National Institute for Health and Care Excellence

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Final

Weight management: preventing, assessing and managing overweight and obesity

[F-B] Inequality analysis of health outcomes of different diets in achieving and maintaining weight loss

NICE Guideline NGXX

Methods, evidence and recommendations

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Final

These evidence reviews were developed by the Guideline Development Team

Disclaimer
Healthcare professionals are expected to take NICE clinical guidelines fully into account when exercising their clinical judgement. However, the guidance does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and/or their guardian or carer.

Contents

1. Introduction

Health inequalities are unfair and avoidable differences in health across the population, and between different groups within society. Although such differences are not new, and have been written about previously (Marmot 20010), Covid-19 has “shone a harsh light” (NHS England) on the need to reduce health inequalities. During the pandemic, people from a black ethnic background had the highest mortality rate, whilst people from a white ethnic background had the lowest (Office for National Statistics 2021). Additionally, those living in the most deprived areas had both a higher diagnosis and death rate than those living in the least deprived areas (Public Health England 2020). These are but two examples from the Covid-19 pandemic highlighting unfair and avoidable differences in health. Thus, reducing health inequalities now features prominently as a national priority, including as a part of the NHS long term plan and as a part of NICE’s 5-year strategy – 2021-26 (NICE 2021). For NICE, this means ensuring that ‘all aspects of our approach – product selections, methods and adoption – are aligned to help reduce health inequalities’.

Economic evaluations have long been an important part of NICE’s work, whether that is in CHTE appraisals that determine if a technology should be routinely commissioned, or in guidelines where models help committees decide if certain recommendations are likely to represent an effective use of NHS resources. However, it has been noted that most economic evaluations focus on the comparative average per person costs and benefits of different treatments (across the population). Missing from such analyses are discussions of equity. Are the treatments likely to increase or reduce socially important inequalities in health?

Methods have been developed to help answer these questions. Now, it is possible to understand the impacts of interventions on health inequalities associated with socioeconomic factors and with inequities in access for disadvantaged groups (NICE 2016). This type of analysis is called ‘distributional cost-effectiveness analysis’ (DCEA) (Griffin et al. 2019).

The Centre for Guidelines is currently trialling a prototype health inequality impact calculation tool.. This decision is consistent both with NICE’s commitment to reducing health inequalities, and NICE’s reputation as a world-leader in supporting evidence-based health and care decision-making.

Developed by the University of York, it calculates potential health inequality impacts due to an intervention by providing a breakdown of the net health effects of an intervention across index of multiple deprivation (IMD) quintiles. The IMD ranks every small area in England from 1 (most deprived) to 32,844 (least deprived). It does so by combining information across 7 domains of deprivation, including income, employment, education, health, crime, barriers to housing and services, and living environment.

The prototype tool (available at **https://shiny.york.ac.uk/nice_equity_tool)** combines input data by IMD quintile to estimate the distribution of health effects for an intervention. Thus, the tool provides useful evidence for committees to consider the potential health inequality impacts that may occur due to the recommendations being made.

This section reports both the input parameters necessary to use the tool, and the results from its use. Given such methods are relatively recent, we also provide an interpretation of the results and how results can be incorporated in the decision making process.

2. Methods

a. Input parameters

To use the health inequalities tool, one must first input the required data on the 'Data inputs' page. There are three tabs on this page: Intervention, CEA inputs and Distributional inputs. The tool is pre-populated with data which can be overwritten if better or more recent estimates are available. The analysis that follows draws on more recent data.

i. Intervention tab

1. Intervention and Comparator information

The intervention name is 'Low-energy total replacement diet', and the comparator name is 'Usual care'. The intervention indication is adults who are overweight (BMI 25-29.9 kg/m^2) or living with obesity (BMI ≥ 30 kg/m^2).

2. Population information

The population type is based on a risk factor population. The risk factor for this analysis is obesity. On selecting obesity as the risk factor of interest, the tool pre-populates an eligible population in England of 13,929,767 people. This number is derived from Hospital Episode Statistics (HES) data from 2012-2013. However, we also calculate our own estimate of this figure by applying the proportion of people who are living with overweight and obesity based on Health Survey for England data to the total population in England (NHS Digital 2023).

To estimate the distribution of eligible population, we need to know both the total population of England and the proportion of English people living with overweight or obesity by IMD quintiles.

Population data for England by IMD in 2019 from the Office for National Statistics is detailed in Table 1.

Table 1: England population data by IMD quintile – 2019

IMD Group	Population
Quintile 1	11,267,059
Quintile 2	11,576,973
Quintile 3	11,424,153
Quintile 4	11,117,694
Quintile 5	10,901,082

The proportions of English people living with obesity by IMD in 2019-2020 are from the Office for Health Improvement & Disparities Fingertips Public Health Data and are detailed in Table 2. Although more recent data in 2020-2021 are also available, we used data in previous years to keep it consistent with the rest of the analysis as most data inputs are from 2019 data sources. While 2020-2021 data show slightly higher proportions of obesity compared with 2019-2020, the distributions across IMD groups appear similar: the percentage of people living with obesity is highest in the most deprived groups, and lowest in the least deprived groups. As our focus here is the distribution of health gains across IMD groups, the direction or magnitude of the results would remain similar no matter which year of data we use.

