



Increased incidence of overweight and obesity among preschool Swedish children during the COVID-19 pandemic

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Background: The COVID-19 pandemic has had wide effects on child health globally. Increased prevalence of childhood obesity has been observed by a number of countries during the pandemic. The absence of a formal societal lockdown during the pandemic, made Sweden stand out compared to other countries. This study aims to examine changes in BMI among preschool children in Sweden before and during COVID-19 pandemic. **Methods:** Retrospective population-based cross-sectional study, with longitudinal follow-up for a portion of the children. The study included 25 049 children from three Swedish regions, with growth measures at 3- ($n = 16\ 237$), 4- ($n = 14\ 437$) and 5-years of age ($n = 11\ 711$). Care Need Index was used as a socioeconomic parameter at health centre level. **Results:** There was an increase in BMI in children aged three ($P = 0.028$) and four ($P < 0.001$) during the COVID-19 pandemic. Obesity in 3-year-old girls increased from 2.8% to 3.9%. Four-year-olds increased in obesity, and overweight (girls) and the prevalence of underweight decreased in boys. No change in BMI was observed in 5-year-olds. Children in areas of low socioeconomic status had higher risk of obesity. **Conclusions:** Overweight and obesity increased among 3- and 4-year-old children in Sweden, findings that were accentuated in children attending child health centres in areas with lower socioeconomic status. The COVID-19 pandemic is likely to have affected health behaviours negatively in Swedish preschool children. Our results expose the need for extended efforts directed to prevent childhood obesity, especially targeting lower socioeconomic areas.

Introduction

As COVID-19 sweeps the globe another silent epidemic is increasingly clear, that of its secondary effects on children. Modelling estimates have indicated that more than 1 million children so far have lost at least one caregiver from COVID-19 resulting in economic and psychosocial difficulties.¹ One recent meta-analysis suggested that the COVID-19 pandemic had negatively affected the mental health of children.² In a comment in the Lancet, Badesha et al.³ highlighted how societal COVID-19 restrictions, such as home schooling and reduced social contact, affected physical activity and child nutrition, which may have increased the risk of childhood obesity.

Childhood obesity is a major health issue affecting further growth of the child, often continuing as obesity in adulthood with increased risk of psychosocial problems, cardiovascular diseases and cancer.^{4–8} Several studies have shown increases in obesity in children during the COVID-19 pandemic. These studies mainly focussed on school age children and adolescents in countries that underwent periods of societal lockdown.^{9–13} Two studies from USA and Israel reported that the youngest children (aged 3–6 years), had a more pronounced increase in body mass index (BMI) and weight gain compared to older children during the pandemic.^{11,14} Sweden differed from most

other countries, especially in the beginning of the COVID-19 pandemic in its absence of formal societal lockdown. For example, preschools and schools for children up to the age of 16, continued to operate to their best capacity.

Preschool in Sweden is highly subsidized and has high coverage. Before the pandemic in 2019, 78% of 1- to 3-year-olds and 94.3% of 4- to 5-year-olds were enrolled in preschool, thus playing an important role in the quality of a child's lifestyle, daily activities and habits.¹⁵ While preschools remained available during the pandemic, access was affected to a larger extent. Some preschools asked guardians to periodically reduce child attendance due to staff shortage. Moreover, children with minor cold symptoms were barred from attending preschool and guardians were reported to keep their children at home out of fear, rather than national recommendations.^{16,17} This phenomenon was particularly observed in areas with low socioeconomic status.¹⁷ It is estimated that the mean time of absence by children in preschools increased by 50% during 2020 and first half of 2021.¹⁶

In Sweden, child growth is monitored regularly as part of the preventive child health programme. During infancy weight and height is measured frequently followed by annual measurements at ages three, four and five. Growth monitoring is part of a broader preventive child programme offered at local child health centres,

which includes vaccinations, child development and behavioural monitoring as well as parental support. The programme is universal and reaches almost all children 0–5 years.¹⁸ Overweight and obesity trends are monitored at an aggregated regional level.¹⁹ The national quality register for child health care ‘Svenska Barnhälsovårdsregistret’ (BHVQ), was launched recently. By the end of 2021, 3 out of Sweden’s 21 regions had joined the registry. Meanwhile, child health nurses in socioeconomically deprived areas in Sweden have signalled a rise in childhood obesity during the pandemic.¹⁷ This anticipation has not yet been analyzed scientifically.

