# Understanding childhood weight in Scotland:

## What can longitudinal data tell us?

Obesity Action Scotland
Healthy weight for all

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This report represents a summary of Miall & Pearce, 2024, Growing Up in Scotland: obesity from early childhood to adolescence, Obesity Action Scotland (doi 10.36399/gla.pubs.319087). For the full analysis and findings please access the full report. The data in this report are from the first birth cohort in the Growing Up in Scotland (GUS) Study. This is a nationally representative study of over 5000 children born in Scotland between 2004-5, who have been followed up regularly since they were aged 10 months[1]

## Key Findings

### Children's Weight

- Half of GUS children were a healthy weight when measured at three time points during childhood (4, 11 and 14 years). Based on the experiences of GUS children, it is likely that at least half of Scottish children today will experience overweight or obesity by the age of fourteen years.
- The prevalence of overweight and obesity increased from 25% at age 4 to 37% at age 14. This was mainly driven by increases in obesity, which rose from 10% to 22%.
- Four in ten children moved BMI category between age 4 and 14, the majority of whom move up a category (for example, from healthy weight to overweight or from overweight to obesity).
- The proportion of children who are underweight was consistently low at 2.5% or less.
- BMI measurements taken at age 4 in Scotland (corresponding to the Primary 1 population-wide monitoring of childhood BMI in Scotland) only provide a crude predictor of BMI-status at age 14.
- Among the GUS participants who experienced obesity at age 14, 48% started Primary school at a healthy weight and less than one third (29%) experienced obesity at age 4 years. In other words, one measurement of weight at school entry fails to identify seven in ten children who go on to experience obesity at age 14.
- Using a longitudinal measure of obesity at ages 4 and 10 improves predictions of obesity at age 14. However, even then it remains a poor predictor - of those experiencing obesity at age 4 or 10, 32% went on to be a healthy weight regardless, and 35% of 14-year-olds currently living with obesity did not experience obesity at age 4 or 10.

### Poverty and Inequalities

- Poverty and other aspects of social disadvantage, including area deprivation, circumstances of the parent(s), food insecurity and a range of other, often co-existing factors, amplify the risk of experiencing overweight and obesity.
- Children who experienced socio-economic disadvantage in the early years were especially more likely to experience obesity (as opposed to underweight, healthy weight or overweight), and this inequality widened with age.
- Children who both lived in the most deprived areas *and* in the lowest income households were at increased risk of obesity compared to experiencing either of these disadvantages in isolation. They were 3.5 times more likely to experience obesity at age 14.

- Children in the lowest household income fifth were 2.6 times as likely to experience obesity at both 4 and 14 (as opposed to no obesity at either age), compared to children in the highest income households.

- Children who experienced food insecurity at a young age were 4 times more likely to experience persistent obesity from the start of Primary school up to age 14 than children who did not experience food insecurity, after adjusting for other socio-economic factors.

## Key Learning

Targeting preventative interventions on the basis of early childhood weight, or even weight at the beginning and end of primary school, is too blunt a tool. Socio-economic inequalities in overweight and obesity are large and pervasive in Scotland, and there are strong associations with food insecurity.

A single population wide measure of BMI at age 4 is not sufficient to understand the challenge we face in achieving child healthy weight. Further research is needed to determine the value of more frequent measurement points.

## Key Actions

Whole population measures, backed by evidence of effectiveness and fairness, that encompass proportionate attention and avoid stigma toward those who experience the effect of inequalities or insecurity would be most effective.

Proportionate universal approaches which include steps to tackle social disadvantage are likely to be important in the desire to reduce the overall prevalence of childhood overweight and obesity while also tackling inequalities and making wider improvements to children's lives.

Children need both continued monitoring and support to prevent overweight and obesity in later childhood and adult life.

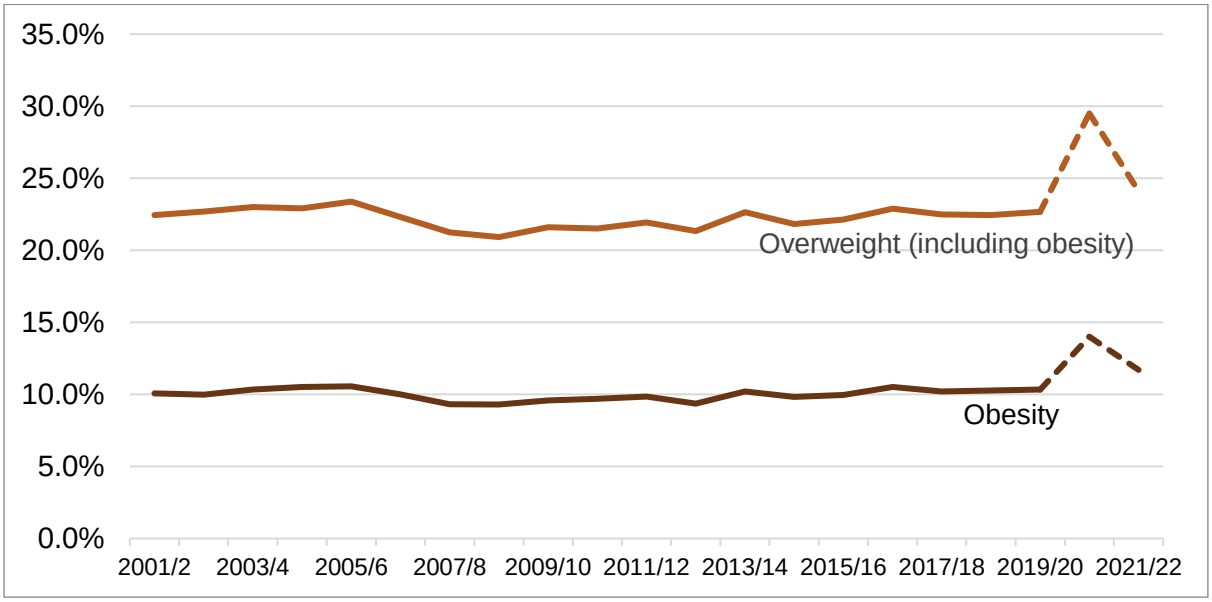
Tackling poverty, food insecurity and its consequences throughout childhood is vital to prevent and address overweight and obesity for children growing up in Scotland.