Table 2: Proportion of English people living with obesity – 2019-2020

IMD Group	People living with obesity % (95% CI)
Decile 1	24.4% (24.2-24.6)
Decile 2	33.8% (32.9-34.5)
Decile 3	29.6% (28.9-30.4)
Decile 4	25.8% (25.1-26.5)
Decile 5	26% (25.2-26.7)
Decile 6	23.3% (22.7-24)
Decile 7	23.1% (22.3-23.8)
Decile 8	22.7% (22.1-23.3)
Decile 9	22% (21.3-22.7)
Decile 10	20.3% (19.7-20.9)

As the IMD groups for the population of England are by quintile (Table 1) and the proportions of English people living with obesity are by deciles (Table 2), we need to transform either dataset to be consistent with the other to allow us to calculate the number of English people living with obesity by IMD groups. There are two approaches: the first method is to split the quintile data in Table 1 into deciles. As the England population data by decile are available in 2020, we use their proportions of deciles in a given quintile to split the 2019 quintile data, following the assumption that the proportions of deciles in a given quintile are the same across these two years. The second method is to average the two proportions by decile in Table 2 to obtain a quintile value, following the assumption that the population size is the same across deciles in a given quintile. However, based on the England population data by decile in 2020, it is clear that the IMD groups are not of equal sizes, so this assumption is unlikely to be satisfied. We therefore follow the first approach as its assumptions were considered more reasonable.

To convert 2019 quintile data in Table 1 into decile data, we take three simple steps:

1) Using England population data by IMD decile in 2020, we estimate the proportion of each decile in a given quintile as shown in Table 3 (or to put it another way, what percent of quintile 1 [which corresponds to the sum of deciles 1 and 2] is decile 1 and whatused I percent of it is decile 2?).

2) We then multiply these proportions with the corresponding quintile data in 2019 to obtain estimates of the number of people in each decile, as detailed in Table 4.

3) Finally, we multiply the proportions of people living with obesity from Table 2 with the number of people by IMD decile from Table 4, as detailed in Table 5.

Table 3: England population data by IMD decile – 2020

IMD Group	Population	Proportion calculation	Proportion of the listed decile to its corresponding quintile
Decile 1	5,603,911[a]	$\frac{a}{a+b}$	49.59%
Decile 2	5,697,232[b]	$\frac{b}{a+b}$	50.41%
Decile 3	5,832,954[c]	$\frac{c}{c+d}$	50.16%
Decile 4	5,796,889[d]	$\frac{d}{c+d}$	49.84%

IMD Group	Population	Proportion calculation	Proportion of the listed decile to its corresponding quintile
Decile 5	5,720,152[e]	$\frac{e}{e+f}$	49.81%
Decile 6	5,764,872[f]	$\frac{f}{e+f}$	50.19%
Decile 7	5,591,424[g]	$\frac{g}{g+h}$	50.02%
Decile 8	5,586,550[h]	$\frac{h}{g+h}$	49.98%
Decile 9	5,512,645[i]	$\frac{i}{i+j}$	50.32%
Decile 10	5,443,509[j]	$\frac{j}{i+j}$	49.68%

Table 4: Estimates of the English population by decile – 2019

IMD Quintile	Population	Corresponding IMD Decile	Proportion of the listed decile to its corresponding quintile	Calculation	Estimate of the 2019 population by IMD decile
Quintile 1	11,267,059[a]	Decile 1	49.59%[f]	$a \times f$	5,587,010
		Decile 2	50.41%[g]	$a \times g$	5,680,049
Quintile 2	11,576,973[b]	Decile 3	50.16%[h]	$b \times h$	5,806,437
		Decile 4	49.84%[i]	$b \times i$	5,770,536
Quintile 3	11,424,153[c]	Decile 5	49.81%[j]	$c \times j$	5,689835
		Decile 6	50.19%[k]	$c \times k$	5,734,318
Quintile 4	11,117,694[d]	Decile 7	50.02%[l]	$d \times l$	5,561,271
		Decile 8	49.98%[m]	$d \times m$	5,556,423
Quintile 5	10,901,082[e]	Decile 9	50.32%[n]	$e \times n$	5,484,935
		Decile 10	49.68%[o]	$e \times o$	5,416,147

Table 5: Estimates of the 2019 English population living with obesity by IMD decile