The main aim of this study is to analyze the change of BMI status before and during the COVID-19 pandemic in Swedish preschool children (aged 3–5 years). The data will also be analyzed for individual longitudinal changes to examine whether pre pandemic weight status could be associated with obesity or overweight during the pandemic.

Methods

Study design

The study was a retrospective population-based cross-sectional study, with longitudinal follow-up for a portion of the children for whom multiple growth measures were available. The longitudinal analysis studied the likelihood that a child changed BMI category from underweight to overweight or obesity, during the COVID-19 pandemic.

Data sources and variables

Anthropometric data were obtained from the national quality register for child health care, BHVQ, for the three available regions of Dalarna, Jönköping and Sörmland in Sweden. Dalarna Region reported data on children born 2011 and onwards, Jönköping from 2013 and Sörmland from 2016. Data were analyzed from May 2015 and onwards. The guardians of the children were informed about the registry at their local child health centre, and were given the chance to opt-out, before data transfer. The Swedish Ethical Review Authority (2021-02905) approved the study.

The original dataset contained 25 801 children. Child age was collected in months and divided into three age-groups defined as follows: 3 (853–973 days), 4 (1401–1551 days) and 5 years (1766–2100 days). Any ages outside these intervals were excluded (752 children). The final study cohort included a total of 25 049 children living in Sweden, with growth measures at 3- ($n = 16\ 237$), 4- ($n = 14\ 437$) and 5-years of age ($n = 11\ 711$). Out of the total number of measures, 23 212 were collected before, and 19 171 during the COVID-19 pandemic time period. Data were collected on birth date (year, month), date of visit to child health centre, length in centimetres, weight in kilograms, name and region of child’s health centre. BMI was calculated and categorized based on sex-specific BMI-for-age in months.²⁰ For children with several measurements, only the visit closest to their birthday was included. The proportion of children covered by the BHVQ depends on when each region started reporting data to the registry. For the region of Dalarna, this coverage varies between 25% and 79% for children born in 2012 and 2017, respectively. For the region of Sörmland, the coverage varies between 2% (2015) and 87% (2018). Lastly, the coverage of the data from the region of Jönköping varies between 33% for children born 2016 and 91% for the children born 2018. A more detailed description of the cohort and dataset is shown in [table 1](#).

Mean and standard deviations were calculated for height in centimetres, weight in kilograms and BMI prior to and during COVID-19. Underweight was defined as ISO BMI < 17, overweight > 25 and obesity > 30. Normal weight status was defined as having an ISO BMI between 17 and 25.

Child specific Care Need Index (CNI) was used as a socioeconomic parameter at aggregated health centre level. CNI is an area specific multicomponent indicator, based on social and demographic parameters.²¹ The CNI was calculated as a regional index by the Swedish Central Bureau of Statistics (Statistics Sweden). The standard deviation for Dalarna Region was 0.22, Jönköping Region SD 0.38 and Sörmland Region 0.44. The CNI was categorized into quartiles, where Quartile 1 represents areas with the highest socioeconomic level. Weight measurements were defined as prior to COVID-19 pandemic (1 May 2015–30 April 2020) and during COVID-19 pandemic (1 May 2020–31 May 2021).

