

Online appendix

Supplementary tables**Supplementary Table S1.**

Hazard ratios for BMI categories by age group from The Global BMI Mortality Collaboration (GBMC) 2016 study¹. Taken from eTable 11 (European studies only).

Age group (years)	Underweight (BMI 15 to <18.5 kg/m ²)	Normal weight (BMI 18.5 to <25 kg/m ²)	Overweight (BMI 25 to <30 kg/m ²)	Obesity Grade I (BMI 30 to <35 kg/m ²)	Obesity Grade II (BMI 35 to <40 kg/m ²)	Obesity Grade III (BMI 40 to <60 kg/m ²)
35-49	1.86	1.00	1.17	1.90	3.01	5.34
50-69	2.25	1.00	1.11	1.60	2.23	4.04
70-89	1.65	1.00	0.98	1.12	1.56	1.91

Supplementary Table S2.

Sample sizes for 35-89 year-olds in 1995 and 2008, Scottish Health Survey (SHeS) and Health Survey for England (HSE).

Age group	SHeS 1995	SHeS 2008	HSE 1995	HSE 2008
35-49	2,381	1,532	3,918	3,547
50-69*	1,801	1,628	3,973	3,692
70-89	0 [†]	669	1,831	1,507
Total	4,182	3,829	9,722	8,746

Methodological note: BMI category proportions for 65-69 and 70-89 years for 1995 SHeS (which only sampled 16-64 years) were derived from analysis of 2003 SHeS data (the first survey that included a sample of all adults aged 16+). Thus, for each BMI category the difference in proportions between 15-64 years and 15-69 years in 2003 were applied to 1995 data for 15-64 years to give a likely estimate for 15-69 years. Similarly, the differences in each category between 50-69 years and 70-89 years in the 2003 survey were then applied to 1995 data to provide an estimate for 70-89 years.

* 50-64 years in 1995 SHeS: in 2003 SHeS there were 1,975 in this age group, including 1,573 in the 50-64 group (as described above, these data were used to derive estimates for 1995)

[†] Sample size in 2003 SHeS (used to derive estimates for 1995) was 779.

Supplementary Table S3.

Hazard ratios for BMI categories by age group approximated from Bhaskaran et al² (sensitivity analyses).

Age group (years)	Underweight (BMI 15 to <18.5 kg/m ²)	Normal weight (BMI 18.5 to <25 kg/m ²)	Overweight (BMI 25 to <30 kg/m ²)	Obesity Grade I (BMI 30 to <35 kg/m ²)	Obesity Grade II (BMI 35 to <40 kg/m ²)	Obesity Grade III (BMI 40 to <60 kg/m ²)
16-49	1.73	1.00	1.27	1.65	2.31	2.84
50-69	1.79	1.00	1.12	1.43	1.89	2.54
70-79	1.88	1.00	1.03	1.27	1.63	2.34
80+	1.25	1.00	0.96	1.07	1.24	1.56

Methodological note: HRs by age group for the same BMI categories used in the GBMC paper were not available. Instead, values were approximated from the Bhaskaran et al paper's Figure 3b ('Association between BMI and all-cause mortality among never-smokers by age') using Digitizeit software (www.digitizeit.de): the latter enabled extraction of approximate data values from the Figure. For each BMI category, the mid-point of the associated HR range was used; this was done separately for each age group[‡]. As the Figure presented logHR values, the extracted data were also exponentiated.

Supplementary Table S4.

Population attributable fractions (PAFs) by age group (main analyses).

Age group (years)	Scotland (SHeS)	England (HSE)
35-49	0.116	0.115
50-69	0.071	0.071
70-89	-0.008	0.028

[‡] Note that for the highest BMI category (Grade III obesity), the mid-point between BMI 40 and the maximum BMI value was used (as BMI values did not exceed 50 in the sample).

Supplementary Table S5.

Comparison of main analyses using 1981-, 1991- and 2001-based mortality projections (2017-19 mortality data)

	Observed rate	BMI-adjusted rate	Projected rate (1981)	% of observed-projected difference attributable to BMI change	Projected rate (1991)	% of observed-projected difference attributable to BMI change	Projected rate (2001)	% of observed-projected difference attributable to BMI change
Scotland, males	1750.7	1718.8	1503.7	12.9%	1447.1	10.5%	1423.7	9.8%
Scotland, females	1268.0	1248.3	1147.4	16.3%	1122.8	13.6%	1106.7	12.2%
England, males	1438.5	1378.6	1183.9	23.5%	1140.6	20.1%	1143.8	20.3%
England, females	1013.5	972.6	927.4	47.5%	896.2	34.9%	847.6	24.7%

Supplementary Table S6.