IMD Decile	Estimate of the 2019 population by IMD decile	Percentage of people living with obesity (95% CI)	Calculation	Estimate of the population living with obesity by IMD decile
Decile 1	5,587,010[a]	24.4%[k]	$a \times k$	1,888,409
Decile 2	5,680,049[b]	33.8%[l]	$b \times l$	1,681,295
Decile 3	5,806,437[c]	29.6%[m]	$c \times m$	1,498,061
Decile 4	5,770,536[d]	25.8%[n]	$d \times n$	1,500,339
Decile 5	5,689,835[e]	26%[o]	$e \times o$	1,325,732
Decile 6	5,734,318[f]	23.3%[p]	$f \times p$	1,324,627
Decile 7	5,561,271[g]	23.1%[q]	$g \times q$	1,262,408
Decile 8	5,556,423[h]	22.7%[r]	$h \times r$	1,222,413
Decile 9	5,484,935[i]	22%[s]	$i \times s$	1,113,442

IMD Decile	Estimate of the 2019 population by IMD decile	Percentage of people living with obesity (95% CI)	Calculation	Estimate of the population living with obesity by IMD decile
Decile 10	5,416,147[j]	20.3%[t]	$j \times t$	958,658

Finally, given the inequalities tool primarily deals with quintile data, we can add the decile data obtained in Table 5 to calculate both estimates of the 2019 English population living with obesity by IMD quintile and the total eligible population for this intervention (the sum of all people living with obesity across all IMD groups). These calculations are detailed in Table 6.

Table 6: Estimates of the 2019 English population living with obesity by IMD quintile

IMD Decile	Estimate of the population living with obesity by IMD decile	Corresponding IMD Quintile	Calculation	Estimate of the population living with obesity by IMD quintile
Decile 1	1,888,409[a]	Quintile 1	$a + b$	3,569,704
Decile 2	1,681,295[b]			
Decile 3	1,498,061[c]	Quintile 2	$c + d$	2,998,400
Decile 4	1,500,339[d]			
Decile 5	1,325,732[e]	Quintile 3	$e + f$	2,650,359
Decile 6	1,324,627[f]			
Decile 7	1,262,408[g]	Quintile 4	$g + h$	2,484,821
Decile 8	1,222,413[h]			
Decile 9	1,113,442[i]	Quintile 5	$i + j$	2,072,100
Decile 10	958,658[j]			
Total number of English people living with obesity				
-	-	-	-	13,775,384

Our estimate for the eligible population, that is the total number of English people living with obesity, is 13,775,384 (Table 6). This figure is slightly different from 13,929,767 people, the estimate of the eligible population provided when obesity is selected as the risk factor. In our analysis we used our calculated figure of 13,775,384 for our eligible population input.

ii. CEA inputs tab

1. Decision threshold

The decision threshold used by NICE for guidelines generally considers an intervention to becost effective if it is less than £20,000 per QALY.

2. Cost-effectiveness analysis results

The results for a mixed population (that is not limited to only people with diabetes) living with obesity (BMI > 30) from the cost-effectiveness analysis are reproduced in Table 7 below. Full results can be viewed in the Economic Model Report for the cost effectiveness of diets in achieving and maintaining weight loss.

Table 7: Cost-effectiveness analysis results

Inc. costs per recipient	Inc. QALYs per recipient
£718.74	0.043512

Abbreviations: Inc = Incremental

iii. Distributional inputs tab

1. Eligible population

Based on the estimates of the population living with obesity by IMD quintile in Table 6, we convert these figures into proportions of the eligible population, detailed in Table 8. This conversion is necessary since the inequality tool requires the numbers to be entered as a proportion (a value between 0 and 1).

Table 8: Proportions of the 2019 English population living with obesity by IMD quintile

IMD Group	Estimate of the population living with obesity by IMD quintile	Calculation	Share of the total eligible population
Quintile 1	3,569,704[a]	$\frac{a}{f}$	0.259
Quintile 2	2,998,400[b]	$\frac{b}{f}$	0.218
Quintile 3	2,650,359[c]	$\frac{c}{f}$	0.192
Quintile 4	2,484,821[d]	$\frac{d}{f}$	0.180
Quintile 5	2,072,100[e]	$\frac{e}{f}$	0.151
Total number of English people living with obesity			
-	13,775,384[f]	-	-

2. Uptake

In the absence of uptake data for diet interventions, we use the number of adults who received tier 2 weight management services from quarter 1 to quarter 3 in 2021/22 as a proxy. This dataset is suboptimal for our purposes, because 1) it is not from our chosen analysis year 2019; 2) the tier 2 weight management services are much broader than the diet interventions we focus on; 3) these are provisional data and subject to change at a later point. However, this is the best quality and most relevant data we could obtain at the time this analysis was performed.

