A prediction of Obesity Trends for Adults and their associated diseases

Analysis from the Health Survey for England 1993 – 2007

Report by the National Heart Forum

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1. Executive summary

The publication of the Foresight Tackling Obesities[i] report in 2007 highlighted the significant public health threat posed by the growth of obesity in the English population and mirrored throughout the UK. Micro-simulation modelling was employed by the National Heart Forum (NHF) to predict future trends in obesity and their consequences for population health. The NHF have continued to develop this work and here present an update to the adult obesity and associated disease statistics.

The original Foresight[ii] report used Health Survey for England (HSE) data from the years 1993 to 2004 inclusive. Since then there have been three more years of data has been published. This report uses the complete data set 1993 to 2007 from which to make future predictions of obesity growth in adults and goes on to set out updated projections for obesity related disease incidence for adults aged 40-65.This work makes use of the most recently available disease incidence, prevalence, mortality and relative-risk statistics to present predictions for arthritis, coronary heart disease, diabetes, gall bladder disease, hypertension, stroke and the following cancers: breast, colorectal, endometrial, kidney, oesophageal and liver.

Unlike the recent report on child obesity[iii] which showed some indications of a plateauing or at least a significant reduction in the rate of obesity, the future projections for adults are less optimistic. Table 1 below shows that by 2020 rates of obesity in adult males and females are predicted to be only marginally less than those predicted in the original Foresight[iv] report. When examined the figures for the older age group are even less optimistic. In both cases the predictions for males and females are within the confidence intervals specified in the Foresight report.

Predictions to 2020	Foresight 1993-2004	All years 1993-2007
Aged 20-65, male	44 (+4,-4)	41 (+2,-2)
Aged 20-65,female	39 (+3,-3)	36 (+2,-2)
Aged 40-65, male	45 (+5,-5)	44 (+3,-3)
Aged 40-65, female	41 (+4,-4)	38 (+3,-3)

Table 1: Adults, predicted BMI distributions >30 at 2020. The numbers in brackets are the statistical uncertainty to the 95% confidence level.

These trends in adult obesity lead to significant rises in the levels of obesity related diseases, particularly the vascular diseases: coronary heart disease, diabetes, hypertension and stroke.

2. Introduction

This report presents analysis that uses the most recent Health Survey for England data to predict future obesity trends and their consequences in terms of the increase incidence of BMI related diseases. The incidence of disease is modelled using a micro-simulation. The simulation makes use of the most recently available disease incidence, prevalence, mortality and relative-risk statistics to present predictions for

arthritis, coronary heart disease, diabetes, gall bladder disease, hypertension, stroke and the following cancers: breast, colorectal, endometrial, kidney, oesophageal and liver. An important development to the disease-modelling is the inclusion of hypertension, it is a significant illness in its own right but it also plays an important intermediate role in raising the relative risks of other diseases. Micro simulation can easily capture and model such dependencies.

3. Overview of methods

The methodology is broadly similar to that of the Foresight report, Tackling Obesities[v]. We use two computer programs developed by the National heart Forum Obesity_distribution.exe and obesity_exe.

The purpose built C++ program Obesity_distribution.exe sorts HSE files to obtain estimates for the proportion of the sampled population that (for example) belong to a particular age group, sex group and BMI group. The micro-simulation program Obesity_exe takes these data, demographic data and disease data to predict the future burden of disease. The detailed methodology is set out in the companion report

4. Trend analysis: Age Group 20-65

A selection of predicted BMI distributions are presented here. The y-axis represents the percentage of the population in each category; the x-axis time. For the full set of BMI distributions for each age group the reader is referred to the companion report

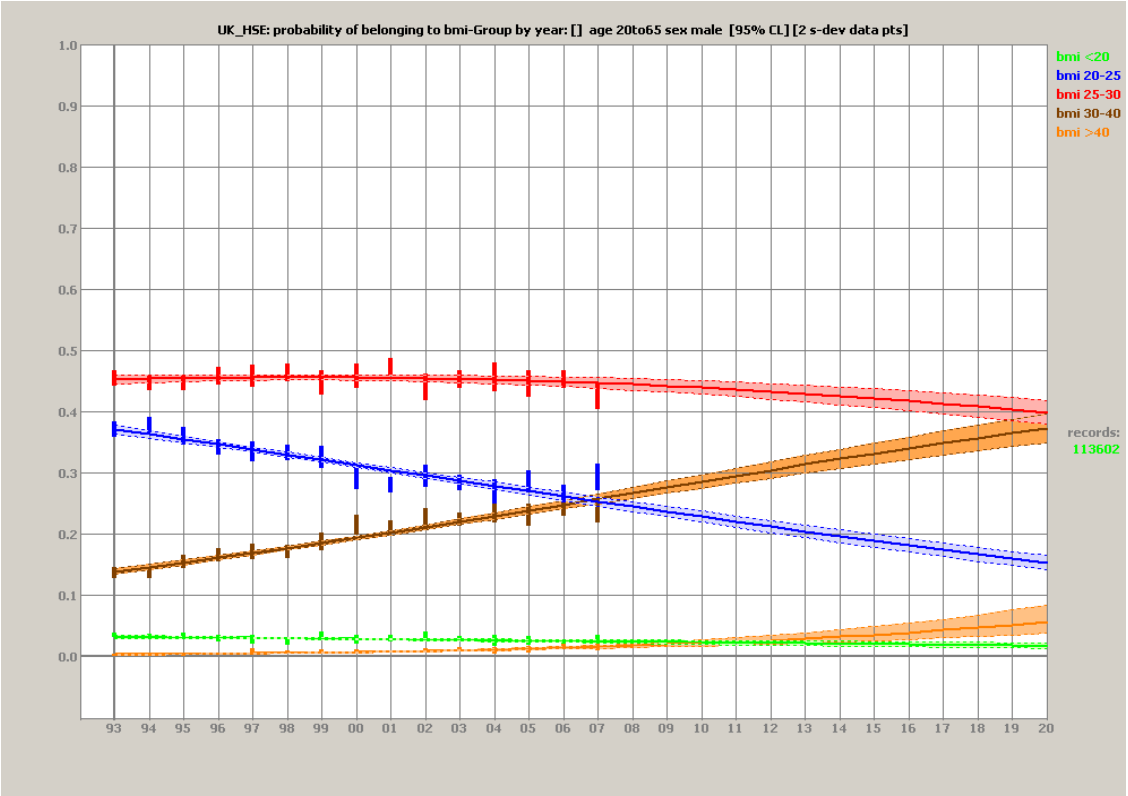


Figure 1: Adult males aged 20-65, predicted BMI membership to 2020 for data years 1993 to 2007 inclusive

Figure 1 shows obesity trends for adult males aged 20-65 to 2020. There is a clear downward gradient for normal weight (blue line) whilst levels of over-weight (red line) remain relatively stable so that decline in normal weight is mirrored by a significant increase in levels of obesity (brown line) and in levels of morbid obesity (orange line). These obesity levels are within the confidence limits of the levels recorded in the earlier Foresight report.