Population attributable fractions (PAFs) by age group using HRs approximated from Bhaskaran et al (sensitivity analyses).

Age group (years)	Scotland (SHeS)	England (HSE)
16-49	0.069	0.055
50-69	0.050	0.046
70-79	0.026	0.043
80+	-0.077	0.004

Supplementary Table S7.

Comparison of main results with sensitivity analyses using PAFs calculated from HRs approximated from Bhaskaran et al and applied to different age-specific mortality analyses, England 2017-19 (and using 1991-based mortality projections).

Methodological note: the PAFs shown in Table S6 above were applied to different age groups in the mortality analysis. For direct comparison with the main results, they were applied to the same 35-89 age band. However, as HRs were available for ages 16-80+ years, they were additionally applied to mortality data with corresponding ages (15 years+, as mortality data were accessed in five year age bands). Further sensitivity analyses restricted the age group to 15-84 years. Results are shown below for England only.

	% observed-projected difference attributable to BMI change			
	Main analyses (35-89 years using GBMC HRs)	Bhaskaran et al HRs, 35-89 years	Bhaskaran et al HRs, 15-84 years	Bhaskaran et al HRs, 15+ years
Males	20.1%	16.4%	15.1%	13.2%
Females	34.9%	28.9%	25.9%	22.9%

Supplementary Table S8.

Population attributable fractions (PAFs) by age group using three-year averages instead of single years (sensitivity analyses).

Methodological note: for English data, comparisons were made between the single year approach (i.e. the change in BMI distribution between 1995 and 2008) and three year averages around those single years (i.e. 1994-96 and 2007-09). This was not possible for Scottish data: there were no surveys run in 1994, 1996 or 2007; thus, comparisons were instead made between 1995 and 2008, and 1995 and 2008-10.

Age group (years)	Scotland (SHeS) 1995 and 2008-10	England (HSE), using 1994-96 and 2007-09
35-49	0.124	0.108
50-69	0.076	0.072
70-89	-0.006	0.023

Supplementary Table S9.

Comparison of main results with sensitivity analyses using PAFs derived from 2008-10 instead of 2008 in the Scottish Health Survey, and applied to analyses of 2017-19 Scottish mortality data (using 1991-based mortality projections).

See methodological note for Supplementary Table S8.

	Observed rate	Projected rate (1991)	Main analyses (1995 and 2008)		Sensitivity analyses (1995 and 2008-10)	
			BMI-adjusted rate	% of observed-projected difference attributable to BMI change	BMI-adjusted rate	% of observed-projected difference attributable to BMI change
Males	1750.7	1447.1	1718.8	10.5%	1713.1	12.4%
Females	1268.0	1122.8	1248.3	13.6%	1244.4	16.3%

Supplementary Table 10.