To calculate the uptake rate by quintile, we take three steps:

1. We convert the data from deciles into quintiles, as shown in Table 9.
2. We estimate the number of people using services for 4 quarters to be consistent with the rest of our input data as they are all reported for the full year. There are two ways to approach this. First, we can simply divide the year-to-date values for each quintile by 3, and then multiply that value by 4. This assumes figures are equal across each quarter. Alternatively, as figures for each quarter are reported, we could model anticipated figures for quarter 4 using the trends in the first 3 quarters. This assumes that the observed trends will continue into the fourth quarter. In looking more closely at the quarterly data, it is clear that referrals and enrolment increases across all IMD groups. That is to say more people are both referred and enrolled in quarter 2 than quarter 1, and more are enrolled

in quarter 3 than quarter 2. The trend for completion is slightly more complicated, though it remains consistent across all IMD groups, with the completion increasing in quarter 2 compared to quarter 1, and decreasing in quarter 3 compared to quarter 2. Both approaches require strong assumptions, however neither approach is likely to change the underlying distribution. Therefore, we used the simpler first assumption, as shown in Table 10.

3. We then use our estimates for the number of people enrolled from Table 10 to calculate referrals, enrolment and completions as a share of the total eligible population, shown in Table 11. The enrolment proportions are then input into the inequalities tool as the uptake rates.

Table 9: 2021-2022 Tier 2 weight management service data for quarter 1 to quarter 3

IMD Decile	Number of people	Corresponding IMD Quintile	Calculation	Number of people
Year to date referred				
Decile 1	3,890	Quintile 1	$Decile\ 1 + Decile\ 2$	7,215
Decile 2	3,325			
Decile 3	2,890	Quintile 2	$Decile\ 3 + Decile\ 4$	5,870
Decile 4	2,980			
Decile 5	2,465	Quintile 3	$Decile\ 5 + Decile\ 6$	4,560
Decile 6	2,095			
Decile 7	2,170	Quintile 4	$Decile\ 7 + Decile\ 8$	4,190
Decile 8	2,020			
Decile 9	1,750	Quintile 5	$Decile\ 9 + Decile\ 10$	3,035
Decile 10	1,285			
Year to date enrolled				
Decile 1	2,150	Quintile 1	$Decile\ 1 + Decile\ 2$	4,140
Decile 2	1,990			
Decile 3	1,725	Quintile 2	$Decile\ 3 + Decile\ 4$	3,460
Decile 4	1,735			
Decile 5	1,435	Quintile 3	$Decile\ 5 + Decile\ 6$	2,640
Decile 6	1,205			
Decile 7	1,355	Quintile 4	$Decile\ 7 + Decile\ 8$	2,595
Decile 8	1,240			
Decile 9	1,035	Quintile 5	$Decile\ 9 + Decile\ 10$	1,825
Decile 10	790			
Year to date completed				
Decile 1	265	Quintile 1	$Decile\ 1 + Decile\ 2$	545
Decile 2	280			
Decile 3	280	Quintile 2	$Decile\ 3 + Decile\ 4$	575
Decile 4	295			
Decile 5	280	Quintile 3	$Decile\ 5 + Decile\ 6$	525
Decile 6	245			
Decile 7	320	Quintile 4	$Decile\ 7 + Decile\ 8$	555
Decile 8	235			
Decile 9	200	Quintile 5	$Decile\ 9 + Decile\ 10$	370
Decile 10	170			

Table 10: 2021-2022 tier 2 weight management service data estimates for 4 quarters

IMD Group	Number of people	Calculation	Number of people
Referred			
Quintile 1	7,215	$\frac{Quintile\ 1}{3} \times 4$	9,620
Quintile 2	5,870	$\frac{Quintile\ 2}{3} \times 4$	7,827
Quintile 3	4,560	$\frac{Quintile\ 3}{3} \times 4$	6,080
Quintile 4	4,190	$\frac{Quintile\ 4}{3} \times 4$	5,587
Quintile 5	3,035	$\frac{Quintile\ 5}{3} \times 4$	4,047
Enrolled			
Quintile 1	4,140	$\frac{Quintile\ 1}{3} \times 4$	5,520
Quintile 2	3,460	$\frac{Quintile\ 2}{3} \times 4$	4,613
Quintile 3	2,640	$\frac{Quintile\ 3}{3} \times 4$	3,520
Quintile 4	2,595	$\frac{Quintile\ 4}{3} \times 4$	3,460
Quintile 5	1,825	$\frac{Quintile\ 5}{3} \times 4$	2,433
Completed			
Quintile 1	545	$\frac{Quintile\ 1}{3} \times 4$	727
Quintile 2	575	$\frac{Quintile\ 2}{3} \times 4$	767
Quintile 3	525	$\frac{Quintile\ 3}{3} \times 4$	700
Quintile 4	555	$\frac{Quintile\ 4}{3} \times 4$	740
Quintile 5	370	$\frac{Quintile\ 5}{3} \times 4$	493

Table 11: Uptake of tier 2 weight management services from the eligible population