Statistical analysis

Means, standard deviations, frequencies and percentages were used for descriptive purposes. Univariate Chi² tests and *t*-tests were used for comparison between participant groups. Multiple binary logistic regressions were performed on the parameters with statistically significant associations ($P < 0.05$). The main dependent variables were obesity in 3-year-olds (yes/no), as well as underweight (yes/no), overweight (yes/no) and obesity (yes/no) in 4-year-olds. In these models, child sex (boy/girl) visit to the child health centre (before/during COVID-19 -pandemic period), the child health centre visited and CNI of the child health centre (CNI quartiles 1–4) were included as independent variables. A cluster design was used based on the child health centre, and region, and CNI was analyzed with fixed effect on the centre. The centre intercept term was used to account for the dependence between children attending the same child health centre. *P*-values, along with odds ratios (OR) and 95% confidence intervals (95% CI), were reported from the models. *P*-values of < 0.05 were used to define statistical significance. SPSS version 27.0.1.0 was used to perform all the analysis.

Prior to the logistic regression analysis, data were checked for multicollinearity through examining variance inflation factor (VIF) values for all independent variables. VIF-values ≥ 10 indicate multi collinearity.²² The VIF-values for the independent variables in the study ranged from 1 to 1.25, meaning that data were not multi collinear.

Results

There was a statistically significant increase in BMI in children aged three ($P = 0.028$), during the COVID-19 pandemic period ([table 2](#)). Obesity in 3-year-olds was more prevalent in girls (2.8% before and 3.9% during the COVID-19 pandemic) than boys (2.4% before and 2.6% during the COVID-19 pandemic). A lower proportion of girls had a normal weight status during (80.9%), compared to before the COVID-19 pandemic (82.6%) ($P = 0.049$), while no difference in normal weight status was found in boys the same age ($P = 0.977$).

There was a statistically significant change in BMI in 4-year-olds ($P < 0.001$) with an increased prevalence of obesity (both girls and boys), overweight (in girls) from 11.1% to 12.8% and a decrease of underweight (in boys) from 2.0% to 1.4%, during the COVID-19 pandemic. No change in BMI was observed in 5-year-olds. The 5-year-olds were therefore excluded in further analyses.

In the analysis of the effect of socioeconomic differences (by CNI quartiles) on BMI classifications, there was no notable change in the first or third quartile, before or during the COVID-19 pandemic, for children aged four. There was a difference in the proportion of children with normal BMI in CNI quartile 2. The largest difference was seen in Quartile 4 as both overweight and obesity increased, and normal weight decreased ($P < 0.001$). In the same CNI category, the proportion of overweight increased from 9.5% to 12.4%, and obesity increased from 2.4% to 4.4% during COVID-19 pandemic ([table 3](#)).

The Multiple binary logistic regression showed no statistically significant associations between the independent variables and the outcome in 3-year-olds. Four-year-old girls were more likely to be obese

Table 1 Number of participating 3-, 4- and 5-year-old children prior to and during the COVID-19 pandemic, stratified on sex and region

	Sex		Region			Total, <i>n</i>
	Boys, <i>n</i> (%)	Girls, <i>n</i> (%)	Dalarna, <i>n</i> (%)	Jönköping, <i>n</i> (%)	Sörmland, <i>n</i> (%)	
3-year-olds						
Prior to COVID-19	4545 (51.8)	4221 (48.2)	5885 (67.1)	2626 (30.0)	255 (2.9)	8766
During COVID-19	3801 (50.9)	3670 (49.1)	2547 (34.1)	3211 (43.0)	1713 (22.9)	7471
4-year-olds						
Prior to COVID-19	4148 (50.1)	3969 (48.9)	4961 (61.1)	3156 (38.9)	0 (0)	8117
During COVID-19	3198 (50.6)	3122 (49.4)	2322 (36.8)	3187 (50.4)	811 (12.8)	6320
5-year-olds						
Prior to COVID-19	3209 (50.7)	3122 (49.3)	3539 (55.9)	2792 (44.1)	0 (0)	6331
During COVID-19	2751 (51.1)	2629 (48.9)	2141 (39.8)	3239 (60.2)	0 (0)	5380

Table 2 Proportions of participants according to BMI classifications prior to and during the COVID-19 pandemic