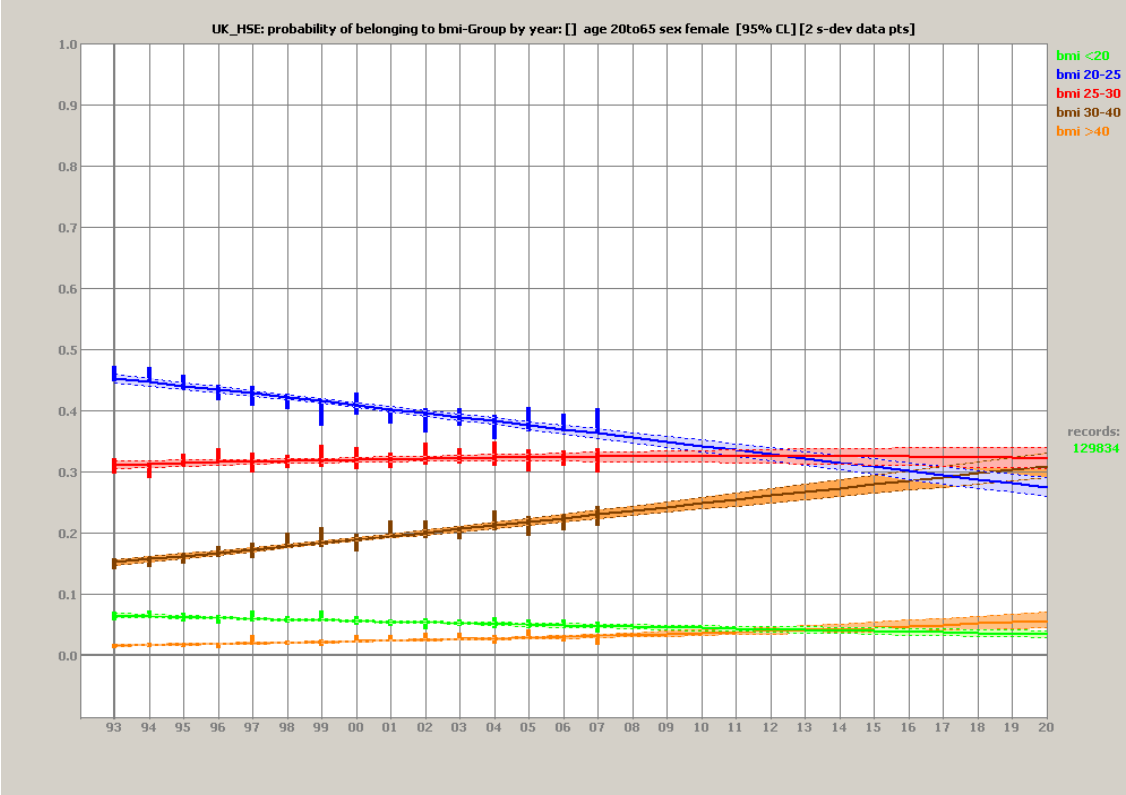


Figure 2: Adult females aged 20-65, predicted BMI membership to 2020 for data years 1993 to 2007 inclusive

Figure 2 shows the trends for adult females aged 20-65. As for the males, normal weight declines, overweight remains relatively constant and obesity and morbid obesity rise - though not to the same extent as the males. Again, these predictions fall within the confidence intervals for female rates of obesity published in the Foresight report.

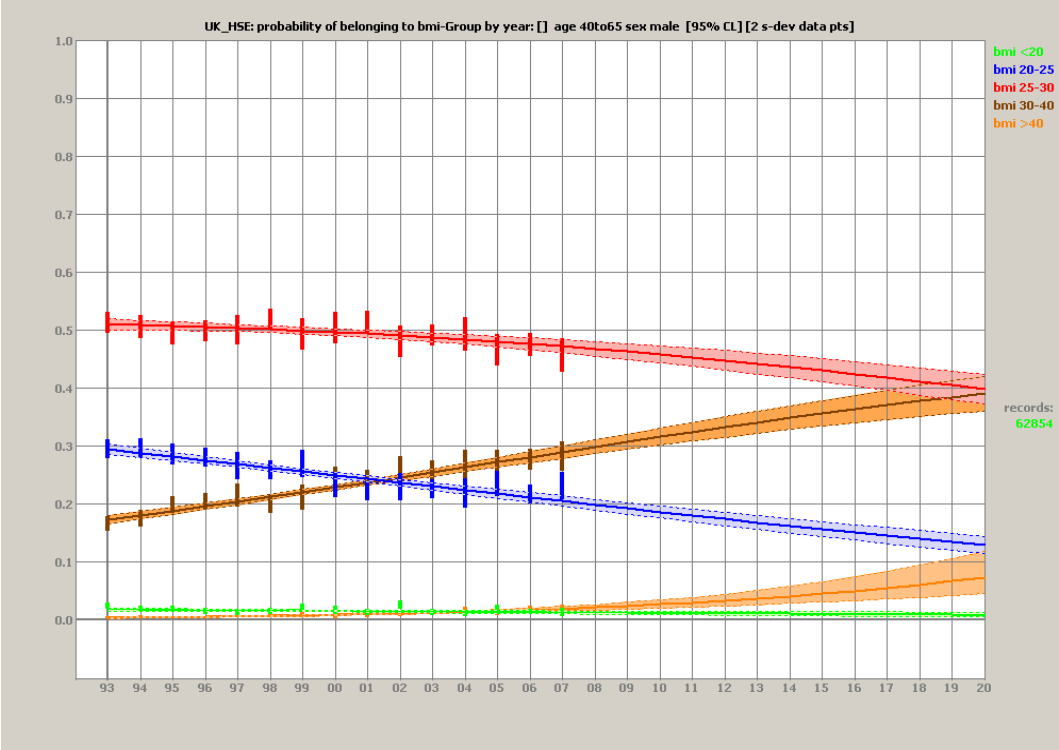


Figure 3: Adult males aged 40-65, predicted BMI membership to 2020 for data years 1993 to 2007 inclusive