IMD Group	Number of people	Estimate of the population living with obesity by IMD quintile	Calculation	Share of the total eligible population
Referred				
Quintile 1	9620[a]	3,569,704[p]	$\frac{a}{p}$	0.00269
Quintile 2	7827[b]	2,998,400[q]	$\frac{b}{q}$	0.00261
Quintile 3	6080[c]	2,650,359[r]	$\frac{c}{r}$	0.00229
Quintile 4	5587[d]	2,484,821[s]	$\frac{d}{s}$	0.00225

IMD Group	Number of people	Estimate of the population living with obesity by IMD quintile	Calculation	Share of the total eligible population
Quintile 5	4047[e]	2,072,100[t]	$\frac{e}{t}$	0.00195
Enrolled				
Quintile 1	5520[f]	3,569,704[p]	$\frac{f}{p}$	0.00155
Quintile 2	4613[g]	2,998,400[q]	$\frac{g}{q}$	0.00154
Quintile 3	3520[h]	2,650,359[r]	$\frac{h}{r}$	0.00133
Quintile 4	3460[i]	2,484,821[s]	$\frac{i}{s}$	0.00139
Quintile 5	2433[j]	2,072,100[t]	$\frac{j}{t}$	0.00117
Completed				
Quintile 1	727[k]	3,569,704[p]	$\frac{k}{p}$	0.000204
Quintile 2	767[l]	2,998,400[q]	$\frac{l}{q}$	0.000256
Quintile 3	700[m]	2,650,359[r]	$\frac{m}{r}$	0.000264
Quintile 4	740[n]	2,484,821[s]	$\frac{n}{s}$	0.000298
Quintile 5	493[o]	2,072,100[t]	$\frac{o}{t}$	0.000238

3. Health effects

For input parameters on health effects, we first calculate three types of conditional probabilities (Table 12):

1. enrolled given referred: the likelihood of someone being enrolled in the programme given that they are referred;
2. completed given referred: the likelihood someone completed the programme given than they are referred; and
3. completed given enrolled: the likelihood someone completed the programme given than they are enrolled.

We use the completed given enrolled probability in the analysis as we are mostly interested in the completion rate among people who were enrolled in the programme, rather than those who were just referred. We preferred this data as this is the population who stand to benefit from the intervention because they completed it. We then divide the proportion of completed given enrolled for each quintile by the weighted average to calculate utility multipliers to be put in the inequality tool, as shown below in Table 13: Health effect multiplier estimates and derivation

IMD Group	Proportion	Calculation	Multipliers for inequalities tool
Completed given enrolled			
Quintile 1	0.132[a]	$\frac{a}{f}$	0.75

IMD Group	Proportion	Calculation	Multipliers for inequalities tool
Quintile 2	0.166[b]	$\frac{b}{f}$	0.95
Quintile 3	0.199[c]	$\frac{c}{f}$	1.13
Quintile 4	0.214[d]	$\frac{d}{f}$	1.22
Quintile 5	0.203[e]	$\frac{e}{f}$	1.16
Weighted average proportion for completed given enrolled			
–	0.175[f]	–	–

4. Health opportunity costs

In the basecase a flat gradient was used for the health opportunity cost. This means the health opportunity costs are distributed equally across deprivation groups. Health opportunity costs represent the health benefits that could have been achieved had the money been spent on another intervention (usually the next best alternative). A recent update of the methodology for estimating these indicates that equality is a reasonable basecase assumption rather the previous assumption that opportunity costs are disproportionately borne by more deprived populations (Cookson and Koh, 2023).

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Entering utility multipliers under health effects is optional and not required to use the tool. The default setting of the tool applies a value of 1 to each IMD. On the assumption that an intervention can only be effective if it is completed we apply different values to each IMD group based on the proportion who complete within each group. It might be that some participants may still benefit from a diet intervention even if they have not managed to complete the full programme. However, given the data available, this assumption appears plausible. Also, the guideline committee agreed it was a reasonable to assume that the intervention can only be effective if it is completed.

Table 12: Conditional probability using tier 2 weight management service data

IMD Group	Number of people who completed the intervention	Number of people who enrolled in the intervention	Proportion who completed the intervention given they enrolled
Quintile 1	727	5520	0.132
Quintile 2	767	4613	0.166
Quintile 3	700	3520	0.199
Quintile 4	740	3460	0.214
Quintile 5	493	2433	0.203
Weighted average	3,427	19,546	0.175

Table 13: Health effect multiplier estimates and derivation

IMD Group	Proportion	Calculation	Multipliers for inequalities tool
Completed given enrolled			

IMD Group	Proportion	Calculation	Multipliers for inequalities tool
Quintile 1	0.132[a]	$\frac{a}{f}$	0.75
Quintile 2	0.166[b]	$\frac{b}{f}$	0.95
Quintile 3	0.199[c]	$\frac{c}{f}$	1.13
Quintile 4	0.214[d]	$\frac{d}{f}$	1.22
Quintile 5	0.203[e]	$\frac{e}{f}$	1.16
Weighted average proportion for completed given enrolled			
–	0.175[f]	–	–

5. Health opportunity costs

In the basecase a flat gradient was used for the health opportunity cost. This means the health opportunity costs are distributed equally across deprivation groups. Health opportunity costs represent the health benefits that could have been achieved had the money been spent on another intervention (usually the next best alternative). A recent update of the methodology for estimating these indicates that equality is a reasonable basecase assumption rather the previous assumption that opportunity costs are disproportionately borne by more deprived populations (Cookson and Koh, 2023).