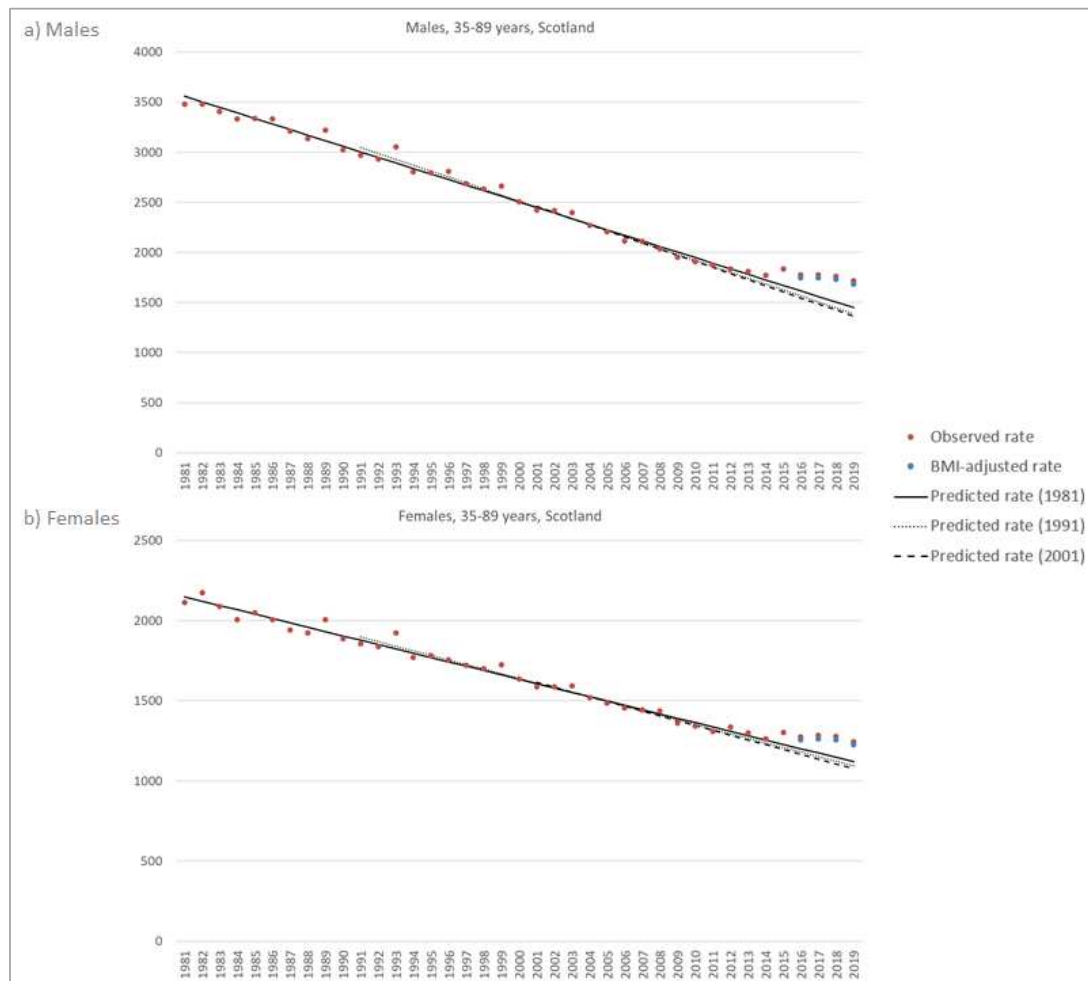
See methodological note for Supplementary Table S8.

Comparison of main results with sensitivity analyses using PAFs derived from 1994-96 and 2007-09 instead of 1995 and 2008 respectively in the Health Survey for England, and applied to analyses of 2017-19 English mortality data (using 1991-based mortality projections)

	Observed rate	Projected rate (1991)	Main analyses (1995 and 2008)		Sensitivity analyses (1994-96 and 2007-09)	
			BMI-adjusted rate	% of observed-projected difference attributable to BMI change	BMI-adjusted rate	% of observed-projected difference attributable to BMI change
Males	1438.5	1140.6	1378.6	20.1%	1383.8	18.4%
Females	1013.5	896.2	972.6	34.9%	976.3	31.7%