## Introduction

Overweight and obesity are highly preventable conditions, yet over the past 20 years there has been little progress in reducing the prevalence of overweight and obesity among children in Scotland (Figure A) [2].

***Figure A**: Prevalence of overweight and obesity between 2001/2 and 2021/22 in Scotland, using Public Health Scotland Primary 1 BMI statistics (school-year 2021 to 22)[3].*

*Note that coverage of child BMI monitoring dropped during the pandemic so figures from 2020/21 and 2021/22 (dotted lines) have greater uncertainty.*




There has been a concerning widening of socio-economic inequalities in childhood overweight and obesity during this period [4]. The prevalence of childhood obesity has increased in the most deprived areas, while declining steadily in the least deprived areas.

Experiencing overweight and obesity in childhood has negative impacts on child mental health, is associated with obesity in adulthood and is a risk factor for type 2 diabetes and hypertension [5 6]. Furthermore, obesity in childhood is associated with premature mortality [7]. These risks can be heightened among children who experience persistent obesity throughout childhood [8].

It is increasingly recognised that childhood obesity and inequalities in obesity cannot be solved by attempts to change individual behaviours alone. Interventions which target only behaviours can heighten inequalities, as families with the resources, including time, income, and social supports, are more likely to benefit [9]. Moreover, an emphasis only on individual behaviours can exacerbate the stigma faced by children living with overweight and obesity [10]. Action to address the social, environmental, and commercial determinants of obesity are also essential. Policies across all sectors and all levels of decision making can be leveraged to ensure that the environment in which children grow up promotes and prioritises their health [11].

This report therefore aims to explore:

a) how overweight and obesity change throughout childhood to early adolescence, and

b) how inequalities in overweight and obesity develop with age, using the Growing Up in Scotland Study.

Section 1 describes the cross-sectional prevalence of overweight and obesity at key points in childhood. Section 2 describes socio-economic inequalities in obesity and overweight at key ages, and Section 3 describes inequalities in the way that weight changes in childhood and adolescence. Section 4 explores the impact that food insecurity can have on overweight and obesity in later childhood.

## Methodology

Growing Up in Scotland is a nationally representative study of over 5000 children born in Scotland between 2004-5, who have been followed up regularly since they were aged 10 months[1]. There are 2238 children who were successfully followed up to age 14. 1697 children had measurements at all relevant time points and are in the main focus of this report. The data were weighted to account for the sample design and loss-to-follow-up and therefore the final results should be representative of all children living in Scotland at the time.

In this report we focus on the measurements taken at ages 4, 10 and 14. The measurement at age 14 is analysed as the most recent measurement available at the time of writing.

