,966	£15,809,301
Urology	£106,672,938	£746,711	–£12,054,042	£12,160,715
Ophthalmology	£86,378,850	£518,273	–£8,378,748	£6,737,550
General Medicine	£632,117,388	–£12,642,348	–£52,465,743	£25,284,696
Accident and Emergency	£20,582,898	–£720,401	–£3,478,510	£1,728,963
Ear, Nose and Throat	£79,653,957	–£4,619,930	–£12,824,287	£2,787,888
Haematology	£112,436,144	–£6,521,296	–£52,844,988	£26,872,238
Oral Surgery and Medicine	£6,326,784	–£442,875	–£1,290,664	£303,686
Medical Other	£44,841,495	–£5,470,662	–£16,053,255	£3,273,429

Speciality	Total HE costs	Total HE costs due to overweight and obesity	Total HE costs due to overweight and obesity 95% CI (lower)	Total HE costs due to overweight and obesity 95% CI (upper)
Geriatric Assessment	£435,300,572	–£55,283,173	–£121,013,559	£3,047,104
Neurology	£37,421,718	–£6,399,114	–£22,191,079	£5,201,619
Respiratory Medicine	£104,512,629	–£17,976,172	–£36,370,395	–£1,985,740
Medical Oncology	£75,690,318	–£23,388,308	–£52,680,461	–£832,593
Total	£4,036,591,047	£116,522,929	–£410,164,140	£559,026,990

Table 4 shows the overall hospitalisation cost estimate attributable to overweight and obesity in this study compared to other similar previous studies. It is lower than estimates published by the Scottish Government in 2010 (2007/8 costs were used) and the Scottish Parliament Information Centre (SPICe) in 2015 (2007/8 figures were inflation adjusted) but these estimates covered a wider range of costs than the present study which only considers HEs. See **Table 4** for details of the costs included in each study. It also differs markedly from Scottish cost estimates made using pro-rata UK figures.[17,18]

Table 4: Cost estimates in the literature compared with the present study

Source	Year of cost estimate	Estimated cost for year	Population included	Costs included
Walker, 2003[19]	Pre 2003††	£171 million	BMI > 30 kg/m^2	GP consultations, cost of drugs prescribed, hospital care
Scarborough, 2011[14]	2006/7	£600 million‡‡	BMI > 21 kg/m^2	Total cost to NHS Scotland
Preventing Overweight and	2007/8	£175 million	BMI > 30 kg/m^2	Total cost to NHS Scotland

†† We don't have the exact year of cost estimate, but given the information it may be before 2003
‡‡ This estimate is pro-rata for Scotland cited in SPICe briefing, 2015.

Source	Year of cost estimate	Estimated cost for year	Population included	Costs included
Obesity in Scotland report, 2010[5]				
Preventing Overweight and Obesity in Scotland report, 2010[5]	2007/8	£312 million	BMI > 25 kg/m^2	Total cost to NHS Scotland
Dobbs et al., 2014[14]	Post 2007[§§]	£706 million[***]	BMI > 25 kg/m^2	Total cost to NHS Scotland
Dobbs et al., 2014[14]	By 2015 (projected)	£706 to £941 million[6]	BMI > 25 kg/m^2	Total cost to NHS Scotland
SPICe briefing 2015[2]	2014/15	£223 million[†††]	BMI > 30 kg/m^2	Total cost to NHS Scotland
SPICe briefing 2015[2]	2014/15	£363 million[7]	BMI > 25 kg/m^2	Total cost to NHS Scotland
This report	2015/16	£117 million (95% CI –£411 million to £560 million)	BMI > 25 kg/m^2	Hospitalisations
Preventing Overweight and Obesity in Scotland report, 2010[5]	By 2030 (projected)	£342 million[‡‡‡]	BMI > 30 kg/m^2	Total cost to NHS Scotland
Preventing Overweight and Obesity in Scotland report, 2010[5]	By 2030 (projected)	£514 million[9]	BMI > 25 kg/m^2	Total cost to NHS Scotland
Dobbs et al., 2014[14]	By 2030 (projected)	£1.18 to 1.41 billion[6]	BMI > 25 kg/m^2	Total cost to NHS Scotland

[§§] We don't have exact year of cost estimate but given the information it seems likely to be after 2007.