3. Results

The results of the health inequalities analysis are located on the 'Equity impact analysis' page. There are four tabs on this page: Input summary, Uptake distribution, Net health benefit distribution and Equity impact summary measures. We present results for the first three tabs.

a. Input summary

The input summary tab provides a table that is a summary of the input parameters, detailed below in Table 14.

Table 14: Summary of socioeconomically varied parameters

Input	IMD 1 (Most deprived)	IMD 2	IMD 3	IMD 4	IMD 5 (Least deprived)
Share of the eligible population	0.259	0.218	0.192	0.180	0.151
Uptake rate (base case scenario)	0.002	0.002	0.001	0.001	0.001
Average incremental QALYs per person	0.033	0.042	0.05	0.054	0.051
Share of health opportunity costs	0.2	0.2	0.2	0.2	0.2

The share of the eligible population are the same proportions from Table 8, and represent the proportion of people living with obesity for each IMD group (i.e. for the most deprived quintile (IMD 1), 25.9% live with obesity). The uptake rate corresponds to the proportion of people enrolled in Tier 2 weight management services from Table 11. Finally, the average incremental QALYs per person is calculated by the health effect multipliers in Table 13: Health effect multiplier estimates and derivation

IMD Group	Proportion	Calculation	Multipliers for inequalities tool
Completed given enrolled			
Quintile 1	0.132[a]	$\frac{a}{f}$	0.75
Quintile 2	0.166[b]	$\frac{b}{f}$	0.95
Quintile 3	0.199[c]	$\frac{c}{f}$	1.13
Quintile 4	0.214[d]	$\frac{d}{f}$	1.22
Quintile 5	0.203[e]	$\frac{e}{f}$	1.16
Weighted average proportion for completed given enrolled			
–	0.175[f]	–	–

1. Health opportunity costs

In the basecase a flat gradient was used for the health opportunity cost. This means the health opportunity costs are distributed equally across deprivation groups. Health opportunity costs represent the health benefits that could have been achieved had the money been spent on another intervention (usually the next best alternative). A recent update of the methodology for estimating these indicates that equality is a reasonable basecase assumption rather the previous assumption that opportunity costs are disproportionately borne by more deprived populations (Cookson and Koh, 2023).

multiplied by 0.044, which is the incremental QALYs per recipient from Table 7. The average incremental QALYs gained per person from more deprived groups (IMD groups 1 and 2) are lower than the average, 0.044, as the health effect multipliers are less than 1. This contrasts with the gains for IMD groups 3-5 which are higher than the average. This indicates that people from less deprived groups benefit more from the interventions than those in the most deprived groups.

b. Uptake distribution

Figure 1 and Table 15 show the uptake distribution by reporting the number of recipients of the intervention, which is obtained by multiplying the eligible population by the uptake rate of the intervention.

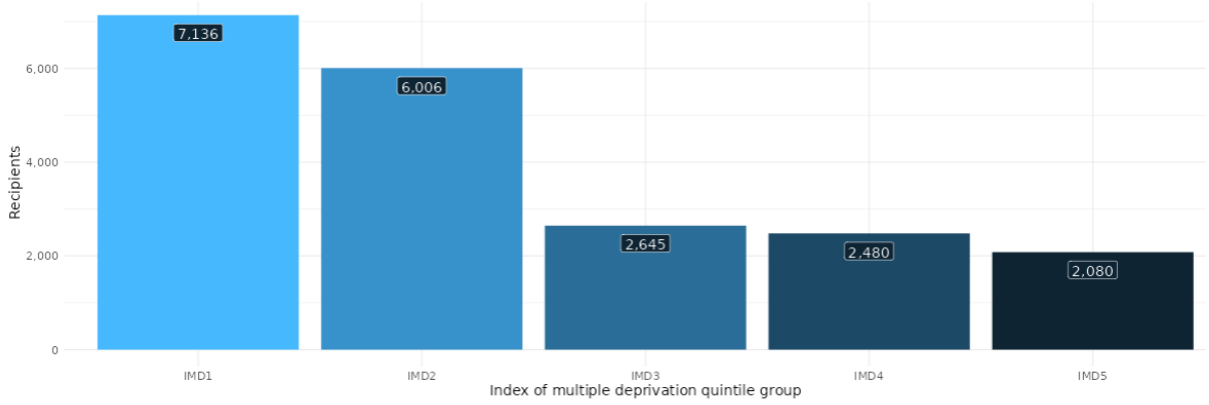

Figure 1: Socioeconomic distribution of intervention recipients

Table 15: Uptake distribution results

Input	IMD 1 (Most deprived)	IMD 2	IMD 3	IMD 4	IMD 5 (Least deprived)	Total
Proportion of recipients	0.351	0.295	0.13	0.122	0.102	1
Number of recipients	7,136	6,006	2,645	2,480	2,080	20,347