## Section 1: How do overweight and obesity change across childhood in Scotland?

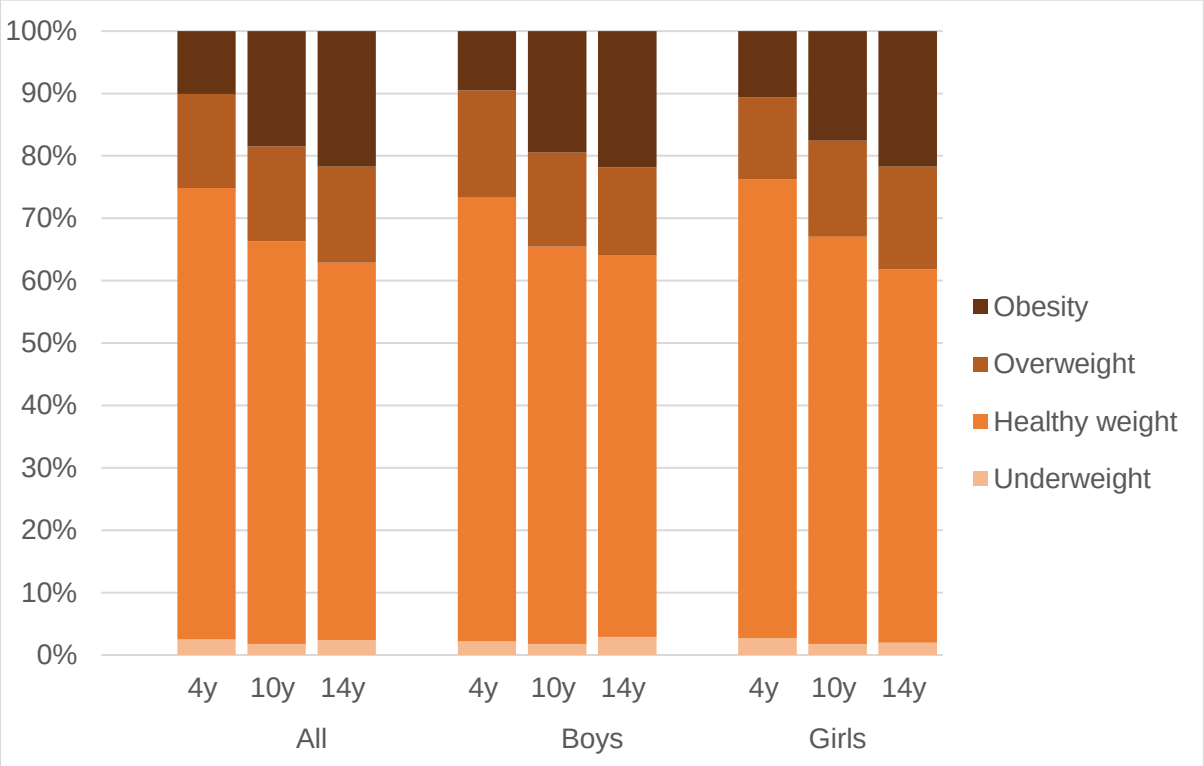
The prevalence of obesity in Scotland is already high at the start of Primary School, and increases further with age (Figure B). There is a doubling in the prevalence of obesity between ages 4 and 14.

The differences between boys and girls were reasonably small at every age, however, especially in the prevalence of obesity.

The majority of children remained at a healthy weight throughout primary school. Healthy weight continued to be the most common pattern between ages 4 and 14.

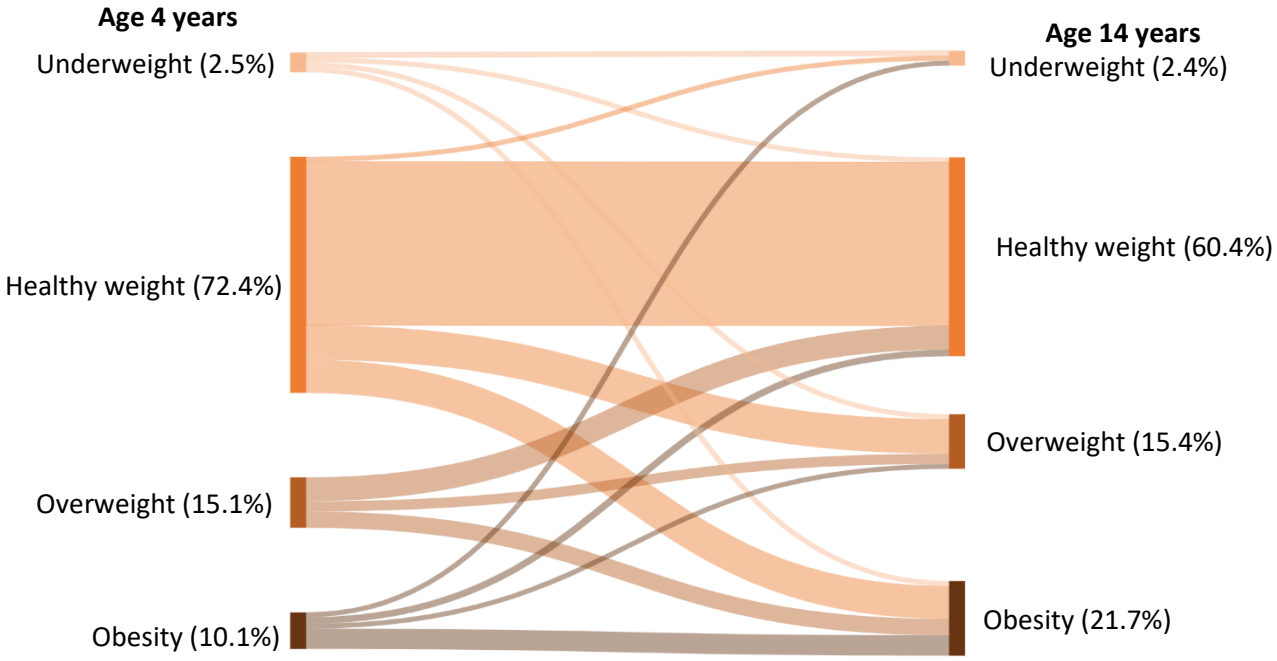
Figure C shows the movement of children between BMI categories at ages 4 (left hand side) and 14 (right hand side). This chart shows that the majority of children who were healthy weight at age 4 continued to be a healthy weight at age 14 (shown by the large, continuously orange strip). Similarly, the majority of those who experienced obesity at age 4 continued to experience obesity at age 14 (shown in the continuously dark red strip at the bottom). However relatively few children who experienced overweight at age 4 were still experiencing overweight at 14.