[***] This estimate is pro-rata for Scotland using information from SPICe, 2015 and Scarborough 2011.

[†††] Inflation adjusted estimates using cost figures from Walker, 2003.

[‡‡‡] Future costs estimated assuming there is no change in current treatment practice for obesity, such as increases in use of pharmacological products or an increase in the numbers of people undergoing bariatric surgery.

Chapter 4: Discussion

Main findings

Overall, approximately 2.6% (95% CI –9.0% to 12.4%) of HEs were attributable to overweight and obesity in 2015/16, with 17 of the specialties showing a positive relationship with increasing BMI and 10 specialties showing an inverse relationship.

The net cost of HEs attributable to overweight and obesity was estimated at approximately £117 million (95% CI £–411 million to £560 million) for all 27 specialties combined or 2.6% of the total cost of hospital admission in 2015/16. Although there was a wide degree of uncertainty around this estimate.

Strengths and limitations

To our knowledge, this is the first study to use specialty-level HE data to explore the impact of overweight and obesity on health service use in Scotland. Stratification of HEs by specialty allowed for groupings which were clinically similar in nature, while allowing average costs per case for each specialty to be applied to the total number of HEs in each specialty. We excluded individuals who had a cancer diagnosis in the five years pre or one year post survey interview, thus minimising the potential for reverse causality whereby a survey participant is underweight due to ill health.

Conversely, there is also the possibility that patients diagnosed with cancer as a result of overweight or obesity in the five years prior to the SHeS study may have been missed. This is a source of potential underestimation.

A major strength of our study was the prospective cohort design based on the use of comprehensive routine datasets (SMR01 and SMR04) linked to SHeS data. This makes causal assertions easier as exposure precedes the outcome.[20] BMI was based on objective measurements of height and weight, minimising any bias from self-reporting.[13] Using the SHeS also allowed us to adjust for socioeconomic position in the generation of IRRs.

The inclusion of overweight individuals as well as obese individuals ensured that the potential costs of being above a healthy weight, and not just obese, were included.

There were also several limitations with our study design. We used a single measure of overweight and obesity in our cohort (BMI). While BMI is a commonly used and well-established indicator, it is a less effective measure of adiposity for certain populations such as those who participate in sports like rugby and have a high muscle mass, or the elderly.[9] Exploring the relationship between high BMI and other available measures of adiposity would offer a sensitivity analysis to the results presented.

It is also likely that some of the population we followed had changes in their weight over time, subsequently leading to misclassification in our analysis. As BMI changes over the life course, and there was a secular upward trend in BMI over the follow-up period, this would have underestimated the link between overweight, obesity and HEs as we will have included more people in the normal weight category than is likely to have actually been the case over the follow-up period.[21] We therefore adjusted for survey wave in regression analyses to partially account for this.

Our modelling, and the point estimates it generated, were very sensitive to changes in the model covariates. CIs are provided to give an indication of the level of precision for each estimate.

Just as a broad definition of exposure can increase the sensitivity of the measure leading to an inflated PAF estimate,[22] it could be argued that a broad definition of the outcome measure may underestimate the PAF through the dilution of the exposure–outcome relationship. This could occur due to the grouping of admissions which are heterogeneous in terms of diagnosis, varying complexity due to multimorbidity or whether or not surgery was undertaken. Further work is required to disentangle these factors in future analyses.

How this fits with existing literature

To our knowledge, there are no directly comparable studies using HEs by specialty as the outcome measure. However, of those focusing on all-cause admission, most

studies found some association between overweight, obesity and hospital admissions.[9,23] Chen et al.[24] found that obesity accounted for approximately 4% of inpatient admissions in Canadian adults, a similar estimate to this study for Scotland. Other studies calculating PAFs for hospital costs attributable to overweight and obesity ranged from 2% to 17%.[9,25,26]