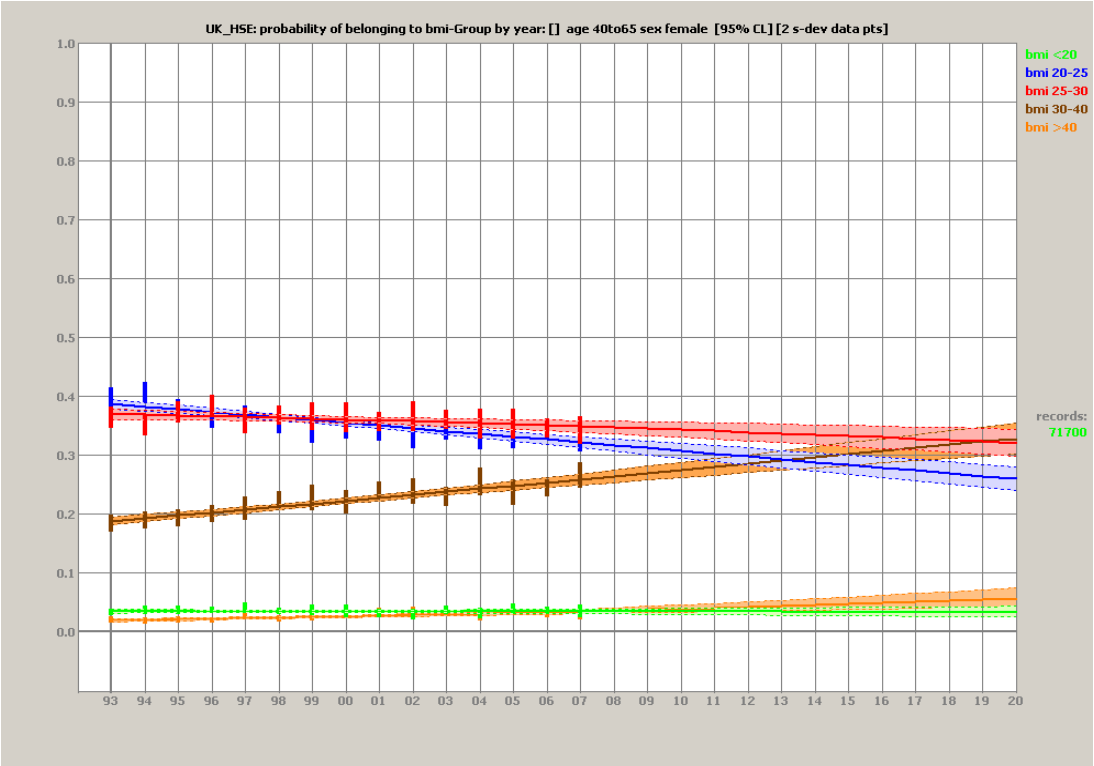


Figure 4: **Adult females aged 40-65, predicted BMI membership to 2020 for data years 1993 to 2007 inclusive**

Figure 3 shows predicted trends for adult males aged 40-65. These are broadly similar to those for all adult males but with steeper trajectories for the obese.

Figure 4 shows the predicted trends for females aged 40-65. Again similar to their male counterparts, the older females are more obese. Both sets of results are broadly similar to those published in the Foresight report.

5. Disease statistics

The figures presented in this report were produced using the most recent software version of the micro simulation (version 7.0) using the most recent (2006) disease statistics. The majority of the relative risk data have been revised in line with recent work [vi]. The impact of the predicted future growth in obesity is calculated by comparing two scenarios, scenario 0 which allows for growth in obesity in line with the predicted trends and scenario 7 where obesity levels are held constant at their 2006 values. This comparison allows population ageing effects to be distinguished from obesity growth effects.

5. 1 Disease Prevalence

The following Figures, 5-7, show the predicted prevalence of selected diseases, expressed as rates per 100,000, for the adult male and female populations. All Figures show the rate by year – results are recorded in one year intervals starting in 2006.

