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Relationships between Social Spending and Childhood Obesity in High-Income Countries: More Welfare, Less Obesity?

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Relationships between Social Spending and Childhood Obesity in High-Income Countries: More Welfare, Less Obesity?

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ABSTRACT (293 words)

Objectives: The burden of childhood obesity is clustered among children in low-socioeconomic groups. Social spending on children—public welfare expenditure on families and education—may curb childhood obesity by reducing socioeconomic disadvantages. The objective of this study was to examine the relationship between social spending on children and childhood obesity across the Organization for Economic Cooperation and Development (OECD) countries.

Design: Ecological study.

Setting: Data on social spending on children were obtained from the OECD Social Expenditure Database and the OECD educational finance indicators dataset during 2000−2015. Data on childhood obesity were obtained from the NCD Risk Factor Collaboration database. Data on other sociodemographic factors were obtained from the OECD.Stat database.

Participants: Aggregated statistics on obesity among children aged 5 to 19 years, estimated for OECD 35 countries based on the measured height and weight on 31.5 million children.

Outcome Measures: Country-level prevalence of obesity among children aged 5 to 19 years.

Results: In cross-sectional analyses in 2015, social spending on children was inversely associated with the prevalence of childhood obesity after adjusting for the gross domestic product (GDP) per capita, unemployment rate, poverty rate (partial correlations: ρ=−0.51; p<0.01 for girls and ρ=−0.43; p=0.01 for boys). In longitudinal analyses from 2000 to 2015, countries with greater increases in social spending on children had smaller increases in childhood obesity (ρ=−0.51; p<0.01 for girls and ρ=−0.42; p=0.02 for boys), after adjusting for the changes in GDP per capita, unemployment rate, and poverty rate. For girls, the dimensions of social spending that contributed to these associations between the changes in social spending on

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children and childhood obesity were early childhood education and care (ECEC) and school education; for boys, ECEC contributed most.

Conclusion: Countries that increase social spending on children tend to experience smaller increases in childhood obesity.

Keywords: Social medicine; Community child health; Health policy; International health services

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ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study that has investigated the relationship between public social spending on children and childhood obesity in the Organization for Economic Cooperation and Development (OECD) countries.
- We further focused on which dimensions of public social spending contributed most to these relationships.
- We did not focus on content and generosity of individual social policies nor private social spending. Future work should focus more on the impact of individual social policies on childhood obesity.
- Our findings were based on OECD countries' data and might not be generalizable to low- and middle-income countries.

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INTRODUCTION

The prevalence of childhood obesity has almost doubled in high-income countries during the last two decades. Current estimates suggest nearly one in ten children are obese.[1] Obesity in early life is an urgent public health issue due to its subsequent health consequences, including adult obesity,[2] early onset of non-communicable diseases,[3] premature death [3,4], and its influence on children's psychosocial development.[5] Childhood obesity is considered to have substantial economic burdens at the societal and individual level,[6,7]. Policymakers are increasingly responding to this growing public health crisis.

Although the proximal causes of this epidemic of obesity primarily are in individual behaviours such as higher consumption of food high in fat and sugar and increased sedentary behaviour,[8] these factors are shaped by upstream determinants related to socioeconomic conditions and the obesogenic environment.[9] Several studies have demonstrated that low-socioeconomic status of households is a risk factor for childhood obesity.[10,11] For example, those with both less education and lower family income are more likely to consume highly obesogenic fast foods.[12] Recognizing such social determinants of obesity, the World Health Organization (WHO) has recently recommended improving access to high-quality food in disadvantaged families in tandem with policies including taxation on unhealthy food and nutritional labels.[13] Besides these public health interventions, another possible approach is to reduce socioeconomic disadvantage itself, through social protection (e.g., income supplements for families and public investments in education).[14] Yet, less attention has been paid to the roles of such social protection policies in childhood obesity prevention. This gap partly relates to the difficulty of estimating social spending at the individual level.

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Although all high-income countries have social protection programs, there are large cross-national variations in their generosity.[15,16] *Social spending*—how much the government spends on social protection [17]—has been considered as an indicator to quantitatively gauge the generosity of social protection programs in a country or region. Several studies have recently recognized the importance of social spending as an indicator of macrosocial determinants of health and demonstrated the association between social spending and better population health outcomes including life expectancy, infant mortality, and low birth weight.[15,18] If the same macrosocial determinants are drivers of childhood obesity, increasing social spending on children will similarly operate as an upstream approach to curb childhood obesity. The possible mechanisms may include tax credits and paid parental leave, that increase or stabilize household income, or food vouchers offered to low-income families, which enable them to improve the quality of family meals.[19] Higher quality nutritional and physical education at school also encourages children to have a healthier diet and to be more active.[20] However, little is known so far about the relationship between gross public social spending on children and childhood obesity.

To bridge this knowledge gap, in this study, we sought to answer the following questions using data from the Organization for Economic Cooperation and Development (OECD) countries. First, is social spending on children associated with the prevalence of childhood obesity? Second, if so, which types of social spending contribute to this association? In this study, we focus on between-country differences, considering gross social spending as a macrosocial indicator. The mechanisms via which social spending may influence childhood obesity are

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numerous and, at the individual level, childhood obesity is likely better predicted by individual circumstance. To estimate the impact of macro-economic policies, we report on differences at this level.

METHODS

Study design and sample

We conducted a panel data analysis of 35 OECD countries using the NCD Risk Factor Collaboration (NCD-RisC) database,[21] which provides trends of childhood obesity during 1975−2016 in 200 countries. We examined social spending on children using (1) the OECD Social Expenditure Database (SOCX) [22] and (2) the OECD educational finance indicators dataset.[23] The SOCX database includes internationally comparable statistics on public social spending ("public" means "by the central, state, or local government" [17]) across 35 OECD countries. The spending is categorised into "old age," "survivors," "incapacity related," "family," "active labour market program," "unemployment," "housing," and "other social policy areas." We focused on the category "family" because this category is most likely to measure direct benefits to children.[24] Although we anticipate that children will benefit from indirect spending on, for example, unemployment programs and housing, including these categories would overestimate the sums reaching families with children). We did not include private social spending ("private" means that it came from other sources than the general government) because it was not available for most countries in the SOCX dataset. Although education is considered as an essential aspect of social spending,[16] while early childhood education and care [ECEC] is included in the SOCX datasets, spending on school education is not. Thus, we obtained information on public social spending on school education from the OECD's educational finance

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indicators dataset. Furthermore, we examined several country-level sociodemographic information, including the population of children aged < 20 years, the gross domestic product [GDP] per capita, unemployment rate, and poverty rate, using the OECD.Stat database.[25] We examined data during 2000−2015, for which reliable data on both childhood obesity and social spending were available. We excluded Lithuania from all analyses due to missing data in most years.

Measures

Prevalence of childhood obesity

We used the age-standardised prevalence (%) of childhood obesity among children aged 5 to 19 years (standardised to the WHO standard population), which has been estimated by sex using a Bayesian hierarchical model based on the measured height and weight on 31.5 million children.[21] Childhood obesity was defined as more than two standard deviations above the age and sex-specific WHO growth reference median.[26]

Social spending on children

Social spending on children was defined as the sum of (1) public social spending on family, which includes benefits on family allowance, maternal and parental leave, ECEC, and others (the components are shown in **eTable 1**),[22] and (2) public social spending on school education (primary to post-secondary non-tertiary). Specifically, public social spending on family includes (a) Child-related cash transfers to families with children, including income-tested child allowances, public income support payments during periods of parental leave, and income support for single-parent families; (b) public spending on services for families with children,

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including the direct subsidisation of childcare and ECEC facilities, public childcare support through earmarked payments to parents, and home help services for families; (c) financial support for families via the tax system, including child tax allowances and tax credits.[27] Public social spending on school education includes direct expenditure on educational institutions (e.g., public spending on instruction services, university research, and ancillary services such as meals and transport to schools) as well as education-related public subsidies given to households and administered by educational institutions.[23,28] Social spending on children was expressed as the purchasing power parity (PPP)-adjusted United States (US) dollars (fixed price, 2010 as the baseline year) per child aged < 20 years.

Statistical analysis

Basic social characteristics derived across the included OECD countries in 2015 were: GDP per capita (PPP-adjusted US dollars), unemployment rate (for the total population), poverty rate (the ratio of the number of people aged 18−65 years whose income falls below half the median household income of the total population, before tax and transfer), and children aged < 20 years as a percentage of total population.

Next, we cross-sectionally investigated the relationship between social spending on children and childhood obesity across OECD countries, using 2015 data. In doing so, we plotted the prevalence of childhood obesity against social spending on children and estimated the correlation between them using a Pearson's correlation. We also analysed the partial correlation between them, including three variables that could influence this relationship: GDP per capita, unemployment rate, and poverty rate. The analyses were separately conducted for each sex here

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(and hereafter) because the pattern of childhood obesity varied by sex across countries.[1] In this analysis, we substituted the latest year data for Denmark, Poland, Netherlands, and New Zealand, for which 2015 data on social spending were unavailable.

Then, we examined the longitudinal trends in social spending and childhood obesity during the period 2000−2015. To account for the difference in economic growth by countries, we first estimated the average annual growth in social spending on children adjusted by the growth in GDP per capita for each country using linear regression (**eMethod 1**). Next, we illustrated the association between the growth in social spending and childhood obesity by plotting the absolute change in the prevalence of childhood obesity from 2000 to 2015 against the average annual change in social spending on children for countries and estimating the correlation between them using a Pearson's correlation. We then analysed the partial correlation between them, including the unemployment rate and poverty rate. In this longitudinal analysis, we substituted the latest year data/the earliest year data when the 2015/2000 data were unavailable.

Finally, we aimed to examine which dimensions of social spending contributed to the relationship between the change in social spending on children and the change in childhood obesity. In doing so, we disaggregated social spending on children into five dimensions following the OECD's datasets: family allowance, maternal and parental leave, ECEC, school education, and other benefits. We estimated the average annual growth in social spending on each category adjusted by the growth in GDP per capita for each country using linear regression (**eMethod 1**). Then, we analysed a partial correlation of the change in childhood obesity with the growth in spending on each of the dimensions, after removing the effect of the growth in

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spending on all the other dimensions and the changes in the unemployment rate and poverty rate.[16] In this analysis, we examined 29 OECD countries for which information on all the dimensions of social spending on children were available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States were excluded). All analyses were conducted using Stata version 15 (College Station, TX; StataCorp LLC.).

Patient and public involvement

The current study involved secondary use of publicly available aggregated data. The study did not involve patients and the public in any way and did not require ethics review.

RESULTS

Basic characteristics across OECD countries

PPP-adjusted GDP per capita varied across OECD countries in 2015, ranging from $16,660 in Mexico to $87,825 in Luxembourg (**Table 1**). The unemployment rate was 7.9% on average, ranging from 3.4% in Japan to 24.9% in Greece. The poverty rate was 20.0% on average, ranging from 8.8% in Switzerland to 29.9% in Ireland. Children aged < 20 years accounted for 23.1% of the total population on average, ranging from 17.3% in Japan to 37.2% in Mexico.