**Figure B:** *Prevalence of underweight, healthy weight, overweight and obesity at ages 4, 10, and 14, among children in the Growing Up in Scotland Study, stratified by gender.*




| | All | | | Boys | | | Girls | | |
|---|---|---|---|---|---|---|---|---|---|
| **Age (sample size)** | **4y (2101)** | **10y (2194)** | **14y (1797)** | **4y (1053)** | **10y (1104)** | **14y (886)** | **4y (1048)** | **10y (1090)** | **14y (911)** |
| *Underweight (%)* | 2.5 | 1.8 | 2.4 | 2.2 | 1.8 | 2.9 | 2.7 | 1.8 | 2.0 |
| *Healthy weight (%)* | 72.4 | 64.5 | 60.4 | 71.2 | 63.7 | 61.1 | 73.6 | 65.3 | 59.8 |
| *Overweight (%)* | 15.1 | 15.2 | 15.4 | 17.2 | 15.1 | 14.2 | 13.1 | 15.4 | 16.5 |
| *Obesity (%)* | 10.1 | 18.5 | 21.7 | 9.5 | 19.5 | 21.8 | 10.6 | 17.6 | 21.7 |
| *Overweight or obesity (%)* | 25.2 | 33.7 | 37.1 | 26.7 | 34.6 | 36.0 | 23.7 | 33.0 | 38.2 |

**Figure C:** *Movement of children between BMI-categories between ages 4 and 14 years, among children in the Growing Up in Scotland Study. The width of the bar is proportional to the proportion of children experiencing this trajectory of BMI status. N=1697.*




| Trajectory between ages 4 and 14 years | Prevalence |
|---|---|
| Underweight to Underweight | <2% |
| Underweight to Healthy weight | <2% |
| Underweight to Overweight | <2% |
| Underweight to Obesity | <2% |
| Healthy weight to Underweight | 2% |
| Healthy weight to Healthy weight | 50% |
| Healthy weight to Overweight | 11% |
| Healthy weight to Obesity | 10% |
| Overweight to Underweight | <2% |
| Overweight to Healthy weight | 7% |
| Overweight to Overweight | 3% |
| Overweight to Obesity | 5% |
| Obesity to Underweight | <2% |
| Obesity to Healthy weight | 2% |
| Obesity to Overweight | 2% |
| Obesity to Obesity | 6% |
| Total | 100% |

Across the population this means that the majority of children (60%) will have the same BMI status at 14 as they did at age 4. However, an increase in BMI group was experienced by 27% of children, and the remaining 13% of children experienced a decrease in BMI. In total, half of children experienced unhealthy weight (underweight, overweight, or obesity) at either age 4 or 14, or both.

## How well does obesity at age 4 predict obesity at 14?

Of children experiencing obesity at 14 years, less than one third (29%) had also experienced obesity at age 4 years. Therefore, if these measurements were used to target interventions to reduce obesity at children who experienced obesity aged 4 years, we might expect 71% of 14-year-olds who live with obesity to have been missed.

Furthermore, 37% of 4-year-olds with obesity did not experience obesity at age 14 years. Therefore, over a third of those who may have been identified for intervention at age 4 may not have needed one, as they would have gone on to experience healthy weight anyway.

## Does adding additional measures at age 10 improve predictions?

Adding a later BMI measurement at age 10 (equivalent to the second National Child Weight Measurement programme in England) improves the prediction of obesity at 14 substantially. If children who experienced obesity at either 4 or 10 years old were targeted, only 35% of 14-year-olds currently living with obesity would have been missed. Moreover, the proportion of children incorrectly targeted is also reduced to 32%.

## What can we conclude about how weight changes between 4 and 14?

The prevalence of overweight and obesity is very high among Scottish children. Already by age 4, one in four children are experiencing overweight (including obesity). The prevalence increases with age, especially for obesity which doubles between ages 4 and 14. The prevalence of overweight and obesity are broadly similar for boys and girls.

Looking to trajectories of obesity and overweight, two in five children will change BMI status between ages 4 and 14, the majority of whom will have increased BMI. One quarter of children experiencing obesity in adolescence (age 14) had been experiencing obesity persistently since at least the start of Primary school, however the rest of this group will have started to experience obesity for the first time after this point, or moved in and out of the obesity category. A single measure of BMI status at the start of primary school is an inaccurate predictor of future BMI. Using longitudinal data from multiple time points can improve predictions and potentially the targeting of interventions to prevent adolescent obesity.