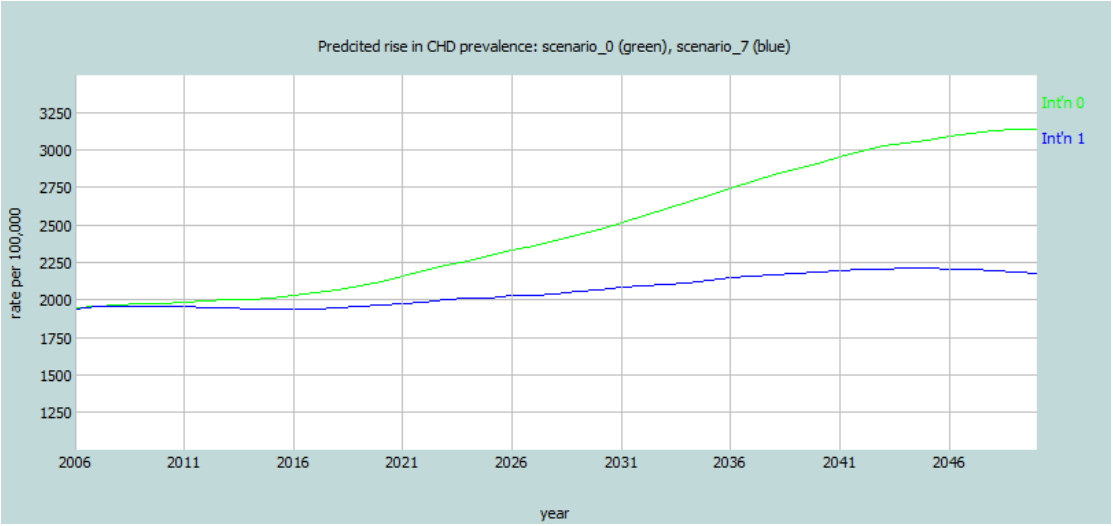


Figure 5: Predicted rise in CHD prevalence

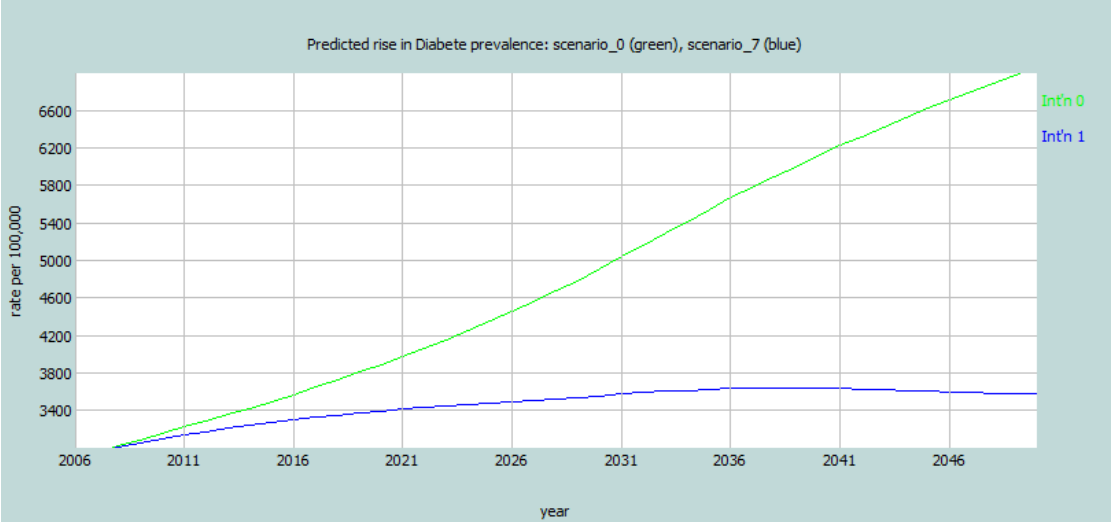


Figure 6: Predicted rise in Diabetes prevalence

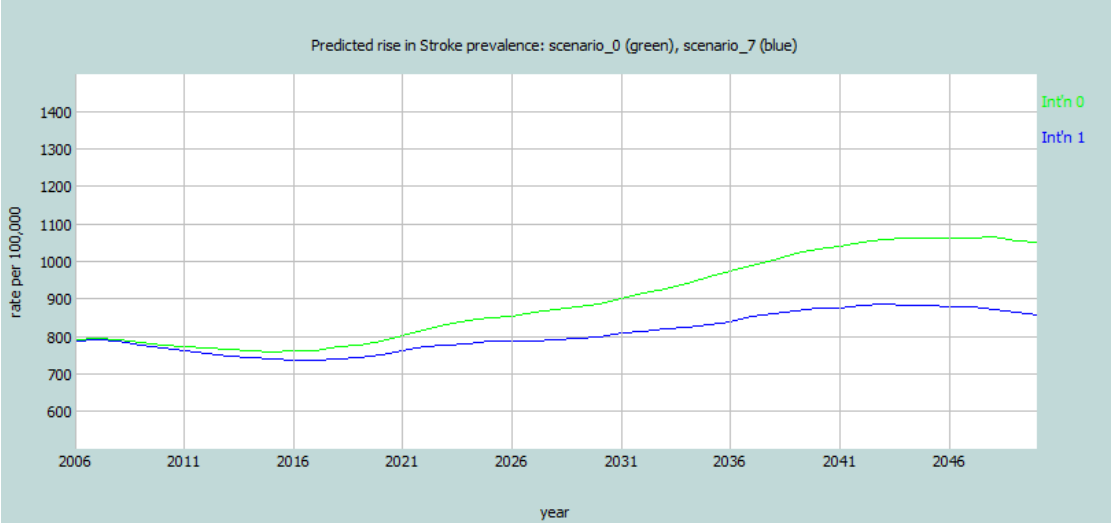


Figure 7: Predicted rise in Stroke prevalence

Figures 5 and 6 show large increases in the prevalence of Coronary Heart Disease and Diabetes. The prevalence of all diseases shows a steady rise, Diabetes is more dramatic than the others.

Figure 5, Figure 6 and Figure 7 draw the absolute predicted disease prevalence for scenario 0 and (for comparison) scenario 7, respectively for CHD, diabetes and stroke. Similar results obtain for all BMI related diseases; their prevalence rates are given for ten year intervals in Table 2

BMI related diseases: predicted rates per 100 000 in ten year intervals						
year	2006	2010	2020	2030	2040	2050
arthritis	603	596	612	649	682	695
breast cancer	792	781	794	827	841	823
coronary heart disease	1944	1974	2123	2471	2909	3139
colorectal cancer	275	293	317	349	370	375
diabetes	2869	3151	3888	4908	6115	7072
endometrial cancer	110	107	116	132	146	156
gall bladder disease	47	44	45	49	54	52
hypertension	5510	5757	6234	6851	7482	7877
kidney cancer	44	49	56	62	68	68
oesophageal cancer	20	27	31	38	43	44
stroke	792	778	789	887	1033	1050
liver cancer	6	7	9	11	13	13

Table 2: predicted disease rates (per 100,000)

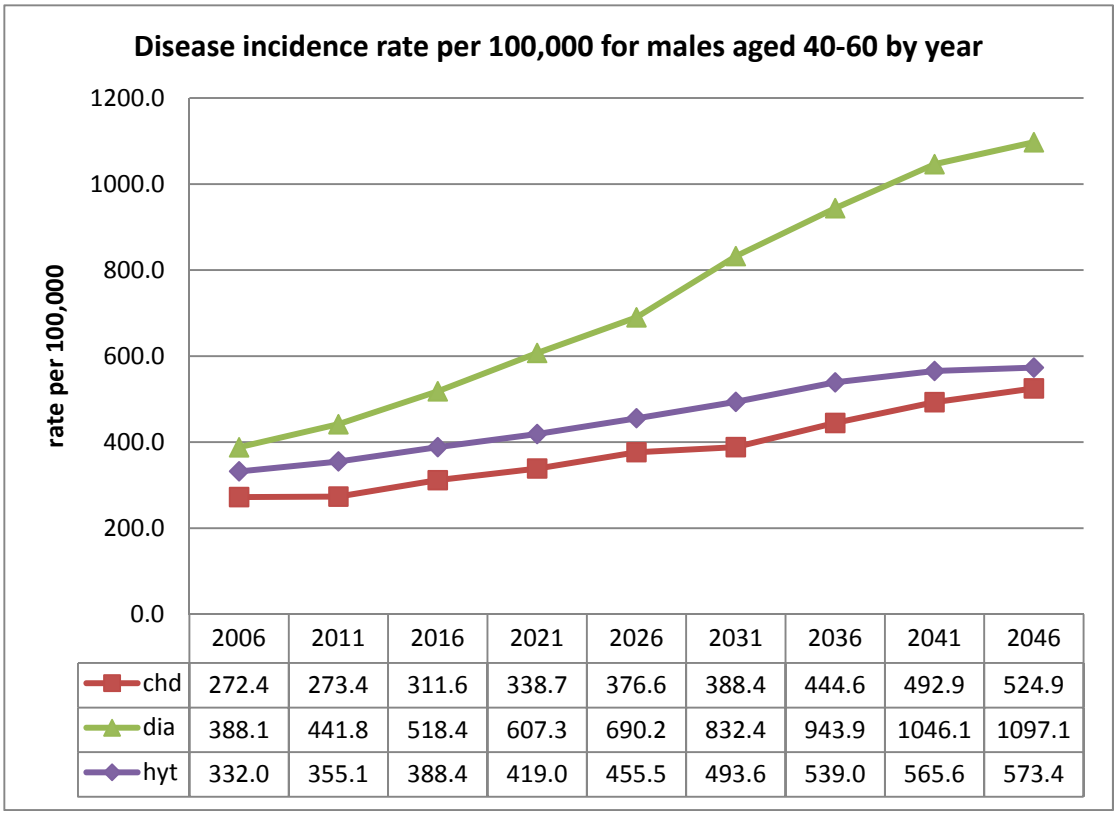
The changing age profile of the population causes some fluctuation in these rates. The percentage increases in rates over their scenario_7 values are listed in Table 3.