Cross-sectional analysis of social spending and childhood obesity

The prevalence of childhood obesity varied across OECD countries in 2015, lowest in Japan (1.7% for girls and 5.0% for boys) and highest in New Zealand (14.7% and 17.1%) with the US as an outlier (19.3% and 23.0%) (**Figure 1**). There was considerable variation in PPP-adjusted social spending on children. Luxemburg was the highest spender, with social spending on

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children amounting to $24,350 per child. The lowest spender was Mexico, which spent $1,901 per child. When splitting countries into two groups (the upper versus lower half of the population proportion of children) and comparing social spending on children in 2015, there was no substantial difference (mean $10,785 versus $8,586; p=0.18 in Brunner-Munzel test). The relationship between social spending on children and the prevalence of childhood obesity was moderate and inverse for girls (Pearson's r=−0.32; p=0.06) and boys (r=−0.35; p=0.04). Since the US appeared to be an outlier for childhood obesity, we conducted a post-hoc estimation of correlation coefficients by excluding the US data, but the associations were qualitatively unchanged (r=−0.37; p=0.03 for girls and r=−0.40; p=0.02 for boys). Estimation of partial correlation illustrates the inverse associations were stronger after we accounted for GDP per capita, unemployment rate, and poverty rate (ρ=−0.51; p<0.01 for girls and ρ=−0.43; p=0.01 for boys).

Longitudinal analysis of social spending and childhood obesity

During the period 2000−2015, all countries experienced increases in the prevalence of childhood obesity, with the exception of girls in Denmark (**Figure 2**). When we examined the changes in social spending adjusted by the growth in GDP per capita and changes in the prevalence of childhood obesity, we observed a moderate inverse association between these variables for girls (Pearson's r=−0.49; p< 0.01) and a weak inverse association for boys (r=−0.28; p=0.10). After we further accounted for the changes in the unemployment rate and poverty rate, the inverse associations were stronger for girls (ρ=−0.51; p<0.01) and boys (ρ=−0.42; p=0.02).

Longitudinal analysis of disaggregated social spending and childhood obesity

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Patterns of spending on specific dimensions within the gross social spending figure varied considerably between countries (**Figure 3)**. On average, 14.5% of social spending on children was used for family allowance, 6.4% for maternal and parental leave, 12.4% for ECEC, 56.2% for school education, and 10.4% for other benefits in 2015. When we focused on the specific dimensions of social spending (**Table 2**), we found a moderate inverse association between the change in spending on ECEC and in the prevalence of childhood obesity for girls (Partial correlation ρ=−0.44; p=0.03) and boys (ρ=−0.45; p=0.03). The inverse relationship between the change in spending on school education and the growth in childhood obesity was moderate for girls (ρ=−0.41; p=0.04), but weak and statistically insignificant for boys (ρ=−0.18; p=0.48). Increasing social spending on family allowance had a weak inverse association with the growth in childhood obesity for both sexes, but we did not find statistical significance (ρ=−0.20; p=0.34 for both sexes). The change in social spending on maternal leave and other benefits were not associated with the growth in the prevalence of childhood obesity for either sex.

DISCUSSION

Among OECD countries, we found an inverse association between the growth in social spending on children and childhood obesity after adjusting for the growth in GDP per capita. This association persisted even when we accounted for the underlying difference in social factors that could drive social spending and childhood obesity, including the unemployment rate and poverty rate. What contributed most to this association was social spending on education: ECEC for both sexes, and social spending on school education also contributed notably for girls. Taken together, these results suggest that OECD countries whose social spending on children increase more tend to experience smaller increases in childhood obesity prevalence in a context where all countries

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except Denmark showed increasing prevalence in childhood obesity. These findings may highlight the importance of social protection programs as macrosocial determinants of childhood obesity. This is the first study that has investigated the relationship between social spending on children and childhood obesity.

It is not clear why the inverse association between social spending and childhood obesity exist, but the finding that the relationship between social spending on children and childhood obesity varies by dimensions of social spending may help to determine the possible mechanisms of this association. Specifically, it is notable that the inverse association with the growth in childhood obesity was strongest for the increase in spending on education. Social spending on ECEC was strongly associated with reduced obesity growth rates for both girls and boys, while school education was strongly associated with reduced growth of obesity among girls. Spending on education may enrich nutritional and physical activity environments that protect against obesity, such as higher quality school meals,[29,30] limited access to energy-dense competitive foods and beverages at school,[31,32] and better access to playing fields.[33] If the high-quality educational environment is protective against childhood obesity, we might predict that public ECEC spending would have a particularly important role since it will increase both quality (e.g. through increasing staff-to-child ratios) and uptake (in a context where ECEC is not mandatory in most OECD countries). For example, Norway is the highest ECEC spender, has mandatory subsidized childcare from 1 year, and provides the highest quality of ECEC among developed countries;[32] and has low growth in obesity rates within the OECD. This relationship with public ECEC spending is particularly interesting since maternal employment and use of childcare in the earliest years (largely financed privately) have been associated with higher rates of

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obesity.[34–36] Our finding supports the view that the reason early childcare is associated with obesity is that it is often lower quality and highly constrained,[36] suggesting the importance of public spending on high quality for reducing childhood obesity. In contrast, in the context of universal provision of school education, the school environment may be more important for girls than boys in influencing levels of physical activity.[37] Other possible mechanisms may be through children's health literacy and socioeconomic conditions in the future resulting from public investments in education.[38] However, without further breakdown of categories of social spending, we can only provide plausible suggestions for what might account for these observed associations.

Among the other dimensions of social spending on children, we observed a weak inverse association with the increase in the family allowance for both girls and boys. These cash benefits mitigate household financial strain and food insecurity.[39] Reductions in financial strain leave more funds available for the purchase of healthy food (e.g., fruits and vegetables) and reduce the consumption of fast food, especially among socioeconomically disadvantaged households.[11,40] Moreover, financial stability may reduce household-level stressors and contribute to a reduction in childhood obesity through biological mechanisms (e.g., by moderating cortisol levels) or improved eating habits.[41]

Our findings add to a body of work that has explored the relationship between social protection, especially social spending as its indicator, and population health outcomes. Bradley and colleagues demonstrated a link between public social spending and better population health measures in terms of life expectancy, infant mortality rate, and low birth weight across OECD

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countries.[15] They also found similar associations in the US between social spending and better health outcomes, including the lower prevalence of adult obesity.[18] A study by Shim further found that social spending on children, especially spending on the family allowance, was associated with reduced infant mortality in OECD 19 countries.[24] In Canada, Ng and Muntaner found that indicators of welfare generosity, including social spending on postsecondary education, were associated with reduced mortality.[42] Our study would extend these previous studies by further focusing on childhood obesity, one of the top public health issues in the modern context, and therefore reinforce the key roles of social protection policies and social spending as their indicator in population health.

Our study has limitations. First, as in any ecological study unmeasured confounding will have influenced our findings. For example, countries that spend more of social spending for families, may also spend more on public health activities for the prevention of childhood obesity (e.g., food labelling and sugar tax) or other social protection programs that can be protective against childhood obesity at the population level (e.g., housing and labour market programs).[43,44] Second, our study was unable to identify the exact mechanisms through which social spending was inversely associated with childhood obesity, even though we broke down social spending into several dimensions. We did not have information on individual social policies (e.g., child care quality and availability or free school meals), and it was difficult to isolate the effect of individual social policies. Nevertheless, our findings suggest that public social spending in the broadest sense may be an important macro-level indicator of child health and wellbeing, such as childhood obesity. Future work should focus more directly on the impact of individual social policies on childhood obesity. Third, the change in social spending on children does not appear

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to explain all the variation of the growth in the prevalence of childhood obesity. For example, Japan, Belgium, and Denmark had a smaller growth in childhood obesity compared to the fitted lines, while several countries, including Hungary, Mexico, and Turkey, experienced a larger growth. Therefore, even when this association is causal, the effect of increasing social spending on children on the prevalence of childhood obesity in an individual country may differ by the country's characteristics such as economic inequalities and cultural factors related to food and physical activity. Fourth, our study captures obesity across a wide age range (5-19 years), while many of these policies are age dependent (e.g. school impacts are likely to be cumulative after school starting age). Fifth, our analysis did not include private social spending. Private social spending may act to partially counter the redistributive impact of public social spending.[45] Further studies on how changes in the public and private mix in social spending may affect childhood obesity may be required.

Our findings were based on OECD countries' data and might not be generalizable to low- and middle-income countries.

In summary, we found that OECD countries whose social spending on children increased more tended to experience a smaller increase in childhood obesity. This association appeared to be explained mainly by the change in social spending on early childhood education and care and school education. Our findings may highlight the importance of social spending as a macrosocial indicator in childhood obesity.

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AUTHOR CONTRIBUSTIONS

A.M. and C.E. conceived the study design. A.M. analysed data. A.M., C.E., P.L., and Y.K. interpreted the data. All authors contributed to the draft manuscript and have approved the final version.

DATA STATEMENT

The datasets are available from the following websites: NCD-RisC datasets (http://ncdrisc.org), OECD SOCX datasets (https://www.oecd.org/social/expenditure.htm), and the public spending on education datasets (https://www.oecd-ilibrary.org/education/public-spending-on-education/indicator/english_f99b45d0-en).

CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

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Table 1. Characteristics of Organization for Economic Cooperation and Development 35 countries in 2015

Country	GDP per capita (US dollars)	Unemployment rate (%)	Poverty rate (%)	Children aged < 20 (% of population)
Australia	45,584	6.1	18.6	25.1
Austria	42,906	5.7	20.9	19.7
Belgium	40,900	8.5	24.5	22.6
Canada	42,498	6.9	20.0	22.0
Chile	20,789	6.2	14.5	28.0
Czech Republic	29,874	5.0	17.3	19.7
Denmark	44,760	6.2	18.7	23.1
Estonia	26,023	6.2	20.0	20.6
Finland	38,272	9.4	23.5	21.9
France	36,902	10.4	26.2	24.6
Germany	42,503	4.6	20.0	18.4
Greece	23,649	24.9	28.9	19.4
Hungary	24,254	6.8	24	19.7
Iceland	43,726	4.0	11.5	27.0
Ireland	58,229	9.9	29.9	27.7
Israel	31,221	5.2	18.8	36.4
Italy	33,164	11.9	23.9	18.4
Japan	37,036	3.4	18.4	17.3
Latvia	22,237	9.9	19.9	19.4
Luxembourg	87,825	6.7	25.0	22.6
Mexico	16,660	4.3	16.6	37.2
Netherlands	45,855	6.9	20.1	22.6
New Zealand	33,981	5.4	15.2	26.8
Norway	59,430	4.3	18.1	24.4
Poland	24,170	7.5	21.2	20.4
Portugal	26,677	12.4	22.9	19.6
Slovakia	28,423	11.5	16.8	20.7
Slovenia	28,203	9.0	21.4	19.4
South Korea	34,193	3.6	13.5	20.1
Spain	31,753	22.1	28.8	19.8
Sweden	44,832	7.4	14.5	22.8
Switzerland	54,453	4.8	8.8	20.3
Turkey	22,709	10.2	15.3	32.7
United Kingdom	38,723	5.3	20.8	23.7
United States (US)	52,105	5.3	19.8	25.7
OECD 35 average	37,558	7.9	20.0	23.1

GDP: gross domestic product. The GDP per capita was measured as purchasing power parity adjusted US dollars (fixed price, 2010 as the baseline year). Poverty rate show the ratio of the number of people aged 18−65 whose income falls below half the median household income of the total population, before tax and transfer.

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Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's $r = -0.32$; $p = 0.06$ for girls and $r = -0.35$; $p = 0.04$ for boys).

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Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's $r = -0.49$; $p < 0.01$ for girls and $r = -0.28$; $p = 0.10$ for boys).

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Figure 3. Specific dimensions of social spending on children in OECD countries compared with the OECD averages in 2015

Source: Authors' analysis of data from Organization for Economic Cooperation and Development (OECD) Social Expenditure Database (SOCX).
Notes: Specific dimensions of social spending on children are shown for 29 OECD countries for which the information on all the dimensions of social spending on children are available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States are excluded). The OECD mean is calculated for these 29 countries. ECEC: Early childhood education and care.