## Section 2: Inequalities in obesity at single ages

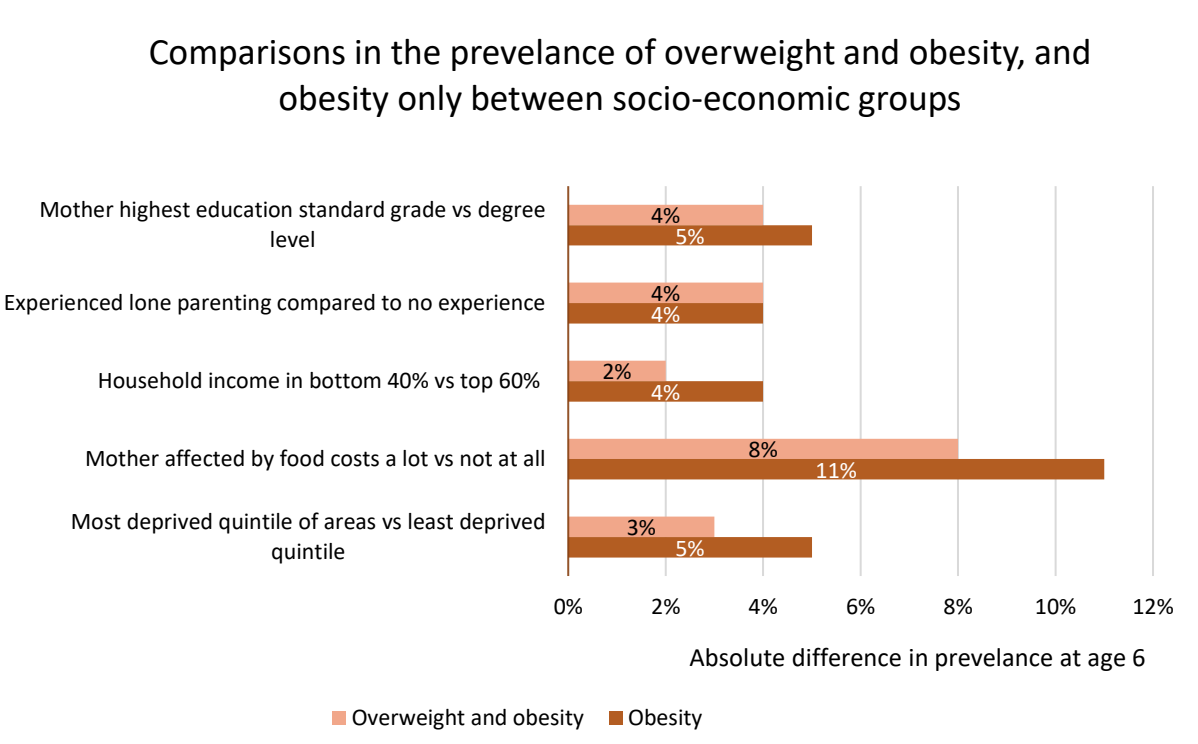
We already know from work elsewhere that there are substantial inequalities in overweight and obesity among primary school age children. [12 13]

For example, earlier GUS analysis found that the prevalence of overweight and obesity is higher at age 6 among children who, compared to their more advantaged peers: [12 13]

- Have mothers who have lower educational qualifications.
- Have experienced lone parenting.
- Experienced persistent poverty in the early years.
- Experience food insecurity.
- Live in more deprived areas.

Moreover, more severe outcomes show wider inequalities. In other words, absolute inequalities in the prevalence of obesity at age 6 (2010/11) are larger than inequalities in overweight (including obesity) (figure D).[13]

**Figure D** *Absolute difference in the prevalence of overweight and obesity, or obesity only, at age 6 (2010/11) between children in the most and least disadvantaged groups according to several measures of socio-economic circumstances. Adapted from Parkes et al [13]*



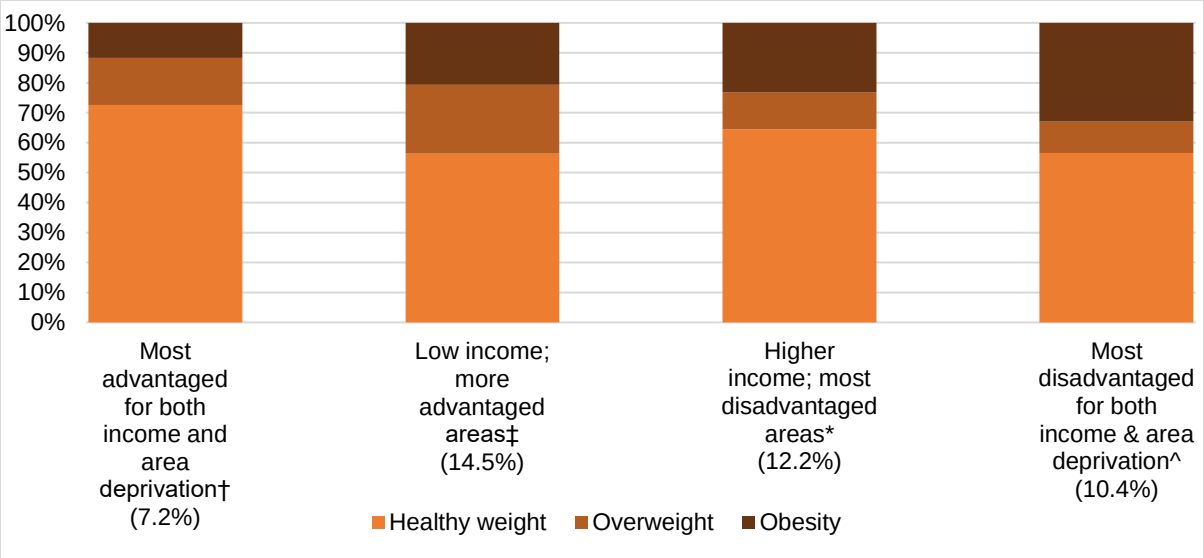

Our analysis of the GUS data clearly shows that these inequalities in obesity at the start of Primary school persist and widen with age.

Living in a household with income in the lowest fifth of the population at age 4 is associated with increased obesity throughout childhood and the strength of the association increases with age. In comparison, inequalities in overweight are relatively low at both ages.