It is very difficult to compare cost estimates, as there is substantial variation in the way studies estimate costs caused by obesity and/or overweight. There is a wide variation in costing methods, range of sources, methodological approaches, perspectives, target groups and included diseases. Some studies consider only direct costs that consist of healthcare and non-healthcare costs while others also take into account indirect costs that estimate cost due to productivity losses as a result of morbidity and mortality, borne by the individual, family, society or the employer. So, while the former can include anything from medical care expenditures for diagnosis, treatment and rehabilitation, to consumption of non-healthcare resources like transportation, household expenditures, relocating, property losses and informal care, the latter usually includes costs incurred due to productivity loss, in some sense estimating a social welfare loss due to diseases. There is also variation in the thresholds of BMI used to categorise people as being obese or overweight which leads to different cost estimates. For example, there are cost estimates looking at only obesity rather than overweight and obesity (without adjustment to account for this), making it difficult to compare with our estimates.[2,5,27]

We also limited our analysis to the costs of hospitalisations rather than total health service costs, which could potentially have reduced our cost estimates in comparison with other studies. Furthermore, we calculated the PAF using Scottish data for the estimation of the prevalence and subsequent hospitalisation rather than using a PAF from the international literature. We aggregated HEs by speciality rather than by disease and estimated costs using Scottish cost data.[15]

Implications and future research

While HEs represent one element of NHS direct costs attributable to overweight and obesity, the impact is much wider and will also include other healthcare resources

such as prescribing and primary care. Furthermore, as highlighted by McCormick and Stone,[28] although significant in their own right and growing rapidly, overall healthcare costs of obesity represent only a minority of the total financial cost. This means that we need to better understand the wider societal costs in order to estimate the broader indirect costs of overweight and obesity. We also need to understand the proportion of these costs which are avoidable through interventions to tackle overweight and obesity and inform economic evaluations.

Conclusions

A small and uncertain percentage of HEs in Scotland, and of hospitalisation costs, are attributable to overweight and obesity in the population. Our best estimate is that 2.6% (95% CI –9.0% to 12.4%) of HEs were attributable to overweight and obesity in 2015/16, equating to an extra 40,506 (95% CI –140,135 to 192,756) episodes. However, the wide CIs around this estimate mean that we cannot conclude that there was a net impact on the overall number of HEs due to overweight and obesity. Similarly, the estimated cost of £117 million (95% CI –£411 million to £560 million) for HEs attributable to overweight and obesity in 2015/16 has a wide degree of uncertainty around it.

Further research is needed to look at alternative means of estimating the direct cost of HEs due to conditions medically related to overweight and obesity, as well as those conditions which may be indirectly aggravated by excess weight, increasing the risk of admission to hospital.

Appendix A: Specialty coding

Table 5: Specialty coding

Specialty	**Codes included in definition**
General Medicine	A1: General Medicine 16: General Medicine A11: Acute Medicine
Medical Other (CB)†	A8: Endocrinology and Diabetes A81: Endocrinology A82: Diabetes H1: Diagnostic Radiology 33: Diagnostic Radiology J5: Immunology AC: Homeopathy 18: Metabolic Diseases
Cardiology	A2: Cardiology 17: Cardiology
Communicable Diseases (CB)/Infectious Diseases (SMR01)	A6: Communicable Diseases 31: Infectious Diseases (other than TB)
Gastroenterology	A9: Gastroenterology 21: Gastroenterology
Geriatric Assessment (CB)/Geriatric Medicine (SMR01)	AB: Geriatric Medicine 50: Geriatric Assessment 51: Geriatric Long Stay
Medical Oncology	AD: Medical Oncology 37: Medical Oncology
Renal Medicine	AG: Renal Medicine 24: Nephrology
Neurology	Ah: Neurology 19: Neurology
Respiratory Medicine	AQ: Respiratory Medicine 28: Respiratory Medicine
Rheumatology	AR: Rheumatology 25: Rheumatology