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Table 2. Correlation coefficients: Changes in social spending on children by changes in the prevalence of childhood obesity by dimensions of social spending (period 2000 to 2015)

Types of social spending	Partial correlation coefficients	P values
Girls		
Family allowance	−0.20	0.34
Maternal and parental leave	0.06	0.77
ECEC	−0.44	0.03
Education	−0.41	0.04
Others	0.09	0.66
Boys		
Family allowance	−0.20	0.34
Maternal and parental leave	0.08	0.71
ECEC	−0.45	0.03
Education	−0.18	0.48
Others	0	0.98

The analyses were conducted for 31 countries. South Korea, Luxembourg, Mexico, and United States of America were excluded because of the average annual change in either dimension of social spending or the average annual change in unemployment rate or poverty rate cannot be calculated because data for more than two years are not available.

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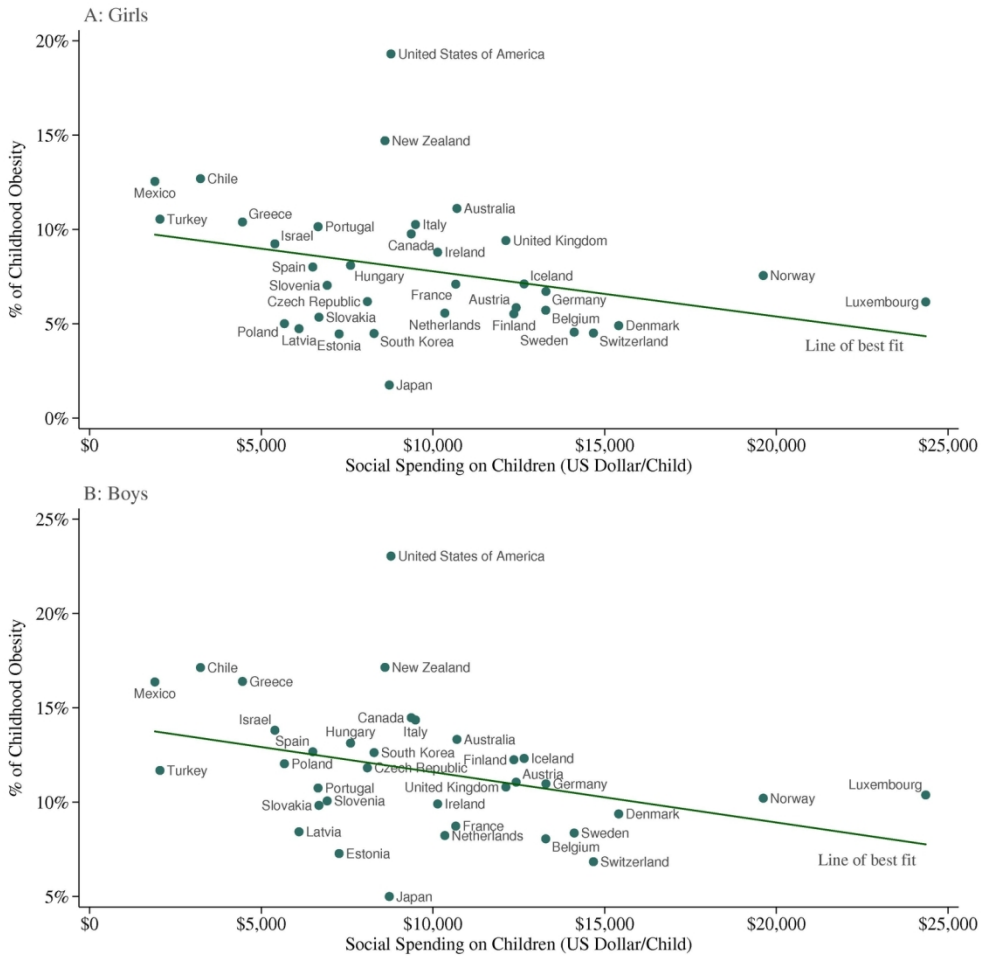

Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's r = −0.32; p = 0.06 for girls and r = −0.35; p = 0.04 for boys).

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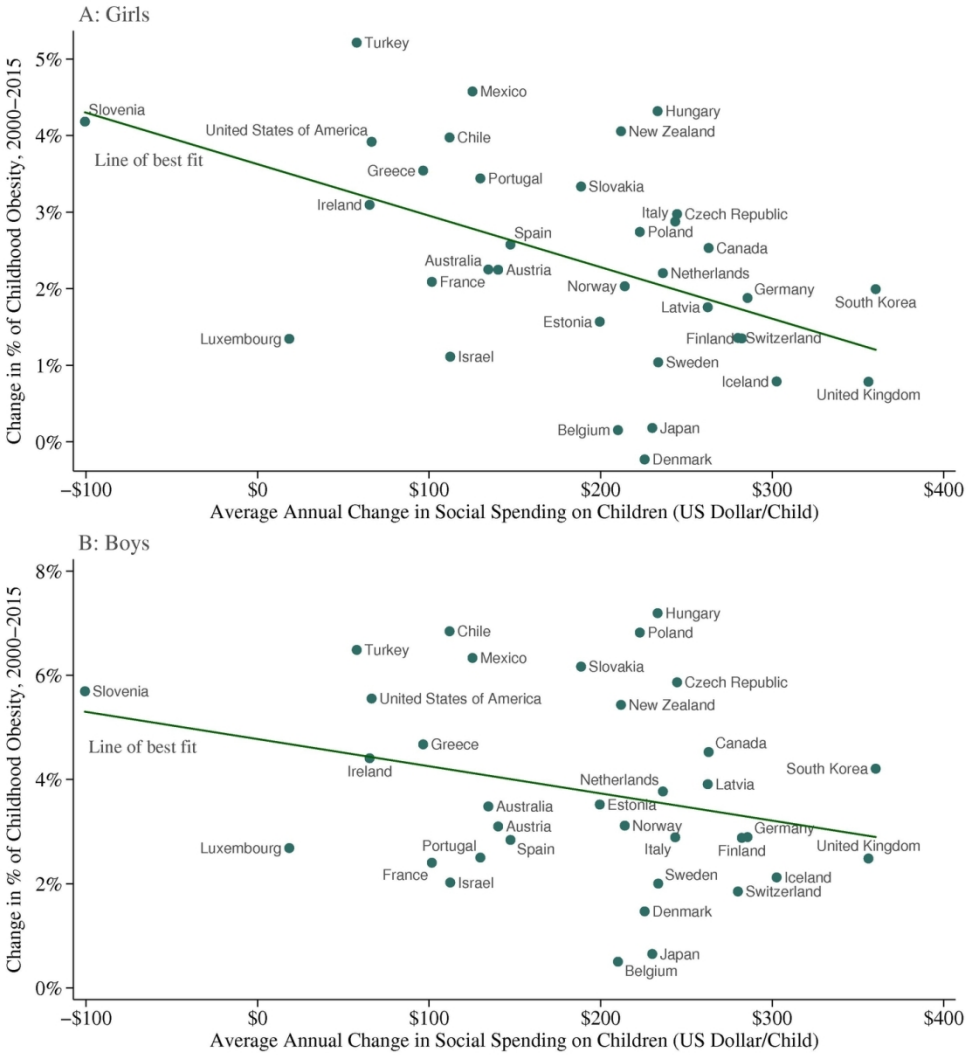

Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's r = −0.49; p <0.01 for girls and r = −0.28; p = 0.10 for boys).

127x139mm (300 x 300 DPI)

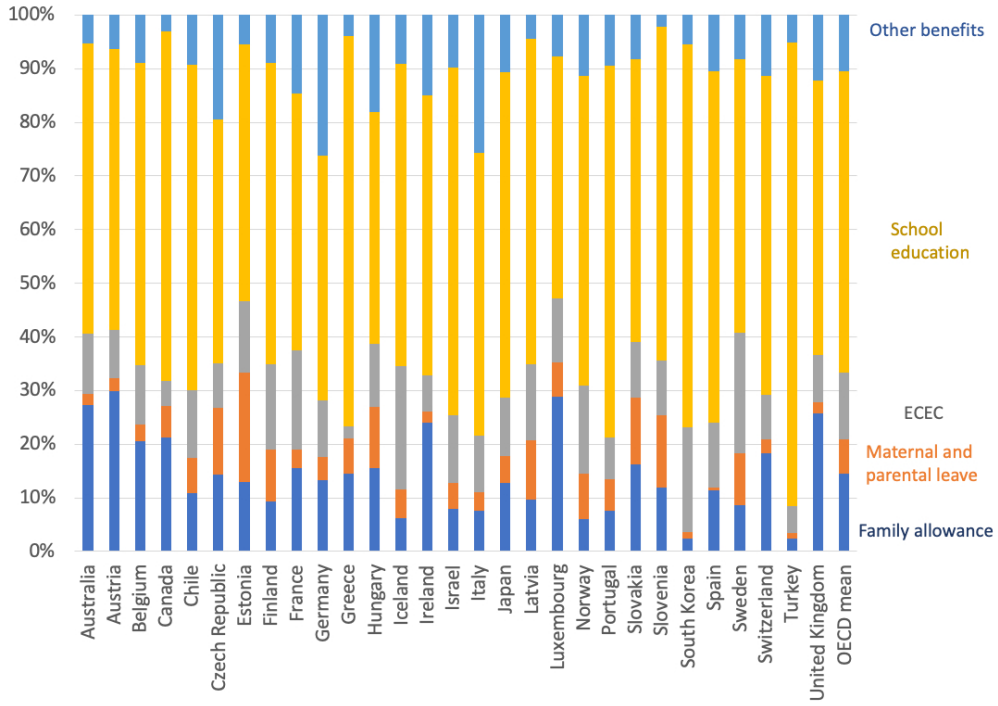

Figure 3. Specific dimensions of social spending on children in OECD countries compared with the OECD averages in 2015

Source: Authors' analysis of data from Organization for Economic Cooperation and Development (OECD) Social Expenditure Database (SOCX).
Notes: Specific dimensions of social spending on children are shown for 29 OECD countries for which the information on all the dimensions of social spending on children are available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States are excluded). The OECD mean is calculated for these 29 countries. ECEC: Early childhood education and care.

254x190mm (108 x 108 DPI)

Appendix

Relationships between Social Spending and Childhood Obesity in High-Income Countries: More Welfare, Less Obesity?

eTable 1. Details of each dimension in social spending on family

Dimensions	Details
Family allowances (Cash benefits / Tax break)	Family allowance
	Family income supplement
	Family allowance supplement
	Basic family payment
	Additional family payment
	Home child care allowance
	Family tax payment
	Family tax benefit (Part A and B)
	More help for families–one-off payments
	Parenting payment (Single and Partnered)
	Single Income Family Bonus (2008)
	Back to School Bonus (2008)
	Economic Security Strategy (2008)
	Single Income Family Supplement
	Schoolkids Bonus
Maternity and parental leave (Cash benefits / Tax break)	Maternity allowances
	Maternity immunization allowance
	Baby Bonus (previously Maternity payment)
	Parental Leave Pay
	Dad and Partner Pay
	Stillborn Baby Payment
Early childhood education and care (ECEC) (Benefits in kind)	National Partnernships on Early Childhood Education and Care - National Occasional Care
	Support for the Child Care System - Child Care Communications Campaign
	Child care support
	Child care for eligible parents undergoing training
	Support for child care
	Support for child care: specific purpose payment
	Child care benefit
	Child care (pre-primary education)
	Child care (pre-primary education - 4-5yo)
	Child Care Tax Rebate
	Support for the Child Care System - Child Care Services Support
	Support for the Child Care System - Job Education and Training
	Child Care Fee Assistance - Child Care Benefit
	Child Care Fee Assistance - Child Care Rebate
	National Partnerships on Early Childhood Education and Care - Indigenous Early Childhood Development Children and Family Centers
	National Partnerships on Early Childhood Education and Care - TAFE Fee Waivers for Child Care Qualifications
	National Partnerships on Early Childhood Education and Care - National Quality Agenda

	State/Territory Child Care Expenditure
	National Partnership on Universal Access to Early Childhood Education
	Early Childhood Education - 4 and 5 year olds in ISCED 1 (Primary school)
Others (Cash benefits / Tax break)	Supporting parent's benefit
	Sole parents pension
	Partner allowance (pension)
	Parenting allowance
	Assistance for Isolated Children
Others (Benefits in kind)	Home help / Accommodation
	Parenting
	Family support services scheme
	Child abuse prevention
	Family violence partnership
	Family violence regional activities
	Grants to family relationship support organizations
	Indigenous parenting and family well-being
	National illicit drug strategy
	Services for families with children
	Stronger families and communities strategy: families initiative
	Services for families with children: specific purpose payment
	Pre-school education
	Family and child welfare - State and Territory
	Child protection and out-of-home care services - State and Territory
	Family Support
	Find and Connect
	Families and Children

Source: OECD's Social Expenditure Database (SOCX).