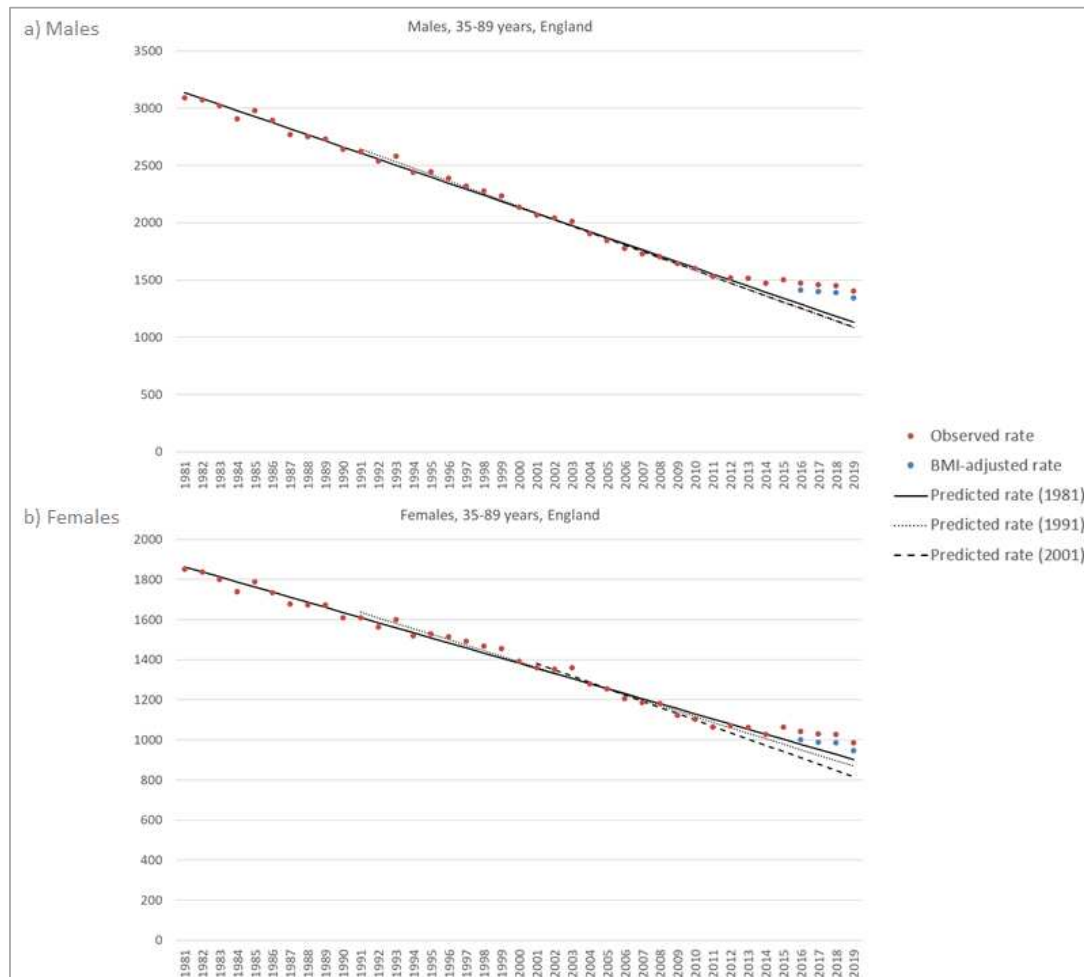
Supplementary Figures**Supplementary Figure S1.**

Observed, predicted and BMI-adjusted European age-standardised mortality rates (EASRs), Scotland 1981-2019 – comparing 1981-, 1991- and 2001-based predictions. Note different y-axis scales for males and females.



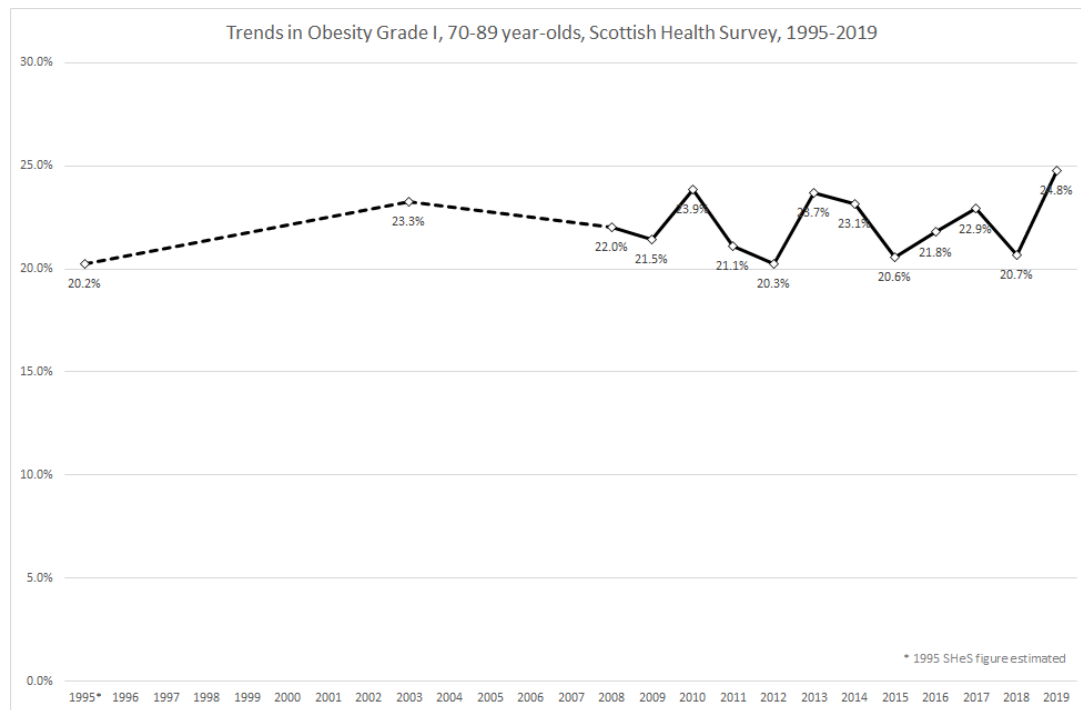
Supplementary Figure S2.