Specialty	Codes included in definition
General Surgery (SMR01)††	C1: General Surgery C11: General Surgery (excl. Vascular) C12: Vascular Surgery 01: General Surgery
Accident and Emergency	C2: Accident and Emergency 49: Accident and Emergency
Acute Other (CB)/Anaesthetics (SMR01)	C3: Anaesthetics C31: Pain Control 98: Acute Other 41: Pain Control (Anaesthetics)
Cardiothoracic Surgery	C4: Cardiothoracic Surgery C41: Cardiac Surgery C42: Thoracic Surgery 07: Cardiothoracic Surgery
Ear, Nose and Throat	C5: Ear, Nose and Throat 03: Ear, Nose and Throat
Neurosurgery	C6: Neurosurgery 06: Neurosurgery
Ophthalmology	C7: Ophthalmology 04: Ophthalmology
Trauma and Orthopaedic Surgery	C8: Trauma and Orthopaedic Surgery 02: Orthopaedic Surgery
Plastic Surgery	C9: Plastic Surgery 08: Plastic Surgery 09: Burns Unit
Urology	CB: Urology 05: Urology
Oral Surgery and Medicine (CB)‡	D3: Oral Surgery D4: Oral Medicine 12: Oral Surgery/Medicine
General Practice (CB)/GP (other than Obstetrics) (SMR01)	E12: GP (other than Obstetrics) 73: GP (excluding Obstetrics) 74: GP (excluding Obstetrics – Long Stay)

Specialty	Codes included in definition
Gynaecology	F2: Gynaecology 42: Gynaecology
General Psychiatry (CB)/General Psychiatry (Mental Illness) (SMR04)	G1: General Psychiatry (Mental Illness) G3: Forensic Psychiatry
Clinical Oncology	H2: Clinical Oncology 34: Radiotherapy
Haematology	J4: Haematology 62: Haematology

Source: ISD specialty mapping/cost book.
CB: cost book; TB, tuberculosis.
Notes: Paediatric specialties excluded.
Excludes the following due to small numbers or no admissions in SHeS cohort: Rehabilitation Medicine, Orthodontics, Restorative Dentistry, Community Dental Practice, Dermatology, Allergy, Oral and Maxillofacial Surgery, Clinical Genetics, Immunology, Homeopathy, General Dental Practice, Integrative Care, Palliative Medicine, Rehabilitation Medicine, Clinical Neurophysiology, Psychotherapy, Geriatric Psychiatry.
† Included under 'Medical Other' in cost book but A8 and H1 are reported separately in SMR01. We have combined them here as per the cost book grouping due to small numbers.
†† Separated in cost book into General Surgery (exc. Vascular) and Vascular Surgery. These were combined in order to apply SMR01 estimate admissions which could not be disaggregated. Separated in cost book into Cardiac Surgery and Thoracic Surgery. These were combined in order to apply SMR01 estimate admissions which could not be disaggregated.
‡ There were < five admissions for Oral Medicine in 2015/16, six admissions to Orthodontics in 2015/16 and 228 admissions to Restorative Dentistry.

Appendix B: IRRs

Table 6: HEs and IRRs for admission by specialty after adjustment for age at baseline (survey), sex, SIMD and survey wave

Specialty	**BMI category**	**HEs per 100 person-years at risk**	**IRR**	**95% CI**	***p*-value**
General Medicine	Healthy	5.60	1		
	Overweight	6.86	0.94	0.83 to 1.07	0.365
	Obese	7.78	0.94	0.82 to 1.08	0.402
Cardiology	Healthy	0.69	1		
	Overweight	1.43	1.37	1.11 to 1.68	0.003
	Obese	1.52	1.30	1.04 to 1.63	0.023
Communicable Diseases	Healthy	0.14	1		
	Overweight	0.14	0.95	0.39 to 2.28	0.904
	Obese	0.19	1.90	0.49 to 7.33	0.350
Geriatric Assessment	Healthy	0.61	1		
	Overweight	0.81	1.03	0.79 to 1.33	0.844
	Obese	0.93	0.93	0.70 to 1.24	0.632
Gastroenterology	Healthy	0.83	1		
	Overweight	1.06	1.36	1.01 to 1.85	0.045
	Obese	1.12	1.24	0.92 to 1.66	0.158
Medical Oncology	Healthy	0.51	1		
	Overweight	0.43	0.49	0.29 to 0.85	0.012
	Obese	0.76	1.09	0.55 to 2.16	0.812
Nephrology	Healthy	0.26	1		
	Overweight	0.26	1.17	0.56 to 2.44	0.680
	Obese	0.24	0.61	0.27 to 1.36	0.225
Neurology	Healthy	0.23	1		
	Overweight	0.12	0.37	0.11 to 1.28	0.116
	Obese	0.22	0.72	0.16 to 3.23	0.671
Respiratory Medicine	Healthy	0.56	1		
	Overweight	0.43	0.59	0.40 to 0.88	0.009
	Obese	0.54	0.42	0.26 to 0.66	<0.001
Rheumatology	Healthy	0.29	1		
	Overweight	0.15	1.04	–1.03 to 1.10	0.271
	Obese	0.19	1.04	1.02 to 1.05	< 0.001
General Surgery	Healthy	4.53	1		
	Overweight	5.43	1.23	1.11 to 1.37	< 0.001
	Obese	5.96	1.28	1.13 to 1.44	< 0.001
Accident and Emergency	Healthy	0.29	1		
	Overweight	0.27	1.26	0.15 to 10.62	0.835
	Obese	0.25	1.25	0.46 to 3.44	0.664