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eMethod 1. Technical appendix

I regressed the average annual growth in social spending on the average annual growth in GDP per capita and calculated the residuals. Then, I calibrated them by adding the average of annual growth in social spending so that "cross-national mean of adjusted average annual growth in social spending" = "cross-national mean of unadjusted average annual growth in social spending."

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	#3	State specific objectives, including any prespecified hypotheses	7-8
Methods			
Study design	#4	Present key elements of study design early in the paper	8
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	8

		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	8
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-9
Bias	#9	Describe any efforts to address potential sources of bias	11
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	11
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	11
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	13
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	12
Participants	#13b	Give reasons for non-participation at each stage	12
Participants	#13c	Consider use of a flow diagram	N/A

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Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	12
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	12
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	12-13
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-14
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	14
Discussion			
Key results	#18	Summarise key results with reference to study objectives	14
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	17
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	14-17
Generalisability	#21	Discuss the generalisability (external validity) of the study results	18
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

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Relationships between Social Spending and Childhood Obesity in OECD Countries: More Welfare, Less Obesity?

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Relationships between Social Spending and Childhood Obesity in OECD Countries: More Welfare, Less Obesity?

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Running title: Social Spending and Childhood Obesity

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Number of figures: 2

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ABSTRACT (300 words)

Objectives: The burden of childhood obesity is clustered among children in low-socioeconomic groups. Social spending on children—public welfare expenditure on families and education—may curb childhood obesity by reducing socioeconomic disadvantages. The objective of this study was to examine the relationship between social spending on children and childhood obesity across the Organization for Economic Cooperation and Development (OECD) countries.

Design: Ecological study.

Setting: Data on social spending on children were obtained from the OECD Social Expenditure Database and the OECD educational finance indicators dataset during 2000−2015. Data on childhood obesity were obtained from the NCD Risk Factor Collaboration database.

Participants: Aggregated statistics on obesity among children aged 5 to 19 years, estimated for OECD 35 countries based on the measured height and weight on 31.5 million children.

Outcome Measures: Country-level prevalence of obesity among children aged 5 to 19 years.

Results: In cross-sectional analyses in 2015, social spending on children was inversely associated with the prevalence of childhood obesity after adjusting for potential confounders (the gross domestic product per capita, unemployment rate, poverty rate, percentage of children aged < 20 years and prevalence of childhood obesity in 2000). In addition, when we focused on changes from 2000 to 2015, an average annual increase of 100 US dollars in social spending per child was associated with a decrease in childhood obesity by 0.6 percentage points for girls (p = 0.007) and 0.7 percentage points for boys (p = 0.04) between 2000 and 2015, after adjusting for the potential confounders. The dimensions of social spending that contributed to these

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associations between the changes in social spending on children and childhood obesity were early childhood education and care (ECEC) and school education for girls and ECEC for boys.

Conclusion: Countries that increase social spending on children tend to experience smaller increases in childhood obesity.

Keywords: Social medicine; Community child health; Health policy; International health services

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ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study that has investigated the relationship between public social spending on children and childhood obesity in the Organization for Economic Cooperation and Development (OECD) countries.
- We further focused on which dimensions of public social spending contributed most to these relationships.
- We did not focus on content and generosity of individual social policies nor private social spending. Future work should focus more on the impact of individual social policies on childhood obesity.
- Although our sample included high- and higher middle-income countries, findings were based on OECD countries' data and might not be generalizable to countries outside of this group.

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INTRODUCTION

The prevalence of childhood obesity has almost doubled in high-income countries during the last two decades. Current estimates suggest nearly one in ten children are obese.[1] Obesity in early life is an urgent public health issue due to its subsequent health consequences, including adult obesity,[2] early onset of non-communicable diseases,[3] premature death [3,4], and its influence on children's psychosocial development.[5] Childhood obesity is considered to have substantial economic burdens at the societal and individual level,[6,7]. Policymakers are increasingly responding to this growing public health crisis.

Although the proximal causes of this epidemic of obesity primarily are in individual behaviours such as higher consumption of food high in fat and sugar and increased sedentary behaviour,[8] these factors are shaped by upstream determinants related to socioeconomic conditions and the obesogenic environment.[9] Several studies have demonstrated that low-socioeconomic status of households is a risk factor for childhood obesity.[10,11] For example, those with both less education and lower family income are more likely to consume highly obesogenic fast foods.[12] Recognizing such social determinants of obesity, the World Health Organization (WHO) has recently recommended improving access to high-quality food in disadvantaged families in tandem with policies including taxation on unhealthy food and nutritional labels.[13] Besides these public health interventions, another possible approach is to reduce socioeconomic disadvantage itself, through social protection (e.g., income supplements for families and public investments in education).[14] Although there is a growing literature on the importance of social protection on adult obesity,[15–17] less attention has been paid to the roles of such social

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protection policies in childhood obesity prevention. This gap partly relates to the difficulty of estimating social spending at the individual level.

Although all high-income countries have social protection programs, there are large cross-national variations in their generosity.[18,19] *Social spending*—how much the government spends on social protection [20]—has been considered as an indicator to quantitatively gauge the generosity of social protection programs in a country or region. Several studies have recently recognized the importance of social spending as an indicator of macrosocial determinants of health and demonstrated the association between social spending and better population health outcomes including life expectancy, infant mortality, and low birth weight.[18,21] If the same macrosocial determinants are drivers of childhood obesity, increasing social spending on children will similarly operate as an upstream approach to curb childhood obesity. The possible mechanisms may include tax credits and paid parental leave, that increase or stabilize household income, or food vouchers offered to low-income families, which enable them to improve the quality of family meals.[22] Higher quality nutritional and physical education at school also encourages children to have a healthier diet and to be more active.[23] However, little is known so far about the relationship between gross public social spending on children and childhood obesity.

To bridge this knowledge gap, in this study, we sought to answer the following questions using data from the Organization for Economic Cooperation and Development (OECD) countries. First, is social spending on children associated with the prevalence of childhood obesity? Second, if so, which types of social spending contribute to this association? In this study, we

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focus on between-country differences, considering gross social spending as a macrosocial indicator. The mechanisms via which social spending may influence childhood obesity are numerous and, at the individual level, childhood obesity is likely better predicted by individual circumstance. To estimate the impact of macro-economic policies, we report on differences at this level.

METHODS

Study design and sample

We conducted a panel data analysis of 35 OECD countries using the NCD Risk Factor Collaboration (NCD-RisC) database,[24] which provides trends of childhood obesity during 1975−2016 in 200 countries. We examined social spending on children using (1) the OECD Social Expenditure Database (SOCX) [25] and (2) the OECD educational finance indicators dataset.[26] The SOCX database includes internationally comparable statistics on public social spending ("public" means "by the central, state, or local government" [20]) across 35 OECD countries. The spending is categorised into "old age," "survivors," "incapacity related," "family," "active labour market program," "unemployment," "housing," and "other social policy areas." We focused on the category "family" because this category is most likely to measure direct benefits to children.[27] Although we anticipate that children will benefit from indirect spending on, for example, unemployment programs and housing, including these categories would overestimate the sums reaching families with children. We did not include private social spending ("private" means that it came from other sources than the general government) because it was not available for most countries in the SOCX dataset. Although education is considered as an essential aspect of social spending,[19] spending on school education is not included in the

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SOCX datasets (early childhood education and care [ECEC] is included). Thus, we obtained information on public social spending on school education from the OECD's educational finance indicators dataset. Furthermore, we examined several country-level sociodemographic variables, including the population of children aged < 20 years, the gross domestic product [GDP] per capita, unemployment rate, and poverty rate, using the OECD.Stat database.[28] We examined data during 2000−2015, for which reliable data on both childhood obesity and social spending were available. We excluded Lithuania from all analyses due to missing data in most years.

Measures

Outcome variable: Prevalence of childhood obesity

We used the age-standardised prevalence (%) of childhood obesity among children aged 5 to 19 years (standardised to the WHO standard population), which has been estimated by sex using a Bayesian hierarchical model based on the measured height and weight on 31.5 million children.[24] Childhood obesity was defined as more than two standard deviations above the age and sex-specific WHO growth reference median.[29]

Exposure variable: Social spending on children

Our primary exposure variable was total social spending on children, which was defined as the sum of (1) public social spending on family, which includes benefits on family allowance, maternal and parental leave, ECEC, and others (the components are shown in **online supplemental table Table S1**),[25] and (2) public social spending on school education (primary to post-secondary non-tertiary). Specifically, public social spending on family includes (a) Child-related cash transfers to families with children, including income-tested child allowances, public

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income support payments during periods of parental leave, and income support for single-parent families; (b) public spending on services for families with children, including the direct subsidisation of childcare and ECEC facilities, public childcare support through earmarked payments to parents, and home help services for families; (c) financial support for families via the tax system, including child tax allowances and tax credits.[30] Public social spending on school education includes direct expenditure on educational institutions (e.g., public spending on instruction services, university research, and ancillary services such as meals and transport to schools) as well as education-related public subsidies given to households and administered by educational institutions.[26,31] Social spending on children was expressed as the purchasing power parity (PPP)-adjusted United States (US) dollars (fixed price, 2010 as the baseline year) per child aged < 20 years.

Our secondary exposure variables were five dimensions of social spending on children (family allowance, maternal and parental leave, ECEC, school education, and other benefits). This disaggregation of social spending on children was conducted following the OECD's datasets to examine which dimensions of social spending contributed to the relationship between the social spending on children and childhood obesity.

Adjustment variables

We adjusted for countries' demographics and the "baseline" prevalence of childhood obesity in 2000. Demographics consisted of three economic indicators (GDP per capita, unemployment rate and poverty rate) and the percentage of children aged < 20 years, because these factors could affect both the social spending on children [19] and the prevalence of childhood obesity. The

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"baseline" prevalence of childhood obesity was also included as countries that had suffered from high obesity prevalence in the past may invest more in social programs to mitigate against childhood obesity.

Statistical analysis

Basic social characteristics derived across the included OECD countries in 2015 were: GDP per capita (PPP-adjusted US dollars), unemployment rate (for the total population), poverty rate (the ratio of the number of people aged 18−65 years whose income falls below half the median household income of the total population, before tax and transfer), and children aged < 20 years as a percentage of total population.