A similar pattern of inequality is seen according to area-level deprivation. Children living in the most deprived areas at the start of primary school are twice as likely to experience obesity in adolescence as children in less deprived areas. However, this is not to say that obesity is only experienced by children from most advantaged backgrounds – we see a social gradient, with the level of risk generally increasing with the degree of social disadvantage.

Figure E shows the prevalence of underweight, healthy weight, overweight and obesity at age 14 according to combinations of area deprivation and income. It shows that children who live in the most disadvantaged households and areas (on the right) are far more likely to experience obesity than those who live in the least disadvantaged households and areas (on the left).

**Figure E:** *The prevalence of healthy weight (or underweight), overweight and obesity at age 14, according to combinations of income and area deprivation, at age 4 among children in the Growing Up in Scotland Study (n=2136).*




| | Prevalence of this socio-economic circumstance (%) | Proportion experiencing obesity at 14 (%) | Odds ratio adjusted for sex (95% CI) |
|---|---|---|---|
| *Most advantaged for both income and area deprivation†* | 7 | 12 | 1.0 (ref) |
| *Most disadvantaged income quintile, more advantaged area‡* | 15 | 20 | 1.9 (1.0-3.7) |
| *Most deprived deprivation quintile, more advantaged income quintile** | 12 | 23 | 2.3 (1.2-4.3) |
| *Most disadvantaged for both income and area deprivation ^* | 10 | 32 | 3.5 (1.7-7.3) |
| *Other* | 56 | 21 | 2.0 (1.2-3.4) |

*†Child lives in the least deprived quintile of areas (SIMD 1) and in the highest household income quintile. ‡Child in the lowest household income quintile but not the most deprived area quintile (ie. SIMD 1-4). *Child lives in the most deprived area quintile (SIMD 5) but not the lowest household income quintile. ^Child in the lowest household income quintile and the most deprived quintile of areas (SIMD 1).*

Alongside household income and area deprivation, this study found inequalities in the risk of obesity at age 14 according to the following factors (measured at age 4), after adjustment for sex:

- Mother's highest educational qualification is lower than degree level (aOR 2.3 [1.7-3.1).
- The family does not own their home (aOR 2.0 [1.5-2.8]).
- Children lived in a single parent household (aOR 1.9 [1.3-2.9[).
- Maternal unemployment (aOR 1.3 [1.0-1.8]).

Socio-economic disadvantage in the early years is associated with higher obesity prevalence, although differences in overweight are small. The inequality in obesity increases with age. Furthermore, disadvantages experienced simultaneously, such as living in the lowest income households *and* in the most deprived fifth of areas are associated with a particularly high obesity prevalence.

## Section 3: Inequalities in longitudinal patterns of overweight and obesity

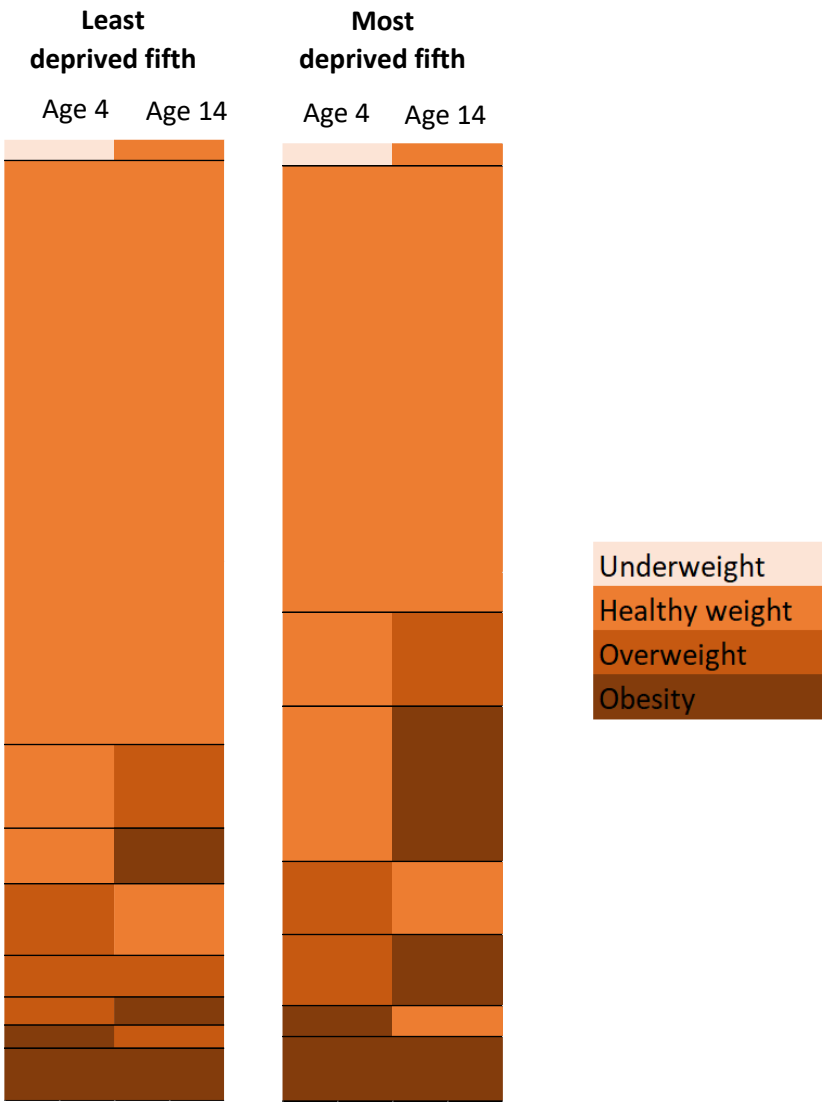
Alongside inequalities in the prevalence of obesity at different ages, as described in section 2, there are inequalities in the way in which a child's BMI changes over childhood.