Observed, predicted and BMI-adjusted European age-standardised mortality rates (EASRs), Scotland 1981-2019 – comparing 1981-, 1991- and 2001-based predictions. Note different y-axis scales for males and females.



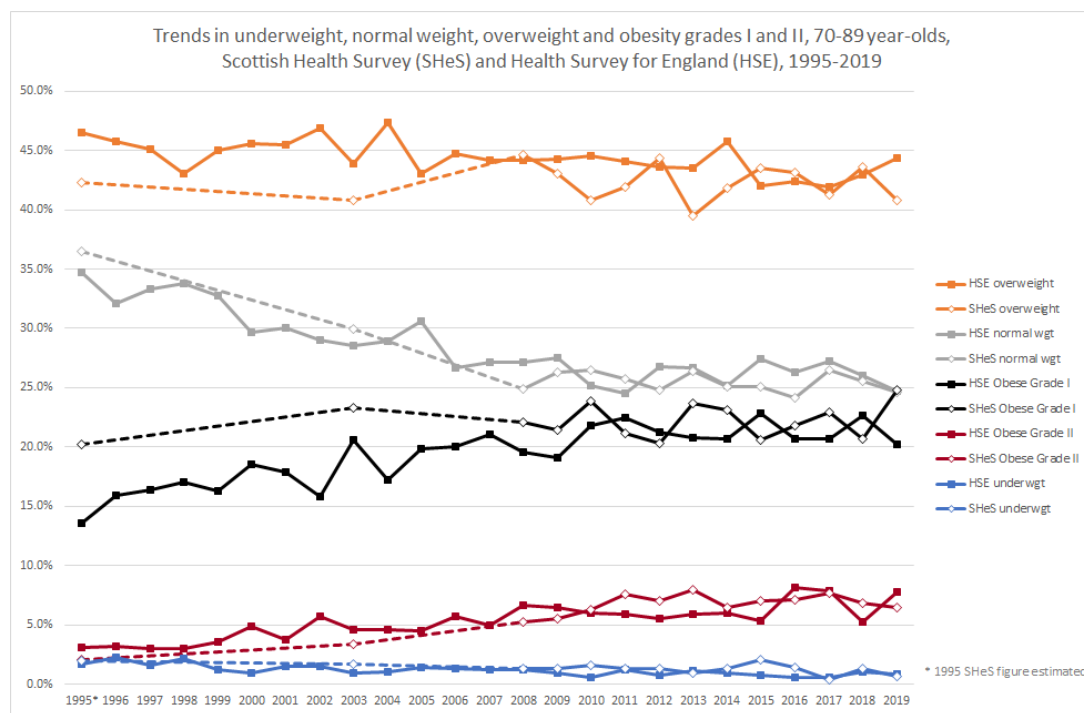
Supplementary Figure S3.

Trends in the percentage of adults aged 70-89 years classed as Obese Grade I (BMI 30 to <35), Scotland, 1995-2019



Supplementary Figure S4.

Trends in the percentage of adults aged 70-89 years in different BMI categories, Scotland and England, 1995-2019



References

¹ Global BMI Mortality Collaboration. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. *Lancet* 2016; 388(10046): 776-86

² Bhaskaran K., Dos-Santos-Silva I., Leon D.A., Douglas I.J., Smeeth L. Association of BMI with overall and cause-specific mortality: a population-based cohort study of 3.6 million adults in the UK. *Lancet Diabetes Endocrinol.* 2018; 6(12): 944-953