Next, we cross-sectionally investigated the relationship between total social spending on children and childhood obesity across OECD countries, using 2015 data. We plotted the prevalence of childhood obesity against social spending on children and estimated the correlation between them using a Pearson's correlation. We also examined the association between them, by using a multivariable linear regression model that adjusted for the demographic indicators (GDP per capita, unemployment rate, poverty rate, and percentage of children aged < 20 years) in 2015, and the prevalence of childhood obesity in 2000. The analyses were separately conducted for each sex here (and hereafter) because the pattern of childhood obesity varied by sex across countries.[1] In this analysis, we substituted the latest year data for Denmark, Poland, Netherlands, and New Zealand, for which 2015 data on social spending were unavailable.

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Then, to effectively investigate the association between social spending on children and childhood obesity within the same country, we examined the longitudinal trends in total social spending on children and childhood obesity during the period 2000−2015. To account for the difference in economic growth by countries, we first estimated the average annual growth in social spending on children adjusted by the growth in GDP per capita for each country using linear regression (**online supplemental method S1**). Next, we illustrated the association between the growth in social spending and childhood obesity by plotting the absolute change in the prevalence of childhood obesity from 2000 to 2015 against the average annual change in social spending on children for countries and estimating the correlation between them using a Pearson's correlation. We then investigated the association between them, by using a multivariable linear regression model that adjusted for the changes in demographic indicators (unemployment rate, poverty rate, and percentage of children aged < 20 years) from 2000 to 2015 and the prevalence of childhood obesity in 2000. In this longitudinal analysis, we substituted the latest year data/the earliest year data when the 2015/2000 data were unavailable.

Finally, we used the secondary exposure variables, by replacing total social spending on children with five dimensions of social spending on children (family allowance, maternal and parental leave, ECEC, school education, and other benefits), and repeated multivariable linear regressions.[16] In this analysis, we examined 29 OECD countries for which information on all the dimensions of social spending on children were available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States were excluded). All analyses were conducted using Stata version 15 (College Station, TX; StataCorp LLC.). $P<0.05$ was considered as statistically significant.

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Post-hoc analyses

To investigate potential heterogeneous effects according to economic development, we divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group (i.e., countries with lower vs countries with upper GDP per capita).

Patient and public involvement

The current study involved secondary use of publicly available aggregated data. The study did not involve patients and the public in any way and did not require ethics review.

RESULTS

Basic characteristics across OECD countries

PPP-adjusted GDP per capita varied across OECD countries in 2015, ranging from $16,660 in Mexico to $87,825 in Luxembourg (**Table 1**). The unemployment rate was 7.9% on average, ranging from 3.4% in Japan to 24.9% in Greece. The poverty rate was 20.0% on average, ranging from 8.8% in Switzerland to 29.9% in Ireland. Children aged < 20 years accounted for 23.1% of the total population on average, ranging from 17.3% in Japan to 37.2% in Mexico.

Cross-sectional analysis of social spending and childhood obesity

The prevalence of childhood obesity varied across OECD countries in 2015, lowest in Japan (1.7% for girls and 5.0% for boys) and highest in New Zealand (14.7% and 17.1%) with the US as an outlier (19.3% and 23.0%) (**Figure 1**). There was considerable variation in PPP-adjusted social spending on children. Luxemburg was the highest spender, with social spending on

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children amounting to $24,350 per child. The lowest spender was Mexico, which spent $1,901 per child. When splitting countries into two groups (the upper versus lower half of the population proportion of children) and comparing social spending on children in 2015, there was no substantial difference (mean $10,785 versus $8,586; p=0.18 in Brunner-Munzel test). The relationship between social spending on children and the prevalence of childhood obesity was moderate and inverse for girls (Pearson's r=−0.32; p=0.06) and boys (r=−0.35; p=0.04). Since the US appeared to be an outlier for childhood obesity, we conducted a post-hoc estimation of correlation coefficients by excluding the US data, but the associations were qualitatively unchanged (r=−0.37; p=0.03 for girls and r=−0.40; p=0.02 for boys). After we adjusted for potential confounders (**Table 2**), we found that countries with higher total social spending on children experienced lower prevalence of childhood obesity ($\beta = -0.3 \times 10^{-3}$; $p = 0.01$ for girls and $\beta = -0.4 \times 10^{-3}$; $p = 0.02$ for boys).

Longitudinal analysis of social spending and childhood obesity

During the period 2000−2015, all countries experienced increases in the prevalence of childhood obesity, with the exception of girls in Denmark (**Figure 2**). When we examined the changes in social spending adjusted by the growth in GDP per capita and changes in the prevalence of childhood obesity, we observed a moderate inverse association between these variables for girls (Pearson's r=−0.49; p< 0.01) and a weak inverse association for boys (r=−0.28; p=0.10). After we adjusted for potential confounders (**Table 3**), we found that countries with greater increases in total social spending on children also had smaller increases in the prevalence of childhood obesity ($\beta = -0.6 \times 10^{-2}$; $p = 0.007$ for girls and $\beta = -0.7 \times 10^{-2}$; $p = 0.04$ for boys). These estimates indicate that a 100 US dollars average annual increase (adjusted by PPP and GDP per

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capita) per child was associated with a decline in childhood obesity between 2000 and 2015 by 0.6% for girls and 0.7% for boys.

Disaggregated social spending and childhood obesity

Patterns of spending on specific dimensions within the gross social spending figure varied considerably between countries (**online supplemental figure S1)**. On average, 14.5% of social spending on children was used for family allowance, 6.4% for maternal and parental leave, 12.4% for ECEC, 56.2% for school education, and 10.4% for other benefits in 2015. When we focused on the specific dimensions of social spending in cross-sectional analyses (**Table 2**), we found no evidence that either dimension of social spending on children was associated with the prevalence of childhood obesity. However, when we focused on the changes over time (**Table 3**), we found an inverse association between the change in spending on ECEC and in the prevalence of childhood obesity for girls ($\beta = -1.2 \times 10^{-2}$; $p = 0.045$) and boys ($\beta = -2.1 \times 10^{-2}$; $p = 0.049$). We also found an inverse relationship between the change in spending on school education and the growth in childhood obesity for girls ($\beta = -1.1 \times 10^{-2}$; $p = 0.01$), but not for boys ($\beta = -0.5 \times 10^{-2}$; $p = 0.43$). The change in social spending on family allowance, maternal leave and other benefits were not associated with the growth in the prevalence of childhood obesity for either sex.

Post-hoc analyses

In the stratified analyses according to GDP per capita in 2000, we found that the cross-sectional inverse relationship between total social spending on children and prevalence of childhood obesity was observed only in countries with higher GDP per capita (p=0.03 for girls and p=0.04

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for boys) (**online supplemental table S2**). In longitudinal analyses, the coefficients for the association between the changes in total social spending and changes in the prevalence of childhood obesity remained negative; however, they did not reach statistical significance regardless of the level of GDP per capita and sex (**online supplemental table S3**).

DISCUSSION

Among OECD countries, we found an inverse association between the growth in social spending on children and childhood obesity, after accounting for the underlying difference in social factors that could drive social spending and childhood obesity. What contributed most to this association was social spending on education: ECEC for both sexes, and social spending on school education also contributed notably for girls. These results suggest that OECD countries whose social spending on children increase more tend to experience smaller increases in childhood obesity prevalence in a context where all countries except Denmark showed increasing prevalence in childhood obesity. These findings may highlight the importance of social protection programs as macrosocial determinants of childhood obesity.

It is not clear why the inverse association between social spending and childhood obesity exist, but the finding that the relationship between social spending on children and childhood obesity varies by dimensions of social spending may help to determine the possible mechanisms of this association. Notably, social spending on ECEC was associated with reduced obesity growth rates for both girls and boys. Moreover, school education was associated with reduced growth of obesity among girls. Spending on these education categories may enrich nutritional and physical activity environments that protect against obesity, such as higher quality school meals,[32,33]

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limited access to energy-dense competitive foods and beverages at school,[34,35] and better access to playing fields.[36] Conversely, schools under financial pressures may adopt unhealthy food policy (sales or advertising of snack foods) in schools or cancel gym classes in order to improve school budgets.[37] If the high-quality educational environment is protective against childhood obesity, we might predict that public ECEC spending would have a particularly important role since it will increase both quality (e.g. through increasing staff-to-child ratios) and uptake (in a context where ECEC is not mandatory in most OECD countries). For example, Norway is the highest ECEC spender, has mandatory subsidized childcare from 1 year, and provides the highest quality of ECEC among developed countries;[35] and has low growth in obesity rates within the OECD. This relationship with public ECEC spending is particularly interesting since maternal employment and use of childcare in the earliest years (largely financed privately) have been associated with higher rates of obesity.[38–40] Our finding supports the view that the reason early childcare is associated with obesity is that it is often lower quality and highly constrained,[40] suggesting the importance of public spending on high quality care for reducing childhood obesity. In contrast, in the context of universal provision of school education, the school environment may be more important for girls than boys in influencing levels of physical activity.[41] However, this mechanism may depend on the social context; another study in the US showed that the protective effect of increased physical education on obesity was concentrated among boys because girls substituted physical education for other activities.[42] Other possible mechanisms may be through children's health literacy and socioeconomic conditions in the future resulting from public investments in education.[43] However, without further breakdown of categories of social spending, we can only provide plausible suggestions for what might account for these observed associations.

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Comparison with other studies

Our findings add to a body of work that has explored the relationship between social protection, especially social spending as its indicator, and population health outcomes. Bradley and colleagues demonstrated a link between public social spending and better population health measures in terms of life expectancy, infant mortality rate, and low birth weight across OECD countries.[18] They also found similar associations in the US between social spending and better health outcomes, including the lower prevalence of adult obesity.[21] A study by Shim further found that social spending on children, especially spending on the family allowance, was associated with reduced infant mortality in OECD 19 countries.[27] In Canada, Ng and Muntaner found that indicators of welfare generosity, including social spending on postsecondary education, were associated with reduced mortality.[44] There is also a growing literature on the effect of social programmes and education on adult obesity.[15–17] Our study extends these previous studies by further focusing on childhood obesity, one of the top public health issues in the modern context, and therefore reinforces the key roles of social protection policies and social spending as their indicator in population health.

Strengths and limitations of this study

This is the first study that has investigated the relationship between social spending on children and childhood obesity. We further focused on which dimensions of public social spending contributed most to these relationships. Moreover, we tested the association between social spending and childhood obesity more robustly by examining the association between longitudinal changes as well as cross-sectional relationships. This would have helped to adjust

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for unobserved country-specific characteristics. For example, the fact that the US was a clear outlier in the cross-sectional analysis might be due to the country's traditional food and agricultural policies that encourages overconsumption.[45] These factors would have been effectively controlled for in the longitudinal analysis but not in the cross-sectional analysis.

Our study has limitations. First, as in any ecological study unmeasured confounding will have influenced our findings. For example, countries that spend more of social spending for families, may also spend more on public health activities for the prevention of childhood obesity (e.g., food labelling and sugar tax) or other social protection programs that can be protective against childhood obesity at the population level (e.g., housing and labour market programs).[46,47] Second, we analysed only 35 countries at most, which limits the number of possible adjustment variables that could be included in the regression analyses. Third, our study was unable to identify the exact mechanisms through which social spending was inversely associated with childhood obesity, even though we broke down social spending into several dimensions. We did not have information on individual social policies (e.g., child care quality and availability or free school meals), and it was difficult to isolate the effect of individual social policies. Nevertheless, our findings suggest that public social spending in the broadest sense may be an important macro-level indicator of child health and wellbeing, such as childhood obesity. Future work should focus more directly on the impact of individual social policies on childhood obesity. Fourth, the change in social spending on children does not appear to explain all the variation of the growth in the prevalence of childhood obesity. For example, Japan, Belgium, and Denmark had a smaller growth in childhood obesity compared to the fitted lines, while several countries, including Hungary, Mexico, and Turkey, experienced a larger growth. Therefore, even when this

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association is causal, the effect of increasing social spending on children on the prevalence of childhood obesity in an individual country may differ by the country's characteristics such as economic inequalities and cultural factors related to food and physical activity. Fifth, our study captures obesity across a wide age range (5-19 years), while many of these policies are age dependent (e.g. school impacts are likely to be cumulative after school starting age). Finally, our analysis did not include private social spending. Private social spending may act to partially counter the redistributive impact of public social spending.[48] Further studies on how changes in the public and private mix in social spending may affect childhood obesity may be required.