Specialty	BMI category	HEs per 100 person-years at risk	IRR	95% CI	*p*-value
Acute Other	Healthy	0.22	1		
	Overweight	0.27	1.78	1.05 to 3.02	0.032
	Obese	0.36	1.41	0.95 to 2.94	0.075
Cardiothoracic Surgery	Healthy	0.31	1		
	Overweight	0.52	1.43	0.88 to 2.31	0.145
	Obese	0.42	1.11	0.68 to 1.81	0.680
Ear, Nose and Throat	Healthy	0.68	1		
	Overweight	0.62	0.86	0.64 to 1.15	0.303
	Obese	0.58	1.00	0.72 to 1.37	0.982
Neurosurgery	Healthy	0.20	1		
	Overweight	0.26	1.08	0.67 to 1.73	0.760
	Obese	0.25	0.70	0.42 to 1.19	0.190
Ophthalmology	Healthy	0.73	1		
	Overweight	1.06	1.00	0.84 to 1.18	0.958
	Obese	1.18	1.05	0.84 to 1.31	0.651
Trauma and Orthopaedic Surgery	Healthy	1.84	1		
	Overweight	2.29	1.01	0.88 to 1.16	0.866
	Obese	2.81	1.30	1.09 to 1.54	0.003
Plastic Surgery and Burns	Healthy	0.41	1		
	Overweight	0.45	1.39	0.98 to 1.99	0.068
	Obese	0.37	1.03	0.60 to 1.76	0.910
Urology	Healthy	1.24	1		
	Overweight	1.74	0.89	0.67 to 1.19	0.469
	Obese	1.68	0.81	0.60 to 1.09	0.159
Oral Surgery and Medicine	Healthy	0.21	1		
	Overweight	0.16	0.66	0.38 to 1.14	0.133
	Obese	0.12	0.54	0.25 to 1.14	0.105
GP (other than Obstetrics	Healthy	0.25	1		
	Overweight	0.33	0.92	0.57 to 1.48	0.732
	Obese	0.40	1.09	0.70 to 1.69	0.713
Gynaecology	Healthy	1.39	1		
	Overweight	0.99	1.08	0.93 to 1.26	0.327
	Obese	1.23	1.19	0.97 to 1.45	0.087
General Psychiatry	Healthy	0.40	1		
	Overweight	0.34	1.62	1.04 to 2.54	0.033
	Obese	0.24	1.14	0.57 to 2.25	0.716
Medical Other	Healthy	0.15	1		
	Overweight	0.14	0.92	0.52 to 1.62	0.762
	Obese	0.17	0.95	0.49 to 1.84	0.885

Specialty	**BMI category**	**HEs per 100 person-years at risk**	**IRR**	**95% CI**	***p*-value**
Clinical Oncology	Healthy	0.46	1		
	Overweight	0.79	1.53	1.02 to 2.28	0.039
	Obese	0.64	1.46	0.92 to 2.30	0.109
Haematology	Healthy	0.68	1		
	Overweight	0.91	0.73	0.39 to 1.39	0.343
	Obese	0.92	0.79	0.37 to 1.67	0.530

Note: Statistical significance level set to $p < 0.002$ after Bonferroni correction for multiple comparisons.

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