	Underweight (BMI < 17), <i>n</i> (%)	Normal weight (BMI 17–25), <i>n</i> (%)	Overweight (BMI 26–29), <i>n</i> (%)	Obesity (BMI ≥ 30), <i>n</i> (%)	Total, <i>n</i>	Stable or decreased BMI classification from prior visit, <i>n</i> (%)	Increased BMI classification from prior visit, <i>n</i> (%)	Total, <i>n</i>
3-year-olds								
Prior to COVID-19	136 (1.6)	7347 (83.8)	1054 (12.0)	229 (2.6)	8766	–	–	–
During COVID-19	93 (1.2)	6198 (83.0)	940 (12.6)	240 (3.2)	7471	–	–	–
4-year-olds								
Prior to COVID-19	156 (1.9)	6890 (84.9)	840 (10.4)	231 (2.9)	8117	3777 (94.7)	211 (5.3)	3988
During COVID-19	93 (1.5)	5258 (83.2)	730 (11.6)	239 (3.8)	6320	4359 (93.5)	304 (6.5)	4663
5-year-olds								
Prior to COVID-19	111 (1.8)	5217 (82.4)	719 (11.4)	284 (4.5)	6331	3110 (92.3)	260 (7.7)	3370
During COVID-19	87 (1.6)	4451 (74.4)	601 (11.2)	241 (4.5)	5380	4275 (92.6)	342 (7.4)	4617

Significant differences ($P < 0.05$) in proportions between time-periods are marked in bold.

than boys. In addition, the odds of being obese and overweight was higher among children in Dalarna than in Jönköping and higher during COVID-19 than before COVID-19 in both regions. Four-year-olds attending a child health centre with a CNI in the third quartile had higher odds of obesity than children in the lowest quartile. Overweight at age four was associated with sex, region and COVID-19.

The odds of children being underweight at the age of four was not associated with any of the independent variables entered in the model. The longitudinal analysis showed an increase in BMI associated with the COVID-19 time period, for the 4-year-old children. Children living in Jönköping region had lower odds of increased BMI classification in comparison with children living in Dalarna Region (table 4).

Discussion

This study shows an increase in overweight and obesity in 3- and 4-year-old children during the COVID-19 pandemic, across three regions of Sweden. Higher prevalence of overweight and obesity was observed in areas with low socioeconomic status. The changes in the proportion of overweight and obese children related to socioeconomic status was however not linear, or the same for both 3- and 4-year-old children. While these results with increased prevalence of overweight and obesity are in concordance with previous findings from Austria, China, Israel, India and USA,^{10–12,23–25} it is particularly remarkable given that Sweden never underwent a formal lockdown.

Changes in lifestyle behaviour during COVID-19 are likely to have contributed to the increase in overweight and obesity. A number of international studies have indicated increase in screen time and decreased physical activity during the COVID-19 pandemic.^{26–28} Swedish surveys among adults have shown a similar pattern with

decreased physical activity and increased sedentary lifestyle, which potentially also could have impacted the lifestyle of Swedish children.²⁹ A recent study including preschool children also found that low family income was associated with increased elimination of outdoor play.³⁰ Dietary habits also seem to have changed during the pandemic, with several studies indicating an increased intake of high-calorie snacks and sweets during the pandemic.^{28,31–33} In Sweden, the sale of sweet products increased during the pandemic.²⁹ Despite the absence of a formal lockdown, the increased hygiene awareness, fewer social contacts and social distance, are also likely to have contributed to lifestyle changes in Swedish families with preschool children, as indicated by the dramatic decrease in pertussis infections in Sweden during 2020.³⁴

It is possible that disruptions of children's preschool attendance during the pandemic might have contributed to these findings. Several factors could have contributed to disrupted preschool attendance, such as stricter health criteria for child preschool attendance, greater sick leave among preschool staff, as well as general parental anxiety for COVID-19 transmission.

At Swedish preschools, children are physically active, screen time is limited, and children are served nutritious meals at set hours, in accordance with national guidelines. Parents carry a greater responsibility for being present, implementing healthy lifestyle habits and setting boundaries, for children who stay at home. An increased importance of parental awareness and presence might explain the higher rates of obesity seen in higher CNI quartiles, suggestive of the importance of preschools to achieve health equity.