predicted percentage increase in disease rates					
year	2010	2020	2030	2040	2050
arthritis	1	3	6	11	16
breast cancer	2	2	3	4	6
coronary heart disease	1	8	20	33	44
colorectal cancer	3	5	8	12	14
diabetes	2	15	38	68	98
endometrial cancer	1	8	17	29	41
gall bladder disease	0	7	11	13	16
hypertension	1	5	13	23	34
kidney cancer	7	10	15	19	21
oesophageal cancer	8	19	36	54	57
stroke	1	5	11	18	23
liver cancer	0	29	38	44	63

Table 3: Predicted percentage increase in disease rates relative to scenario_7

5.2 Disease Incidence

The following Figures show predicted, incidence statistics expressed as rates per 100,000 for the adult male and female populations. All graphs show the rate for the year – results were recorded in 5 year intervals starting in 2006.



	2006	2011	2016	2021	2026	2031	2036	2041	2046
chd	272.4	273.4	311.6	338.7	376.6	388.4	444.6	492.9	524.9
dia	388.1	441.8	518.4	607.3	690.2	832.4	943.9	1046.1	1097.1
hyt	332.0	355.1	388.4	419.0	455.5	493.6	539.0	565.6	573.4

Figure 8: CHD, Diabetes and Hypertension incidence rates for males aged 41-60

Figure 8 shows the growth of the incidence rates of CHD, diabetes and hypertension for males aged 40 to 60; Figure 10 shows the comparable graphs for females. Both graphs were produced using the complete HSE data set {1993-2007} running scenario 0 for which there are no interventions

Figure 9 shows the essentially the same set of male graphs with the addition of the results for scenario 7 – zero BMI growth. The scenario 7 rates remain, as might be expected, roughly equal to their 2006 starting values.