Although our sample includes both high- and higher middle-income countries, findings were based on OECD countries' data and might not be generalizable to countries outside of this group.

CONCLUSIONS

In summary, we found that OECD countries with larger increases in social spending on children between 2000 and 2015 tended to experience a smaller increase in childhood obesity over the same period. This association appeared to be explained mainly by the change in social spending on early childhood education and care and school education. Our findings may highlight the importance of social spending as a macrosocial indicator in childhood obesity.

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AUTHOR CONTRIBUSTIONS

A.M. and C.E. conceived the study design. A.M. analysed data. A.M., C.E., P.L., and Y.K. interpreted the data. All authors contributed to the draft manuscript and have approved the final version.

DATA STATEMENT

The datasets are available from the following websites: NCD-RisC datasets (http://ncdrisc.org), OECD SOCX datasets (https://www.oecd.org/social/expenditure.htm), and the public spending on education datasets (https://www.oecd-ilibrary.org/education/public-spending-on-education/indicator/english_f99b45d0-en).

CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

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Table 1. Characteristics of Organization for Economic Cooperation and Development 35 countries in 2015

Country	GDP per capita (US dollars)	Unemployment rate (%)	Poverty rate (%)	Children aged < 20 (% of population)
Australia	45,584	6.1	18.6	25.1
Austria	42,906	5.7	20.9	19.7
Belgium	40,900	8.5	24.5	22.6
Canada	42,498	6.9	20.0	22.0
Chile	20,789	6.2	14.5	28.0
Czech Republic	29,874	5.0	17.3	19.7
Denmark	44,760	6.2	18.7	23.1
Estonia	26,023	6.2	20.0	20.6
Finland	38,272	9.4	23.5	21.9
France	36,902	10.4	26.2	24.6
Germany	42,503	4.6	20.0	18.4
Greece	23,649	24.9	28.9	19.4
Hungary	24,254	6.8	24.0	19.7
Iceland	43,726	4.0	11.5	27.0
Ireland	58,229	9.9	29.9	27.7
Israel	31,221	5.2	18.8	36.4
Italy	33,164	11.9	23.9	18.4
Japan	37,036	3.4	18.4	17.3
Latvia	22,237	9.9	19.9	19.4
Luxembourg	87,825	6.7	25.0	22.6
Mexico	16,660	4.3	16.6	37.2
Netherlands	45,855	6.9	20.1	22.6
New Zealand	33,981	5.4	15.2	26.8
Norway	59,430	4.3	18.1	24.4
Poland	24,170	7.5	21.2	20.4
Portugal	26,677	12.4	22.9	19.6
Slovakia	28,423	11.5	16.8	20.7
Slovenia	28,203	9.0	21.4	19.4
South Korea	34,193	3.6	13.5	20.1
Spain	31,753	22.1	28.8	19.8
Sweden	44,832	7.4	14.5	22.8
Switzerland	54,453	4.8	8.8	20.3
Turkey	22,709	10.2	15.3	32.7
United Kingdom	38,723	5.3	20.8	23.7
United States (US)	52,105	5.3	19.8	25.7
OECD 35 average	37,558	7.9	20.0	23.1

GDP: gross domestic product. The GDP per capita was measured as purchasing power parity adjusted US dollars (fixed price, 2010 as the baseline year). Poverty rate show the ratio of the number of people aged 18−65 whose income falls below half the median household income of the total population, before tax and transfer.

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Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's $r = -0.32$; $p = 0.06$ for girls and $r = -0.35$; $p = 0.04$ for boys).

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Table 2. Association between total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%): Cross sectional analyses in 2015

Types of social spending	Coefficients	95% CI		P value	R squared
		Lower	Upper		
		Girls			
Total social spending [a]	-0.3×10^{-3}	-0.5×10^{-3}	-0.1×10^{-3}	0.01	0.92
By dimension [b]					0.89
Family allowance	-0.2×10^{-3}	-0.9×10^{-3}	0.4×10^{-3}	0.43	
Maternal and parental leave	0.7×10^{-3}	-0.6×10^{-3}	1.9×10^{-3}	0.28	
ECEC	-0.5×10^{-3}	-1.5×10^{-3}	0.5×10^{-3}	0.32	
Education	-0.5×10^{-3}	-1.1×10^{-3}	0.04×10^{-3}	0.07	
Others	0.1×10^{-3}	-0.7×10^{-3}	0.9×10^{-3}	0.79	
		Boys			
Total social spending [a]	-0.4×10^{-3}	-0.7×10^{-3}	-0.1×10^{-3}	0.02	0.83
By dimension [b]					0.79
Family allowance	-0.1×10^{-3}	-1.0×10^{-3}	0.8×10^{-3}	0.79	
Maternal and parental leave	1.3×10^{-3}	-0.5×10^{-3}	3.1×10^{-3}	0.14	
ECEC	-0.7×10^{-3}	-2.1×10^{-3}	0.8×10^{-3}	0.37	
Education	-0.7×10^{-3}	-1.5×10^{-3}	0.1×10^{-3}	0.07	
Others	0.1×10^{-3}	-1.0×10^{-3}	1.1×10^{-3}	0.87	

CI: Confidence interval. ECEC: Early childhood education and care.

For each sex, we examined the association between social spending on children (PPP-adjusted US dollars) and prevalence of childhood obesity (%) by using a multivariable linear regression model that adjusted for the countries' demographics (employment rate, poverty rate, and percentage of children aged < 20 years) in 2015 and the prevalence of childhood obesity in 2000. We reported the coefficient. For example, our results indicated that among girls, a 1000 US dollar difference in total social spending per children was associated with a 0.3 percentage points lower prevalence of childhood obesity.

[a] We regressed the prevalence of childhood obesity on total social spending on children. These analyses were conducted for all the 35 countries.
[b] We regressed the prevalence of childhood obesity on five dimensions of social spending on children. These analyses were conducted for 33 countries. Mexico and United States of America were excluded because either dimension of social spending is not available.

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Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's $r = -0.49$; $p < 0.01$ for girls and $r = -0.28$; $p = 0.10$ for boys).

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Table 3. Association between changes in total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%): Longitudinal analyses from 2000 to 2015

Types of social spending	Coefficients	95% CI		P value	R squared
		Lower	Upper		
		Girls			
Total social spending [a]	-0.6×10^{-2}	-1.0×10^{-2}	-0.2×10^{-2}	0.007	0.65
By dimension [b]					0.72
Family allowance	-0.8×10^{-2}	-2.0×10^{-2}	0.5×10^{-2}	0.20	
Maternal and parental leave	1.0×10^{-2}	-1.5×10^{-2}	3.5×10^{-2}	0.42	
ECEC	-1.2×10^{-2}	-2.4×10^{-2}	0.03×10^{-2}	0.045	
Education	-1.1×10^{-2}	-1.9×10^{-2}	0.3×10^{-2}	0.01	
Others	0.4×10^{-2}	-0.5×10^{-2}	1.3×10^{-2}	0.35	
		Boys			
Total social spending [a]	-0.7×10^{-2}	-1.3×10^{-2}	-0.03×10^{-2}	0.04	0.55
By dimension [b]					0.57
Family allowance	-1.2×10^{-2}	-3.4×10^{-2}	0.9×10^{-2}	0.26	
Maternal and parental leave	0.1×10^{-2}	-3.9×10^{-2}	4.1×10^{-2}	0.96	
ECEC	-2.1×10^{-2}	-4.1×10^{-2}	-0.01×10^{-2}	0.049	
Education	-0.5×10^{-2}	-2.0×10^{-2}	0.9×10^{-2}	0.43	
Others	0.2×10^{-2}	-1.3×10^{-2}	1.7×10^{-2}	0.79	

CI: Confidence interval. ECEC: Early childhood education and care.

For each sex, we examined the association between the changes in social spending on children (PPP-adjusted US dollars) and the prevalence of childhood obesity (%) from 2000 to 2015, by using a multivariable linear regression model that adjusted for average annual changes in employment rate and poverty rate, changes in the percentage of children aged < 20 years, and the "baseline" prevalence of childhood obesity in 2000. We reported the coefficient. For example, our results indicated that among girls, a 100 US dollar average annual increase in total social spending per child was associated with a 0.6 percentage points decrease in the prevalence of childhood obesity between 2000 and 2015.

[a] We regressed the change in the prevalence of childhood obesity on the change in total social spending on children. The analyses were conducted for 33 countries. South Korea and Luxembourg were excluded because the average annual change in unemployment rate or poverty rate cannot be calculated (data for more than two years are not available).

[b] We regressed the change in the prevalence of childhood obesity on the changes in five dimensions of social spending on children. The analyses were conducted for 31 countries. South Korea, Luxembourg, Mexico, and United States of America were excluded because the average annual change in either dimension of social spending or the average annual change in unemployment rate or poverty rate cannot be calculated (data for more than two years are not available).

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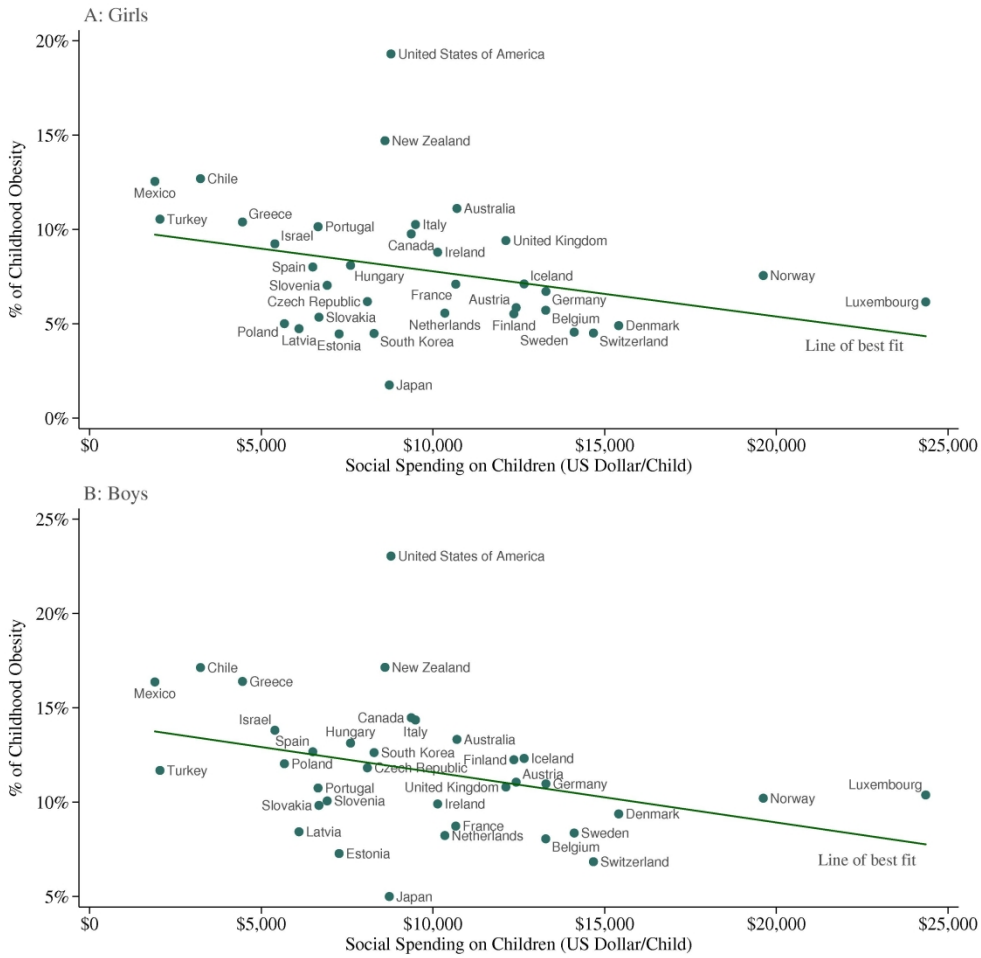

Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's r = −0.32; p = 0.06 for girls and r = −0.35; p = 0.04 for boys).