While the study showed an increase in overweight and obesity in ages three and four, no such trend was seen for the 5-year-olds. We do not know whether 5-year-olds might have had a higher preschool attendance compared to younger children, and thereby more continuous healthy habits. Another explanation might be that the 5-year-olds already had established more stable behavioural and

Table 3 Proportions of participants according to BMI classifications, prior to and during the COVID-19 pandemic and in CNI quartiles

	CNI in quartiles				
	First quartile, n (%)	Second quartile, n (%)	Third quartile, n (%)	Fourth quartile, n (%)	Total, n (%)
3-year-olds, prior to COVID-19					
Underweight	28 (1.5)	35 (1.4)	40 (1.5)	33 (1.8)	136 (1.6)
Normal weight	1558 (84.8)	2054 (83.9)	2147 (82.0)	1588 (85.3)	7347 (83.8)
Overweight	217 (11.8)	299 (12.2)	346 (13.2)	192 (10.3)	1054 (12.0)
Obesity	35 (1.9)	60 (2.5)	85 (3.3)	49 (2.6)	229 (2.6)
Total	1838 (100)	2448 (100)	2618 (100)	1862 (100)	8766 (100)
3-year-olds, during COVID-19					
Underweight	20 (0.8)	15 (1.1)	23 (1.5)	35 (1.6)	93 (1.2)
Normal weight	2023 (84.1)	1180 (84.2)	1243 (81.8)	1752 (81.6)	6198 (83.0)
Overweight	301 (12.5)	168 (12.0)	200 (13.2)	271 (12.6)	940 (12.6)
Obesity	61 (2.6)	38 (2.7)	53 (3.5)	88 (4.2)	240 (3.2)
Total	2405 (100)	1401 (100)	1519 (100)	2146 (100)	7471 (100)
4-year-olds, prior to COVID-19					
Underweight	35 (2.0)	36 (1.6)	42 (1.8)	43 (2.6)	156 (1.9)
Normal weight	1532 (87.2)	1964 (85.0)	1963 (82.5)	1431 (85.6)	6890 (84.9)
Overweight	160 (9.1)	242 (10.5)	280 (11.8)	158 (9.4)	840 (10.4)
Obesity	30 (1.7)	68 (2.9)	93 (3.9)	40 (2.4)	231 (2.8)
Total	1757 (100)	2310 (100)	2378 (100)	1672 (100)	8117 (100)
4-year-olds, during COVID-19					
Underweight	27 (1.4)	14 (1.1)	26 (1.8)	26 (1.6)	93 (1.5)
Normal weight	1645 (85.1)	1087 (82.3)	1230 (83.1)	1296 (81.7)	5258 (83.2)
Overweight	210 (10.9)	165 (12.5)	159 (10.7)	196 (12.4)	730 (11.6)
Obesity	50 (2.6)	55 (4.1)	65 (4.4)	69 (4.3)	239 (3.7)
Total	1932 (100)	1321 (100)	1480 (100)	1587 (100)	6320 (100)

Table 4 Results from the multilevel binary logistic regression analyses of family and child health centre characteristics associated with obesity, overweight underweight and having increased in BMI from 3 to 4 years of age