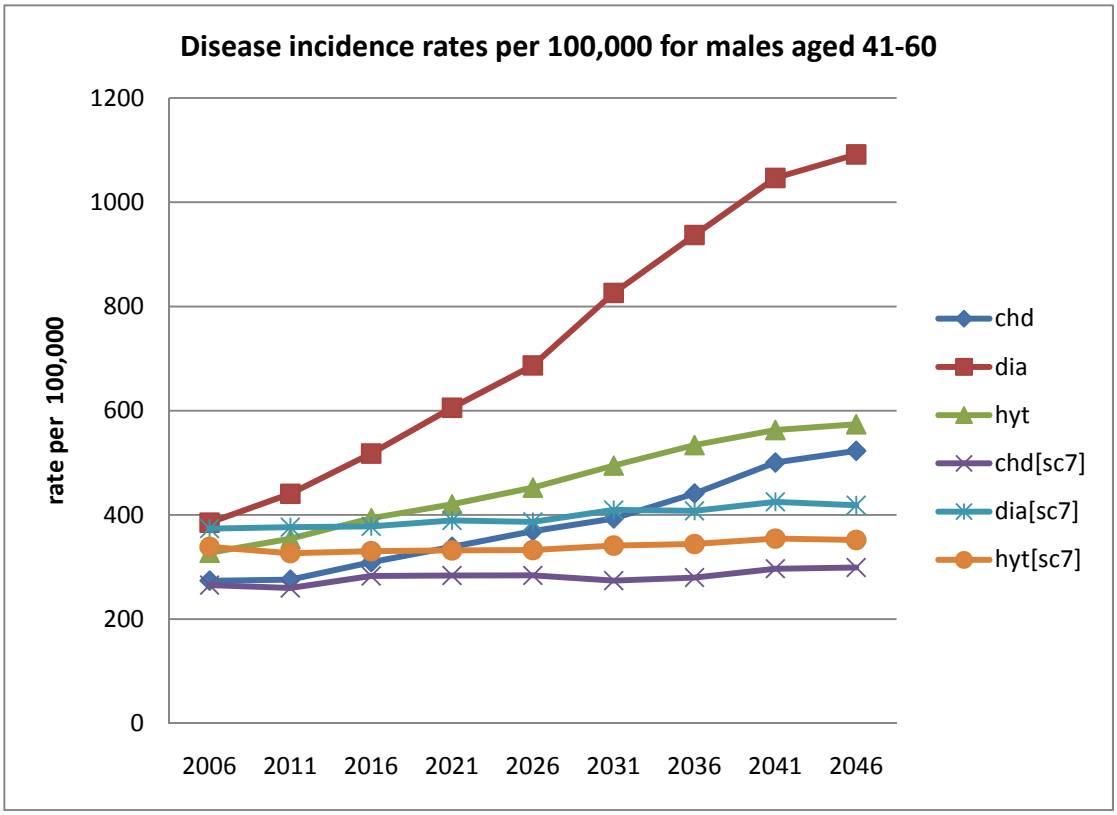
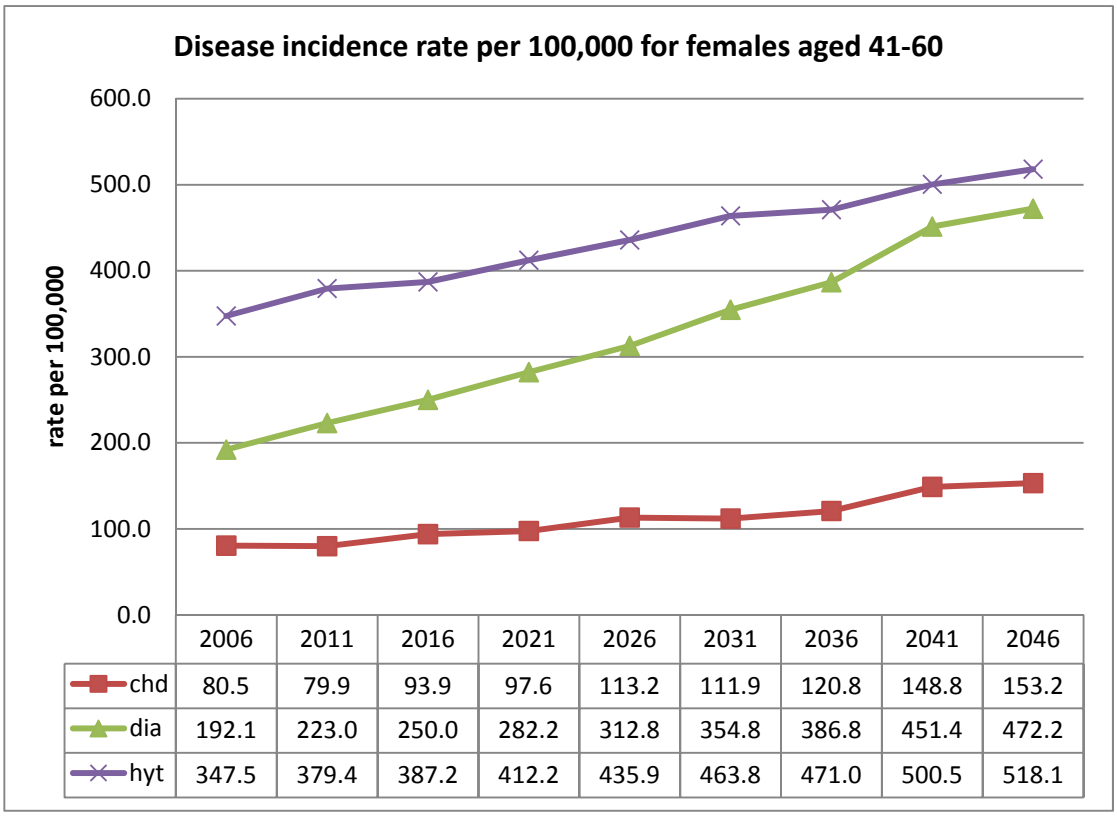
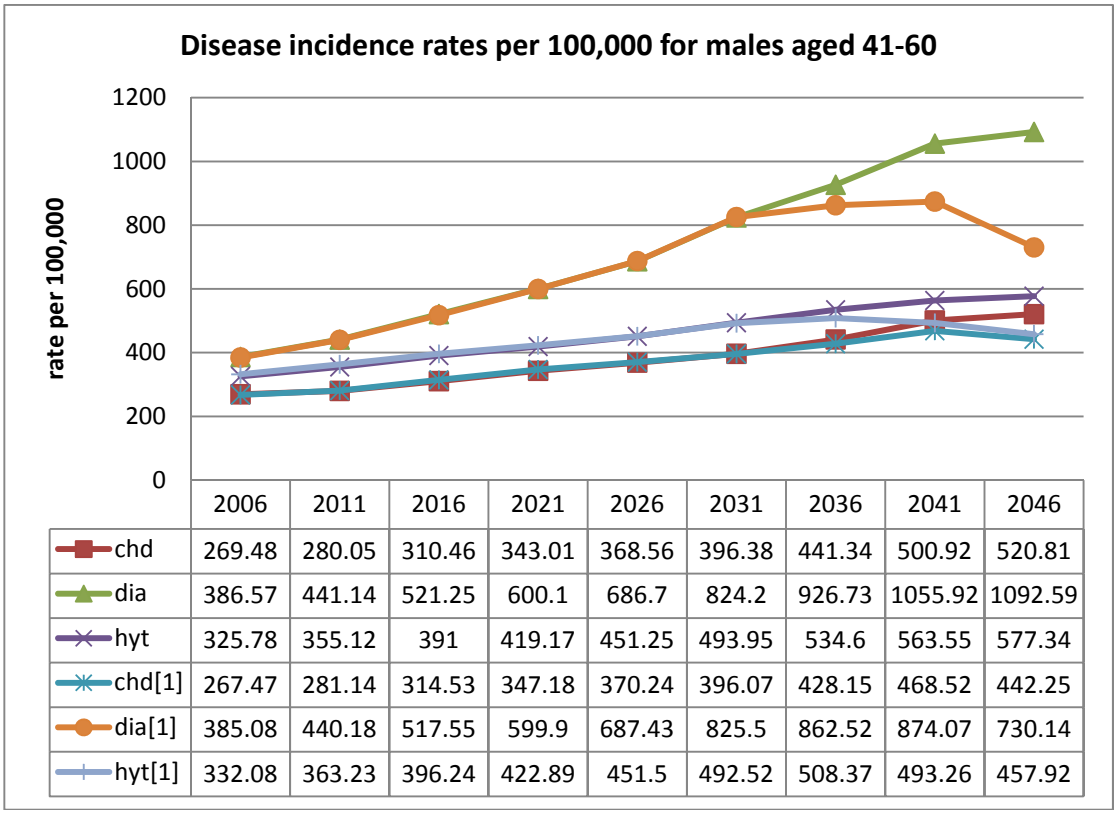


Figure 9: Scenario 0 (as Figure) and scenario 7 comparison



	2006	2011	2016	2021	2026	2031	2036	2041	2046
chd	80.5	79.9	93.9	97.6	113.2	111.9	120.8	148.8	153.2
dia	192.1	223.0	250.0	282.2	312.8	354.8	386.8	451.4	472.2
hyt	347.5	379.4	387.2	412.2	435.9	463.8	471.0	500.5	518.1

Figure 10: CHD, Diabetes and Hypertension incidence rates for females aged 41-60



	2006	2011	2016	2021	2026	2031	2036	2041	2046
chd	269.48	280.05	310.46	343.01	368.56	396.38	441.34	500.92	520.81
dia	386.57	441.14	521.25	600.1	686.7	824.2	926.73	1055.92	1092.59
hyt	325.78	355.12	391	419.17	451.25	493.95	534.6	563.55	577.34
chd[1]	267.47	281.14	314.53	347.18	370.24	396.07	428.15	468.52	442.25
dia[1]	385.08	440.18	517.55	599.9	687.43	825.5	862.52	874.07	730.14
hyt[1]	332.08	363.23	396.24	422.89	451.5	492.52	508.37	493.26	457.92

Figure 11: Male incidence rates for scenario 0 and scenario 1

Figure11 shows the effect of an intervention (labelled1) for which, from 2010, there was no BMI growth for people aged less than 20. There is an obvious lag of 20 years or so before the effects of this unrealizable Intervention are apparent. More realistic interventions directed at reducing child obesity would be expected produce disease incidence curves lying between the upper and lower limits shown here – for example, obesity reduction interventions aimed solely at the under 20s should result in diabetes incidence rates in 2014 lying between 875 and 1056 cases per 100000 of the population; in subsequent years the gap should widen.