As shown in both

Figure 1 and Table 15, both the proportion and number of recipients of the intervention are largest in the most deprived groups and smallest in the least deprived groups (left skewed). These results occur because for both the prevalence of obesity, as well as the uptake of the intervention, the exact same distributions are observed; specifically, figures are largest in the most deprived groups and smallest in the least deprived groups. Thus, in multiplying the number of people living with obesity, by the uptake of the intervention, the only possible result is the one we observe – where most recipients of the intervention are in the most deprived groups, with the fewest in the least deprived groups.

c. Net health benefit distribution

The net health benefit distribution tab produces Figure 2 as well as Table 16. The first part of Figure 2 shows the distribution of intervention health effects which is positive for all groups and highest in the most deprived groups (IMD 1 and IMD2). This is a function of the higher prevalence and uptake of the intervention among these more deprived groups (IMD 1&2) even though the completion rates (proxy for differential effectiveness) are higher for the least deprived groups IMD 3-5. The latter is reflected in Table 14 which shows that the average per person incremental QALY gains are smallest in the most deprived group (IMD) and highest in the least deprived groups (IMD4 and 5).

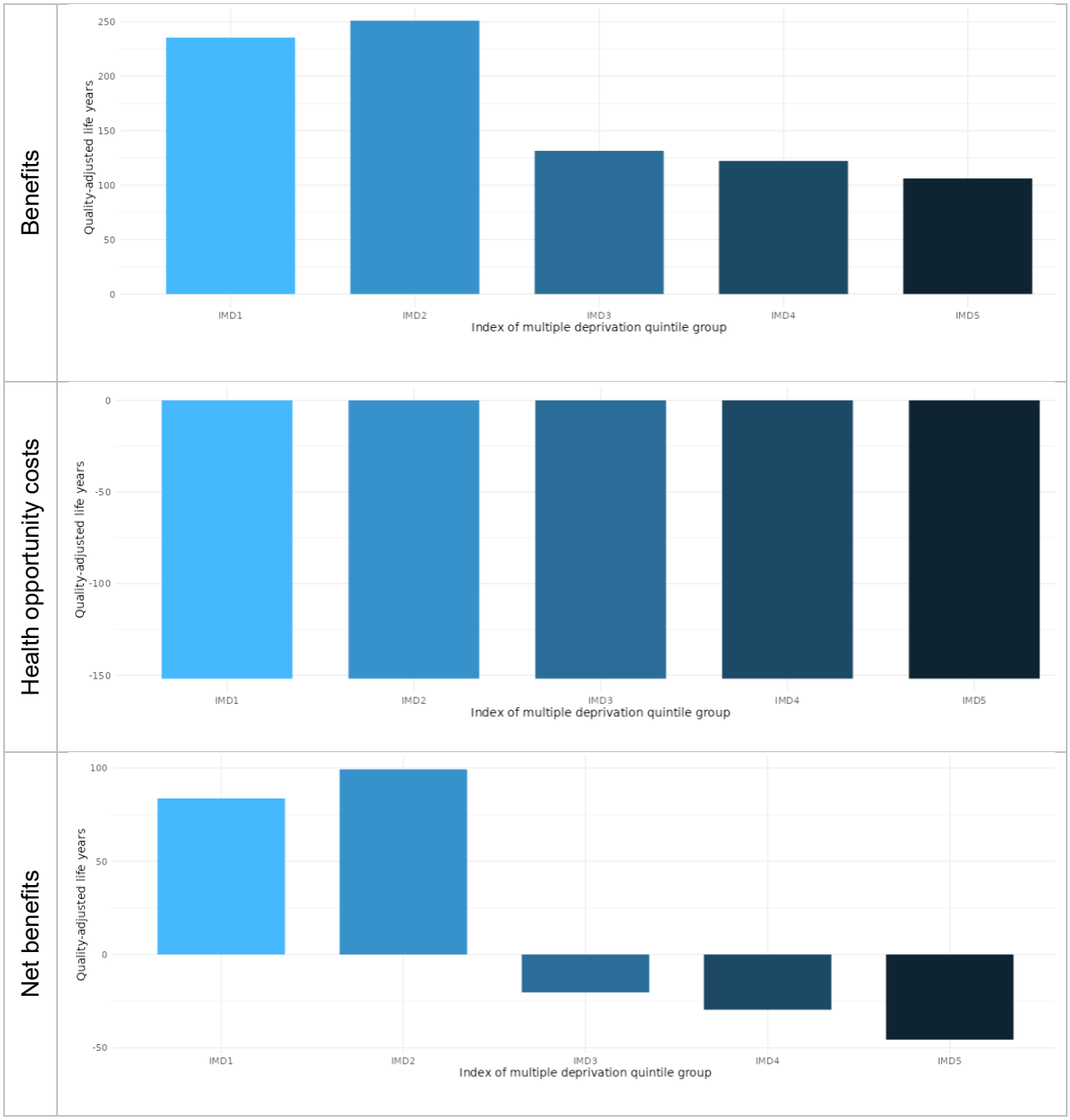

Figure 2: Distribution of intervention health effects (population totals)