Age in years and BMI classification	Obesity in 3-year-olds	Obesity in 4-year-olds	Overweight in 4-year-olds	Underweight in 4-year-olds	Increased in BMI from 3 to 4 years of age
Independent variables	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Intercept	0.04 (0.03–0.05)	0.04 (0.03–0.05)	0.11 (0.09–0.13)	0.04 (0.03–0.05)	0.06 (0.05–0.08)
CNI fourth quartile ^a	1.14 (0.92–1.41)	1.15 (0.91–1.44)	1.05 (0.88–1.26)	1.08 (0.85–1.39)	1.19 (0.92–1.54)
CNI third quartile ^a	1.18 (0.95–1.47)	1.27 (1.02–1.60)	1.10 (0.91–1.33)	1.03 (0.80–1.32)	1.04 (0.80–1.34)
CNI second quartile ^a	1.04 (0.83–1.32)	1.13 (0.89–1.44)	1.08 (0.89–1.31)	0.98 (0.75–1.27)	1.05 (0.81–1.37)
Sörmland Region ^b	1.19 (0.93–1.54)	1.09 (0.77–1.54)	1.01 (0.78–1.31)	1.03 (0.67–1.56)	0.77 (0.50–1.19)
Jönköping Region ^b	0.86 (0.72–1.03)	0.80 (0.67–0.95)	0.78 (0.68–0.91)	1.09 (0.90–1.32)	0.72 (0.57–0.90)
Girl ^c	1.14 (0.98–1.32)	0.13 (0.98–1.32)	1.12 (1.10–1.36)	0.99 (0.83–1.17)	1.14 (0.96–1.35)
During COVID-19 ^d	1.08 (0.92–1.27)	1.18 (1.01–1.39)	1.17 (1.04–1.31)	0.92 (0.76–1.10)	1.37 (1.13–1.67)

a: Ref. CNI first quartile.

b: Ref. Dalarna Region.

c: Ref. boy.

d: Ref. prior to Covid-19.

feeding habits compared to 3- and 4-year-old children, thereby counteracting negative effects of the COVID-19 pandemic.

The health effect of the COVID-19 pandemic has shown an inequitable impact, with higher risk of morbidity and mortality among lower socioeconomic groups.^{35,36} There is an obvious risk of increased inequality in long-term health as a consequence of the pandemic. This study emphasizes this inequality, the higher prevalence of overweight and obesity in lower socioeconomic areas may lead to long-term health consequences for these children.

Strengths and limitations

The strength of this study is that it contains population-based registry data that allows for cross-sectional as well as longitudinal analyses. The registry has a population-based coverage from three regions in Sweden. However, they only represent 10% of the children of age 3–5 in Sweden, which limits the national representativeness of the data. The register also includes only part of the population in each region, depending on when the region took part of the registry,

and also by the fact that one of the regions started with electronic health records just some years ago (data from paper-based health records have not been included in the register). The three regions are socioeconomically different. Sörmland represents an area with higher degrees of social needs, while Jönköping and Dalarna are regions with below average social needs. The socioeconomic differences are not fully shown since each region has standardized the CNI values, with a mean CNI of 1.0 in each region, where differences between regions in CNI are blunted. That fact may reduce the effect of different socioeconomic backgrounds, and the impact of low socioeconomic status on the risk of childhood obesity may be even higher than seen in this study.

None of the regions contain any of the major urban areas of Sweden and might therefore not accurately reflect trends in these more segregated areas. Children outside large urban areas might also have other lifestyle and dietary conditions that might skew results in either direction. Another limitation of this study is that it can only control for variables that are included in the registry, i.e. socioeconomic data, CNI and comorbidity data at individual levels are absent.

More detailed data on lifestyle and behavioural data, such as preschool attendance, screen time and dietary trends, could also have explained the findings indicated in this article more accurately.

Conclusions

This study is one of the few that has analyzed BMI changes during the COVID-19 pandemic in children of preschool age. To our knowledge, it is also the first study analyzing changes in weight status during childhood in a country that did not undergo a formal lockdown. We have shown an increase in both obesity and overweight and a decrease in underweight in 3- and 4-year-olds, a trend that was more accentuated in the lowest socioeconomic quartile. Our study highlights the need for further efforts to prevent childhood obesity, with targeted programmes towards children in areas with lower socioeconomic conditions.

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Conflicts of interest: None declared.

Key points

- Despite no formal lockdown, this study shows increased prevalence of overweight and obesity in 3- to 4-year-old Swedish children during the COVID-19 pandemic.
- No significant changes in weight status for 5-year-old children were seen.
- Already at age three and four were socioeconomic differences seen, with higher proportions of children being overweight and obese in areas with lower socioeconomic status.
- This study highlights the need for further efforts to prevent childhood obesity, especially in areas of lower socioeconomic status.

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