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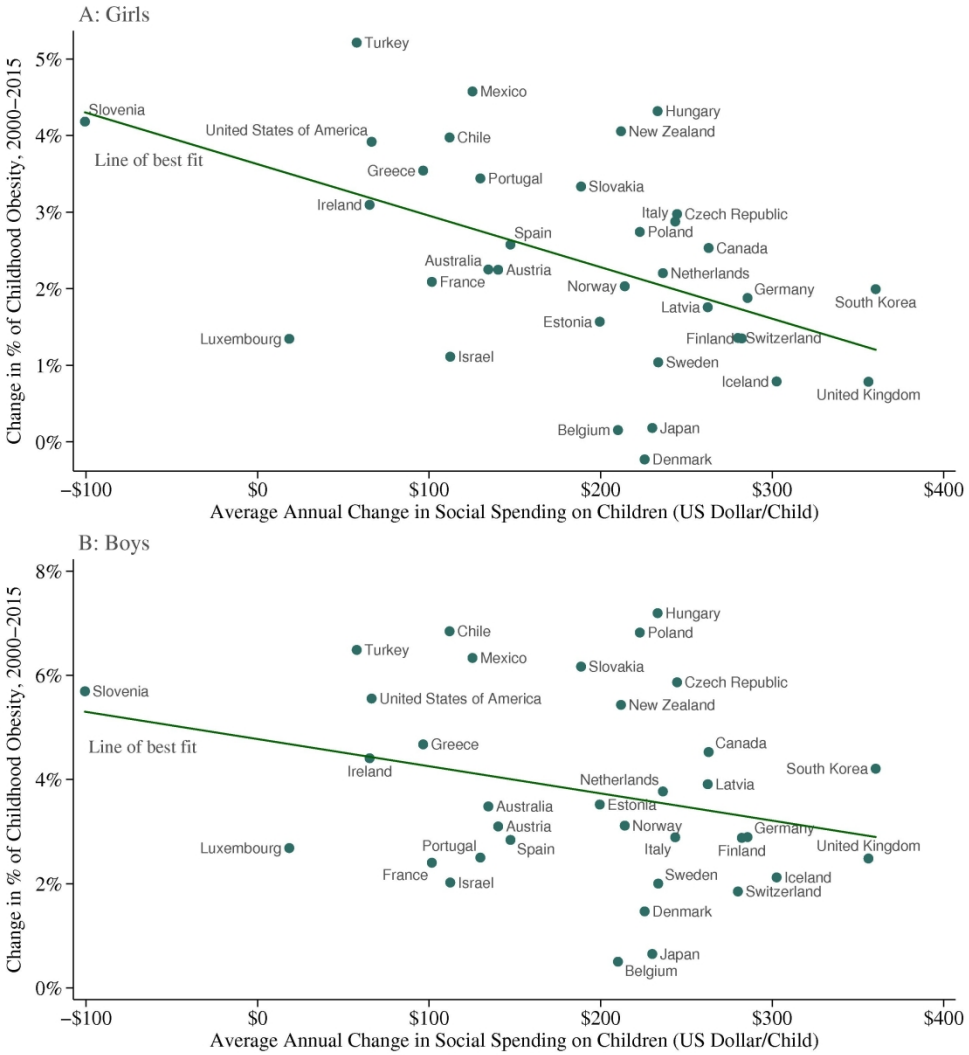

Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's r = −0.49; p <0.01 for girls and r = −0.28; p = 0.10 for boys).

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Supplementary Material

Relationships between Social Spending and Childhood Obesity in OECD Countries: More Welfare, Less Obesity?

Atsushi Miyawaki, Charlotte E.L. Evans, Patricia J. Lucas, Yasuki Kobayashi

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Table S1. Details of each dimension in social spending on family

Dimensions	Details
Family allowances (Cash benefits / Tax break)	Family allowance
	Family income supplement
	Family allowance supplement
	Basic family payment
	Additional family payment
	Home child care allowance
	Family tax payment
	Family tax benefit (Part A and B)
	More help for families–one-off payments
	Parenting payment (Single and Partnered)
	Single Income Family Bonus (2008)
	Back to School Bonus (2008)
	Economic Security Strategy (2008)
	Single Income Family Supplement
	Schoolkids Bonus
Maternity and parental leave (Cash benefits / Tax break)	Maternity allowances
	Maternity immunization allowance
	Baby Bonus (previously Maternity payment)
	Parental Leave Pay
	Dad and Partner Pay
	Stillborn Baby Payment
Early childhood education and care (ECEC) (Benefits in kind)	National Partnerships on Early Childhood Education and Care - National Occasional Care
	Support for the Child Care System - Child Care Communications Campaign
	Child care support
	Child care for eligible parents undergoing training
	Support for child care
	Support for child care: specific purpose payment
	Child care benefit
	Child care (pre-primary education)
	Child care (pre-primary education - 4-5yo)
	Child Care Tax Rebate
	Support for the Child Care System - Child Care Services Support
	Support for the Child Care System - Job Education and Training
	Child Care Fee Assistance - Child Care Benefit
	Child Care Fee Assistance - Child Care Rebate
	National Partnerships on Early Childhood Education and Care - Indigenous Early Childhood Development Children and Family Centers
	National Partnerships on Early Childhood Education and Care - TAFE Fee Waivers for Child Care Qualifications
	National Partnerships on Early Childhood Education and Care - National Quality Agenda
	State/Territory Child Care Expenditure
	National Partnership on Universal Access to Early Childhood Education
	Early Childhood Education - 4 and 5 year olds in ISCED 1 (Primary school)

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Others (Cash benefits / Tax break)	Supporting parent's benefit
	Sole parents pension
	Partner allowance (pension)
	Parenting allowance
	Assistance for Isolated Children
Others (Benefits in kind)	Home help / Accommodation
	Parenting
	Family support services scheme
	Child abuse prevention
	Family violence partnership
	Family violence regional activities
	Grants to family relationship support organizations
	Indigenous parenting and family well-being
	National illicit drug strategy
	Services for families with children
	Stronger families and communities strategy: families initiative
	Services for families with children: specific purpose payment
	Pre-school education
	Family and child welfare - State and Territory
	Child protection and out-of-home care services - State and Territory
	Family Support
	Find and Connect
	Families and Children

Source: OECD's Social Expenditure Database (SOCX).

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Method S1. Technical appendix

I regressed the average annual growth in social spending on the average annual growth in GDP per capita and calculated the residuals. Then, I calibrated them by adding the average of annual growth in social spending so that "cross-national mean of adjusted average annual growth in social spending" = "cross-national mean of unadjusted average annual growth in social spending."

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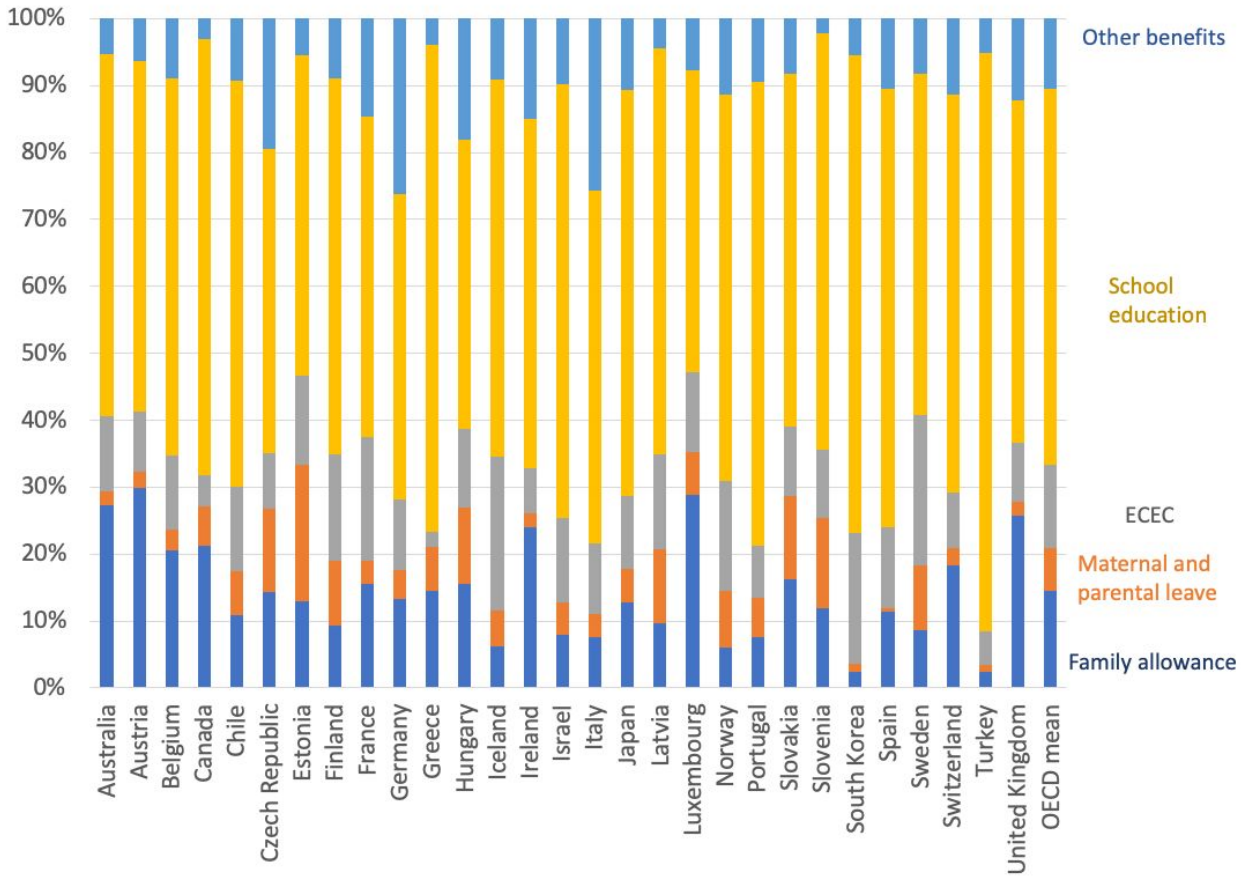
Figure S1. Specific dimensions of social spending on children in OECD countries compared with the OECD averages in 2015



Source: Authors' analysis of data from Organization for Economic Cooperation and Development (OECD) Social Expenditure Database (SOCX).

Notes: Specific dimensions of social spending on children are shown for 29 OECD countries for which the information on all the dimensions of social spending on children are available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States are excluded). The OECD mean is calculated for these 29 countries. ECEC: Early childhood education and care.