Previous research had shown that children who have experienced longer durations of household poverty and lone parenting, or who have mothers with no educational qualifications, are more likely to experience persistently high or increasing risk of overweight and obesity at age 6.[14] Furthermore, children in the most deprived fifth of areas are 50% more likely to experience persistently high or increasing overweight between ages 6 and 10 than children in the least deprived areas[12]

In this report we find that children who are in the most deprived fifth of areas at the start of primary school (at age 4) are more likely to experience obesity at age 14 than children in the least deprived areas, no matter what BMI status they experience at the start of Primary school.

Inequalities in obesity at age 14, between more and less deprived areas, are largely driven by more children moving into obesity between the ages of 4 and 14 in the most deprived areas (Figure F). The proportion of children who experience persistent obesity is only moderately higher in the most compared to the least deprived fifth of areas (sex-adjusted odds ratio 1.4, 95% CI 0.5-4.4)

**Figure F:** *Movements between underweight, healthy weight, overweight and obesity between ages 4 and 14*, among children in the least (n=437) and most (n=229) deprived area quintiles.*




| | Most deprived quintile (%) | Least deprived quintile (%) |
|---|---|---|
| *Underweight at both* | <2 | <2 |
| *Underweight to healthy weight* | 2 | 2 |
| *Underweight to overweight* | <2 | <2 |
| *Underweight to obesity* | <2 | <2 |
| *Healthy weight to underweight* | <2 | <2 |
| *Healthy at both* | 58 | 44 |
| *Healthy to overweight* | 8 | 9 |
| *Healthy to obesity* | 6 | 15 |
| *Overweight to underweight* | <2 | <2 |
| *Overweight to healthy weight* | 7 | 7 |
| *Overweight at both* | 4 | <2 |
| *Overweight to Obesity* | 3 | 7 |
| *Obesity to underweight* | <2 | <2 |
| *Obesity to healthy weight* | <2 | 3 |
| *Obesity to overweight* | 2 | <2 |
| *Obesity at both* | 5 | 6 |

*combinations which were rare (<2%) are not shown in the graphic

Children living in higher deprivation areas at the start of primary school are more likely to move into obesity category by age 14 than children in less deprived areas.

When we look at household income we find that children in the lowest income fifth have 2.6 (95% CI 1.2-5.6) times greater odds of experiencing persistent obesity than children in the highest income fifth

We can also see that

- Children whose mother's highest educational qualification is lower than degree level are 2.5 times as likely to experience persistent obesity (compared to no obesity) than children whose mothers have degree level qualifications (OR: 2.5 (1.4-4.3))
- Children whose families do not own their home at age 4 are 1.8 times as likely to experience persistent obesity (OR: 1.8 (1.0-3.4))
- Children living in a single parent household at age 4 are 1.8 times as likely to experience persistent obesity. (OR: 1.8 (0.8-4.0))
- Children whose mothers are not employed when they are 4 years old are 1.5 times as likely to experience persistent obesity. (OR: 1.5 (0.8-2.7))

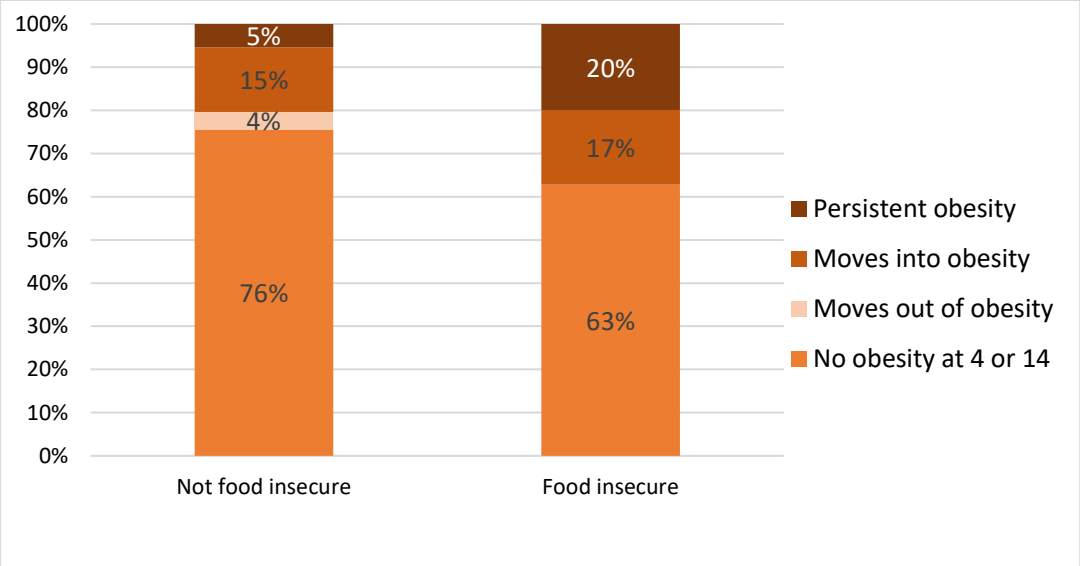
## Section 4: Food insecurity and children's weight

Food insecurity, which is concentrated in less advantaged groups, is a growing concern for the health and wellbeing of children in Scotland.