Incidence rates for all BMI related diseases are listed in Table (age group 41-60) and Table (age group 51-60).

male				Rates per 100,000										
Age Group	year	male	art	br_C	chd	cr_C	dia	en_C	gbd	hyt	ki_C	oe_C	str	li_C
41-60	2006		9.9	0.0	272.4	46.7	388.1	0.0	13.6	332.0	15.3	13.4	53.2	4.8
41-60	2011		9.9	0.0	273.4	47.3	441.8	0.0	13.0	355.1	18.0	14.6	53.5	6.0
41-60	2016		12.2	0.0	311.6	54.4	518.4	0.0	15.0	388.4	18.4	15.6	58.9	6.7
41-60	2021		10.1	0.0	338.7	56.8	607.3	0.0	15.1	419.0	18.1	19.1	66.3	7.7
41-60	2026		12.6	0.0	376.6	55.3	690.2	0.0	14.8	455.5	20.9	22.5	71.7	8.9
41-60	2031		11.9	0.0	388.4	55.6	832.4	0.0	16.3	493.6	18.4	22.0	72.2	9.1
41-60	2036		14.7	0.0	444.6	62.5	943.9	0.0	16.4	539.0	20.1	26.8	73.7	11.0
41-60	2041		15.8	0.0	492.9	69.3	1046.1	0.0	18.8	565.6	22.7	27.0	84.5	10.4
41-60	2046		16.5	0.0	524.9	72.0	1097.1	0.0	17.6	573.4	23.6	31.9	87.1	11.3
female				Rates per 100,000										
Age Group	year	male	art	br_C	chd	cr_C	dia	en_C	gbd	hyt	ki_C	oe_C	str	li_C
41-60	2006		40.5	216.0	80.5	35.1	192.1	25.2	15.4	347.5	8.7	5.1	30.7	2.1
41-60	2011		40.6	208.7	79.9	32.8	223.0	28.0	15.1	379.4	9.8	5.3	31.0	2.3
41-60	2016		42.9	225.0	93.9	34.8	250.0	32.3	18.3	387.2	8.7	5.4	34.5	2.9
41-60	2021		42.4	227.0	97.6	35.4	282.2	32.0	20.0	412.2	8.4	5.0	34.6	2.9
41-60	2026		46.0	232.0	113.2	38.8	312.8	36.2	20.1	435.9	8.9	5.6	34.9	3.1
41-60	2031		42.6	222.8	111.9	39.1	354.8	33.2	19.6	463.8	8.8	6.8	35.9	2.1
41-60	2036		50.4	235.6	120.8	37.4	386.8	33.1	19.7	471.0	9.1	5.8	37.6	2.4
41-60	2041		52.7	241.6	148.8	42.3	451.4	41.5	22.1	500.5	11.8	6.6	39.2	3.4
41-60	2046		56.2	241.9	153.2	41.1	472.2	44.2	20.5	518.1	11.4	8.5	40.7	2.9

Table 3: Predicted disease incidence statistics for males and females aged 41-60

male				Rates per 100,000									
age group	year	art	br_C	chd	cr_C	dia	en_C	gbd	hyt	ki_C	oe_C	str	li_C
51-60	2006	14.0	0.0	420.9	77.8	459.4	0.0	18.1	381.6	23.8	24.1	83.5	8.8
51-60	2011	14.5	0.0	403.5	76.7	518.6	0.0	19.2	395.6	27.1	25.1	80.8	9.9
51-60	2016	16.5	0.0	436.5	82.4	606.5	0.0	21.8	424.1	27.2	25.2	83.8	9.6
51-60	2021	13.9	0.0	472.4	86.3	681.5	0.0	22.1	453.4	26.5	30.8	94.5	10.8
51-60	2026	16.6	0.0	550.4	88.3	797.2	0.0	22.7	500.8	31.9	35.8	103.4	13.9
51-60	2031	17.3	0.0	567.7	87.0	897.7	0.0	25.9	539.1	28.6	35.5	107.2	13.7
51-60	2036	18.2	0.0	628.1	96.2	1036.4	0.0	24.6	577.8	30.3	44.5	107.5	15.5
51-60	2041	20.8	0.0	698.9	106.0	1140.3	0.0	27.1	623.4	32.0	39.9	122.7	16.2
51-60	2046	23.5	0.0	758.9	113.6	1185.3	0.0	25.9	620.9	33.8	50.9	128.3	16.6
female				Rates per 100,000									
agegroup	year	art	br_C	chd	cr_C	dia	en_C	gbd	hyt	ki_C	oe_C	str	li_C
51-60	2006	42.8	273.8	137.0	55.1	249.4	42.0	24.4	390.0	13.4	8.5	44.6	3.9
51-60	2011	42.6	265.6	127.4	51.1	274.1	43.7	20.1	417.1	15.8	8.9	49.1	3.4
51-60	2016	47.0	278.2	144.7	49.6	293.1	49.1	25.4	406.5	13.7	8.6	48.7	3.9
51-60	2021	45.3	275.5	143.5	47.6	317.2	48.8	28.8	441.4	11.4	6.9	48.5	4.9
51-60	2026	50.1	283.9	177.0	54.5	344.9	53.2	27.2	442.5	13.4	9.0	49.1	4.7
51-60	2031	43.9	273.2	166.8	57.1	373.1	52.9	26.9	463.2	14.3	10.6	49.8	3.7
51-60	2036	48.9	287.0	174.9	51.8	389.1	48.3	25.8	471.8	13.5	8.2	51.0	2.7
51-60	2041	57.5	286.2	212.1	61.2	444.8	57.7	28.6	487.9	17.1	10.2	52.3	4.5
51-60	2046	56.7	296.3	233.9	58.4	457.4	63.8	27.2	503.8	15.3	13.1	56.0	4.1

Table 4: Predicted disease incidence statistics for males and females aged 51-60

6 Conclusions

Unlike the latest trends for child obesity which give some measured cause for optimism the trends for adults are broadly similar to those published in the original Foresight report. The number of normal weight individuals is inexorably falling, those overweight remaining broadly steady and those obese rising. Of equal concern is a significant rise in rates of morbid obesity BMI>40 which have extremely high associated disease risks. These predicted levels of obesity will lead to significant rises in the levels of vascular diseases. Though not calculated here this will create substantial resource implications for both the NHS and the wider society.