Table 16: Net health benefit results

Input	IMD 1 (Most deprived)	IMD 2	IMD 3	IMD 4	IMD 5 (Least deprived)
Health benefit	235	251	132	122	106
Health opportunity cost	152	152	152	152	152
Net benefit	84	99	-20	-30	-46

The net health benefits, which take into account opportunity costs, show the benefits for the most deprived groups (IMD 1 and 2) remain positive whereas for IMD groups 3-5 they become negative. This indicates that for IMD groups 3-5 the health benefits of the 'new' intervention are not sufficient to outweigh the health losses that arise from the intervention(s) that are displaced in order to fund the new intervention.

d. Discussion

i. Principal findings

The results of the health inequalities analysis show that at the population level the intervention yields the greatest health benefit (total QALYs) in the most deprived groups (IMD 1 and 2). In so doing, it has the potential to contribute to a reduction in health inequalities in people living with obesity or overweight.

However, the results also suggest that due to the higher completion rates among the least deprived groups, the average QALY gain (health benefit) at an individual level is highest in the least deprived group (IMD 5). By contrast, the average per person QALY gain in the most deprived group is the lowest. This suggests that additional health benefits could be achieved in the groups most at risk of suffering from the diseases caused by living with obesity or overweight if the reasons for the low completion rates could be identified and addressed.

Additionally, the analyses show how prevalence, uptake and completion of an intervention all work together to impact the distribution of health benefits of an intervention. Despite completion favouring the least deprived groups, this was somewhat offset by the prevalence of people living with obesity and the uptake of the intervention being greater in the more deprived groups. This in itself is a useful finding as it helps to identify the key drivers in this analysis.

It is well known that obesity and overweight are influenced by a variety factors including genetic, biological and social factors. The latter includes health inequalities which in this analysis were captured using the index of multiple deprivation which covers 7 domains(e.g. income, education, housing). Tackling the wider determinants of obesity and overweight go beyond the assessment of the distributional impact of the dietary intervention considered in this analysis.

ii. Strengths

This is the first inequality impact analysis of this decision problem. Its development was informed by a multidisciplinary committee of clinical and patient experts who advised on assumptions and potential data sources, and provided validation of model outputs. The model clearly demonstrates how health benefits of a low energy diet intervention are distributed across the 5 IMD quintiles, which has not been quantified before.

iii. Limitations

Our analysis is driven by two assumptions, each with their own limitations: 1) tier 2 weight management services and diet interventions 2) completion rates and health effect multipliers.

Regarding the first point, the model relies on tier 2 weight management services data as a proxy for low-energy diet intervention data. This assumption is necessary as not only is there no data for low-energy diets by IMD groups, there is no data for diet interventions more broadly by IMD groups. Thus, assuming tier 2 weight management services data is a suitable proxy for low-energy diets is required to obtain the uptake and completion data required to perform the analysis. Without this assumption, there would be no data on enrolment or

completion, and this analysis would not be possible. The committee expressed concerns about this assumption, noting that the tier 2 weight management service data was generally considered to be of low quality. The committee however acknowledged this assumption was necessary in order to enable the analysis, and that the important thing to validate was the distribution of the data. Even if the specific numbers were to be considered poor, with a potential high risk of bias, as long as the overall trends were believed to be the same (i.e. that enrolment is higher in the more deprived groups), then this bias, although still present, would likely be smaller in effect.

With regard to the second point, as previously discussed, the analysis assumes that completion rate is a reasonable proxy measure for determining if someone benefits from a program. Again, it is entirely possible for someone to enrol in a program and see a health benefit (in this case weight loss) despite not completing the program. The learning this person may achieve is therefore not entirely associated with them completing the program. However, as agreed with the committee, it is difficult to imagine a single factor more likely to affect the success of a program than completion. The committee therefore agreed the assumption underpinning this approach was reasonable.

iv. Comparison with other published evidence

Our health inequality impact analysis produced findings consistent with results from a review of the NHS diabetes prevention programme (Ross et al. 2022), which showed 1) a higher proportion in the most deprived quintile compared with least deprived quintile and 2) a large benefit observed in the second least deprived quintile. It is worth noting this study is specifically looking at people with prediabetic status, and therefore is more specific than our population. However, we feel it appropriate to include here despite its population being narrower.

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