One in five households with children were forced to rely on low-cost food and imbalanced meals, or did not have enough to eat, due to food and cooking costs in January 2023[15]. Some studies have suggested that food insecurity is a cause of obesity in childhood [16], however the evidence for this remains mixed [17]. This study examined the association between food security in childhood and changes in obesity in the Growing Up in Scotland Study.

Food insecurity in toddlerhood (age 2) was experienced by 6% of participating GUS households.

**Figure G**: *The prevalence of four BMI-trajectory groups between ages 4 and 14: persistent obesity, moving into obesity (i.e. has obesity at age 14 but not age 4), moving out of obesity (i.e. has obesity at age 4 but not age 14), and does not have obesity at either time point, stratified by food security measured at age 2 (n=1,695).*




After adjustment for sex and socio-economic circumstances, children with higher food insecurity were 1.9 times as likely to experience obesity at age 4 than those who did not experience food insecurity (95% confidence interval 0.9-3.8) (n= 2086), and also 1.9 times as likely to experience obesity at age 14 (95% CI 1.1-3.4) (n= 1784).

Shockingly, children experiencing food insecurity at age 2 are 4 times more likely to experience obesity at both ages 4 and 14 (compared to at neither age) than children not experiencing food insecurity at 2 (95% CI 1.8-8.9), after adjustment

Food insecurity is associated with persistent childhood overweight and obesity throughout childhood and adolescence. Interventions to tackle childhood food insecurity are likely to be particularly pressing in order to address inequalities in obesity during childhood.

## Limitations and Gaps

There are factors which are known to be important for health in Scotland, but our understanding of how they are related to childhood obesity is limited due to shortcomings in the available data. These factors include disability and ethnicity. Studies using the Growing Up in Scotland study to explore inequalities related to ethnicity have previously shown that the association with obesity trajectories is not straightforward, with minority ethnicities overrepresented in the high/increasing obesity group but underrepresented in the high and increasing overweight groups[14]

We know that the co-occurrence of different types of social disadvantage is important in determining health outcomes. In this report we have explored the co-occurrence of area deprivation and income to some extent. This type of analysis focuses heavily on just the most deprived groups, which misses the experiences across the gradient of disadvantage.

We have chosen to focus on early years measures, to demonstrate the impact that disadvantage experienced early in childhood had well into adolescence. Transient experiences of disadvantage are likely to have different impacts on health to persistent disadvantage.

## Conclusions

The prevalence of obesity is already concerningly high by the start of Primary school amongst children in Scotland and increases further into adolescence. By age 14, more than one in five children will be living with obesity.

Based on the experiences of GUS children, we might expect that half of children will be a healthy weight at both age 4 and age 14. Two in five children will experience changes in BMI category between age 4 and 14, the majority of whom will experience an increase in BMI. Focusing on children living with obesity at age 14 shows that one quarter have experienced obesity persistently throughout primary school (at ages 4 and 10 as well as 14). In contrast, nearly half of children living with obesity at age 14 started primary school at a healthy weight and moved into obesity in later childhood or adolescence.

These changes in BMI status between age 4 and age 14 mean that using the Primary 1 BMI measures to target interventions or policies may miss as many as seven in ten children who go on to experience obesity in adolescence. Using a longitudinal measure of BMI trajectory between ages 4 and 10 improves the ability to predict obesity at later ages, but it is still far from ideal.

Experiencing socio-economic disadvantages in the early years is associated with increased risk of obesity at every age, and inequalities widen for older age groups. Children who experience social disadvantages across area deprivation, household income, maternal educational qualifications, family structure and household tenure are all more likely to be living with obesity at age 14. The risk is especially raised for children experiencing both income and area-based deprivation at the start of Primary school, who experience a 3.5 times higher risk of obesity at age 14 than children in the most affluent income and area-deprivation fifths.

Socio-economic disadvantage is additionally associated with increased risk of experiencing persistent obesity over Primary school and into adolescence. Children in the lowest household income fifth at age 4 are 2.6 times as likely to experience obesity at both age 4 and age 14 compared to no obesity at either age.

Food insecurity among children is of growing concern, with increasing numbers of families facing financial barriers to accessing sufficient, good quality food. Across the UK food insecurity among children has doubled between 2021 and 2022. Experiencing food insecurity as a toddler in Scotland in the mid-2000s was associated with a quadrupling in the risk of living with persistent obesity between ages 4 and 14, even after accounting for sex area deprivation, lone parenting and maternal education.

Without action to address causes and drivers of obesity, especially among children living in disadvantaged circumstances, Scotland risks establishing health conditions and health inequalities at early ages that are likely to persist and widen into adulthood.

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