These trends demonstrate that Government will have a large challenge just to arrest the growth in obesity. As better evidence becomes available we will be able to incorporate evidence from real rather than hypothetical interventions into the micro simulation. However, at present, that evidence is sketchy particularly with respect to upstream interventions.

7 Appendix

Appendix A

specification	Value at end of last run
time of run	Friday, Dec 11, 2009, 7:41:38
data set	UK_HSE
trials	10000000
start year	2006
stop year	2050
random number seed	-27
stats year	2006
all deaths file	C:\Program Files\obesity project\diseases\alldeaths.tab
male age distribution file	MbyAGE-2008.pf
female age distribution file	FbyAGE-2008.pf
sex distribution file	EWPopbySex.pf
class distribution file	ClassPdf.pf
ethnicity distribution file	PopByEth07.pf
region distribution file	RegionPdf.pf
birth distribution file	BirthByAge.pf
males	26780300

females	27659400
births mean TFR	2
bmi related disease batch	C:\Program Files\obesity project\DiseasesJuly09\DiseaseBatchNov09.bat
bmi *.ab file	ASbmi6_00to07.ab
bmi intervention	scenario_0: 2000 to 2080; No interventions; ASbmi6_00to07.ab
bmi parameters	{UK|RR+, RR|dia+, sd 0.2, ASbmi6_00to07.ab}
smk related disease batch	
smk *.ab file	ASsmk2000_2006.ab
smk intervention	
smk parameters	
this config filename	C:\Program Files\obesity project\RunData\Friday_Dec_11_2009_7_41_38.tab

Table 1: micro simulation configuration file

Appendix B

disease incidence rates per 100000									
arthr									
AgeGp	15-24	25-34	35-44	45-54	55-64	65-74	>75		
male	3	3	3	9	19	13	54		
female	3	12	30	41	48	44	25		
br_C									
AgeGp	15-19	20-24	25-29	30-34	35-39	40-44	45-49		
male	0	0	0	0	0	0	0		
female	0	1	8	27	58	120	185		
AgeGp	50-54	55-59	60-64	65-69	70-74	75-79	80-84	>85	
male	0	0	0	0	0	0	0	0	
female	263	282	334	405	328	349	397	410	
chd									
AgeGp	0-34	35-44	45-54	55-64	65-74	>75			
male	3	61	197	446	799	2158			
female	1	13	41	135	327	1473			
cr_C									
AgeGp	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	
male	0	0	1	2	3	5	12	26	
female	0	0	1	2	2	6	10	23	
AgeGp	50-54	55-59	60-64	65-69	70-74	75-79	80-84	>85	
male	47	89	143	230	323	410	488	473	
female	38	57	89	133	192	255	314	332	
diabetes									
AgeGp	0-15	16-24	25-34	35-44	45-54	55-64	65-74	>75	
male	0	20	50	202	439	543	691	141	
female	0	30	20	111	181	345	533	151	
en_C									
AgeGp	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	
male	0	0	0	0	0	0	0	0	
female	0	0	2	2	6	14	29	54	
AgeGp	60-64	65-69	70-74	75-79	80-84	>85			
male	0	0	0	27	38	50			
female	65	75	78	69	64	55			
gbd									
AgeGp	35-44	45-54	55-64	65-74	>75				
male	5	11	29	93	265				
female	7	11	33	95	517				
hyt									
AgeGp	16-44	45-64	65-74	>75					
male	153	409	487	778					
female	173	439	495	767					

ki_C									
AgeGp	0-4	5-19	10-14	15-19	20-24	25-29	30-34	35-39	40-44
male	0	0	0	0	0	0	0	0	6
female	2	0	0	0	0	0	1	1	2
AgeGp	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	>85
male	10	17	27	38	50	68	83	90	96
female	5	9	13	18	26	35	39	41	41
oe_C									
AgeGp	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
male	0	0	1	3	7	16	27	42	55
female	0	0	0	1	2	5	8	15	20
AgeGp	70-74	75-79	80-84	>85					
male	70	92	109	117					
female	30	44	58	62					
stroke									
AgeGp	0-34	35-44	45-54	55-64	65-74	>75			
male	2	12	35	84	328	2069			
female	1	7	21	48	181	1804			
liver_C									
AgeGp	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44
male	0	0	0	0	0	0	0	1	2
female	1	0	0	0	0	0	0	0	1
AgeGp	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	>85
male	3	7	8	13	19	32	40	46	47
female	1	3	3	6	9	14	18	20	25
unspec									
AgeGp	0-34	35-44	45-54	55-64	65-74	>75			
male	60	126	230	513	1341	11713			
female	35	60	144	333	847	9747			

Table 2: Disease incidence statistics

abbreviation	disease	abbreviation	disease
arthr	Arthritis	ki_c	Kidney cancer
br_C	Breast cancer	oe_C	Oesophageal cancer
cr_C	Colo-rectal cancer	stroke	Stroke
diabetes	Diabetes	liver_c	Liver cancer
en_C	Endometrial cancer	unspec	unspecified
gbd	Gall bladder disease		
hyt	hypertension		

Table 3: Key to disease abbreviations

Appendix C

The relative risk statistics are too numerous to include here and supplied on the Excel file diseaseRelRisk.xls that accompanies this report.

[i] McPherson K., Marsh T., Brown M. (2007), Foresight Tackling Obesity: Future Choices – Modelling Future Trends in Obesity and Their Impact on Health. Government Office for Science

[ii] ibid

[iii] McPherson K., Marsh T., Brown M. (2007), Obesity Trends for Children Aged 2-11: Analysis from the Health Survey for England 1993 - 2007

[iv] McPherson K., Marsh T., Brown M. (2007), Foresight Tackling Obesity: Future Choices – Modelling Future Trends in Obesity and Their Impact on Health. Government Office for Science

[v] Ibid

[vi] Relative Risk estimates for the majority of the diseases were derived from estimates by the International Association for the Study of Obesity as part of the EU-funded project on dynamic modeling for health impact assessment (DYNAMO-HIA, http://www.dynamo-hia.eu/). Relative Risk estimates for the remaining diseases were calculated by the authors from published sources.