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Table S2. Association between total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%) for countries with lower vs. higher gross domestic product (GDP) per capita: Cross sectional analyses in 2015

	Lower GDP per capita				Higher GDP per capita				P-for-interaction
Types of social spending	Coefficients	95% CI		P value	Coefficients	95% CI		P value	
		Lower	Upper			Lower	Upper		
Girls									
Total social spending [b]	0.05×10^{-3}	-1.1×10^{-3}	1.2×10^{-3}	0.93	-0.2×10^{-3}	-0.4×10^{-3}	-0.02×10^{-3}	0.03	0.12
By dimension [c]									
Family allowance	2.4×10^{-3}	-1.6×10^{-3}	6.3×10^{-3}	0.19	-0.4×10^{-3}	-2.5×10^{-3}	1.8×10^{-3}	0.68	0.21
Maternal and parental leave	-2.6×10^{-3}	-6.8×10^{-3}	1.5×10^{-3}	0.17	0.5×10^{-3}	-7.3×10^{-3}	8.4×10^{-3}	0.87	0.33
ECEC	-2.0×10^{-3}	-5.9×10^{-3}	2.0×10^{-3}	0.27	-0.7×10^{-3}	-4.8×10^{-3}	3.5×10^{-3}	0.70	0.49
Education	-0.5×10^{-3}	-3.7×10^{-3}	2.8×10^{-3}	0.74	-0.3×10^{-3}	-1.1×10^{-3}	0.6×10^{-3}	0.49	0.61
Others	-0.5×10^{-3}	-3.1×10^{-3}	2.1×10^{-3}	0.67	-0.01×10^{-3}	-1.9×10^{-3}	1.9×10^{-3}	0.99	0.78
Boys									
Total social spending [b]	-0.1×10^{-3}	-1.5×10^{-3}	1.4×10^{-3}	0.92	-0.2×10^{-3}	-0.5×10^{-3}	-0.1×10^{-3}	0.04	0.07
By dimension [c]									
Family allowance	3.1×10^{-3}	-0.2×10^{-3}	6.3×10^{-3}	0.06	-0.4×10^{-3}	-2.0×10^{-3}	1.3×10^{-3}	0.58	0.33
Maternal and parental leave	-4.8×10^{-3}	-8.6×10^{-3}	-1.0×10^{-3}	0.02	1.3×10^{-3}	-5.4×10^{-3}	8.0×10^{-3}	0.64	0.41
ECEC	-2.3×10^{-3}	-5.7×10^{-3}	1.3×10^{-3}	0.17	-1.3×10^{-3}	-4.2×10^{-3}	1.7×10^{-3}	0.32	0.64
Education	-2.2×10^{-3}	-4.8×10^{-3}	0.4×10^{-3}	0.09	-0.3×10^{-3}	-1.2×10^{-3}	0.7×10^{-3}	0.54	0.35
Others	-1.3×10^{-3}	-3.5×10^{-3}	1.0×10^{-3}	0.22	0.1×10^{-3}	-1.5×10^{-3}	1.6×10^{-3}	0.92	0.99

We divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group. See Table 2 in the main text of the manuscript for more details.

[a] We formally tested the interaction between the level of GDP per capita in 2000 (lower vs. upper) and social spending on children using a Wald test.

[b] We regressed the prevalence of childhood obesity on total social spending on children. These analyses were conducted for 18 countries with lower GDP per capita in 2000 and 17 countries with higher GDP per capita in 2000.

[c] We regressed the prevalence of childhood obesity on five dimensions of social spending on children. These analyses were conducted for 17 countries with lower GDP per capita in 2000 and 16 countries with higher GDP per capita in 2000. Mexico and United States of America were excluded because either dimension of social spending is not available.

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Table S3. Association between changes in total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%) for countries with lower vs. higher gross domestic product (GDP) per capita: Longitudinal analyses from 2000 to 2015

	Lower GDP per capita				Higher GDP per capita				P-for-interaction
Types of social spending	Coefficients	95% CI		P value	Coefficients	95% CI		P value	
		Lower	Upper			Lower	Upper		
Girls									
Total social spending [b]	-0.3×10^{-2}	-0.9×10^{-2}	0.3×10^{-2}	0.30	-0.4×10^{-2}	-1.1×10^{-2}	0.3×10^{-2}	0.26	0.46
By dimension [c]									
Family allowance	-5.8×10^{-2}	-13.4×10^{-2}	1.7×10^{-2}	0.11	-0.7×10^{-2}	-3.1×10^{-2}	1.6×10^{-2}	0.46	0.38
Maternal and parental leave	1.7×10^{-2}	-3.1×10^{-2}	6.4×10^{-2}	0.42	-0.5×10^{-2}	-3.4×10^{-2}	2.4×10^{-2}	0.67	0.58
ECEC	1.2×10^{-2}	-4.9×10^{-2}	7.3×10^{-2}	0.65	1.6×10^{-2}	-4.2×10^{-2}	7.3×10^{-2}	0.52	0.11
Education	0.6×10^{-2}	-1.1×10^{-2}	2.4×10^{-2}	0.41	1.4×10^{-2}	-2.5×10^{-2}	5.3×10^{-2}	0.39	0.90
Others	-1.0×10^{-2}	-3.5×10^{-2}	1.4×10^{-2}	0.33	-1.3×10^{-2}	-4.0×10^{-2}	1.5×10^{-2}	0.29	0.91
Boys									
Total social spending [b]	-0.3×10^{-2}	-1.3×10^{-2}	0.7×10^{-2}	0.52	-0.2×10^{-2}	-1.3×10^{-2}	0.8×10^{-2}	0.64	0.36
By dimension [c]									
Family allowance	-5.5×10^{-2}	-19.7×10^{-2}	8.6×10^{-2}	0.38	-0.8×10^{-2}	-4.5×10^{-2}	3.0×10^{-2}	0.62	0.61
Maternal and parental leave	1.4×10^{-2}	-7.7×10^{-2}	10.4×10^{-2}	0.73	0.1×10^{-2}	-5.1×10^{-2}	5.2×10^{-2}	0.97	0.41
ECEC	0.7×10^{-2}	-9.2×10^{-2}	10.7×10^{-2}	0.86	1.1×10^{-2}	-8.8×10^{-2}	11.0×10^{-2}	0.78	0.29
Education	0.1×10^{-2}	-3.1×10^{-2}	3.3×10^{-2}	0.92	1.0×10^{-2}	-5.1×10^{-2}	7.1×10^{-2}	0.68	0.91
Others	-0.2×10^{-2}	-4.7×10^{-2}	4.4×10^{-2}	0.93	-0.7×10^{-2}	-5.7×10^{-2}	4.3×10^{-2}	0.74	0.44

We divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group. See Table 3 in the main text of the manuscript for more details.

[a] We formally tested the interaction between the level of GDP per capita in 2000 (lower vs. upper) and changes in social spending on children using a Wald test.

[b] We regressed the change in the prevalence of childhood obesity on the change in total social spending on children. The analyses were conducted for 17 countries with lower GDP per capita in 2000 and 16 countries with higher GDP per capita in 2000.

[c] We regressed the change in the prevalence of childhood obesity on the changes in five dimensions of social spending on children. The analyses were conducted for 16 countries with lower GDP per capita in 2000 and 15 countries with higher GDP per capita in 2000.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3
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Setting	#5	Describe the setting, locations, and relevant dates, including periods of	8-9

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Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	12
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Relationships between Social Spending and Childhood Obesity in OECD Countries: An Ecological Study

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ABSTRACT (300 words)

Objectives: The burden of childhood obesity is clustered among children in low-socioeconomic groups. Social spending on children—public welfare expenditure on families and education—may curb childhood obesity by reducing socioeconomic disadvantages. The objective of this study was to examine the relationship between social spending on children and childhood obesity across the Organization for Economic Cooperation and Development (OECD) countries.

Design: Ecological study.

Setting: Data on social spending on children were obtained from the OECD Social Expenditure Database and the OECD educational finance indicators dataset during 2000−2015. Data on childhood obesity were obtained from the NCD Risk Factor Collaboration database.

Participants: Aggregated statistics on obesity among children aged 5 to 19 years, estimated for OECD 35 countries based on the measured height and weight on 31.5 million children.

Outcome Measures: Country-level prevalence of obesity among children aged 5 to 19 years.

Results: In cross-sectional analyses in 2015, social spending on children was inversely associated with the prevalence of childhood obesity after adjusting for potential confounders (the gross domestic product per capita, unemployment rate, poverty rate, percentage of children aged < 20 years and prevalence of childhood obesity in 2000). In addition, when we focused on changes from 2000 to 2015, an average annual increase of 100 US dollars in social spending per child was associated with a decrease in childhood obesity by 0.6 percentage points for girls (p = 0.007) and 0.7 percentage points for boys (p = 0.04) between 2000 and 2015, after adjusting for the potential confounders. The dimensions of social spending that contributed to these

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associations between the changes in social spending on children and childhood obesity were early childhood education and care (ECEC) and school education for girls and ECEC for boys.

Conclusion: Countries that increase social spending on children tend to experience smaller increases in childhood obesity.

Keywords: Social medicine; Community child health; Health policy; International health services

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ARTICLE SUMMARY

Strengths and limitations of this study

- This is the first study that has investigated the relationship between public social spending on children and childhood obesity in the Organization for Economic Cooperation and Development (OECD) countries.
- We further focused on which dimensions of public social spending contributed most to these relationships.
- We did not focus on content and generosity of individual social policies nor private social spending. Future work should focus more on the impact of individual social policies on childhood obesity.
- Although our sample included high- and higher middle-income countries, findings were based on OECD countries' data and might not be generalizable to countries outside of this group.

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INTRODUCTION

The prevalence of childhood obesity has almost doubled in high-income countries during the last two decades. Current estimates suggest nearly one in ten children are obese.[1] Obesity in early life is an urgent public health issue due to its subsequent health consequences, including adult obesity,[2] early onset of non-communicable diseases,[3] premature death [3,4], and its influence on children's psychosocial development.[5] Childhood obesity is considered to have substantial economic burdens at the societal and individual level,[6,7]. Policymakers are increasingly responding to this growing public health crisis.

Although the proximal causes of this epidemic of obesity primarily are in individual behaviours such as higher consumption of food high in fat and sugar and increased sedentary behaviour,[8] these factors are shaped by upstream determinants related to socioeconomic conditions and the obesogenic environment.[9] Several studies have demonstrated that low-socioeconomic status of households is a risk factor for childhood obesity.[10,11] For example, those with both less education and lower family income are more likely to consume highly obesogenic fast foods.[12] Recognizing such social determinants of obesity, the World Health Organization (WHO) has recently recommended improving access to high-quality food in disadvantaged families in tandem with policies including taxation on unhealthy food and nutritional labels.[13] Besides these public health interventions, another possible approach is to reduce socioeconomic disadvantage itself, through social protection (e.g., income supplements for families and public investments in education).[14] Although there is a growing literature on the importance of social protection on adult obesity,[15–17] less attention has been paid to the roles of such social

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protection policies in childhood obesity prevention. This gap partly relates to the difficulty of estimating social spending at the individual level.

Although all high-income countries have social protection programs, there are large cross-national variations in their generosity.[18,19] *Social spending*—how much the government spends on social protection [20]—has been considered as an indicator to quantitatively gauge the generosity of social protection programs in a country or region. Several studies have recently recognized the importance of social spending as an indicator of macrosocial determinants of health and demonstrated the association between social spending and better population health outcomes including life expectancy, infant mortality, and low birth weight.[18,21] If the same macrosocial determinants are drivers of childhood obesity, increasing social spending on children will similarly operate as an upstream approach to curb childhood obesity. The possible mechanisms may include tax credits and paid parental leave, that increase or stabilize household income, or food vouchers offered to low-income families, which enable them to improve the quality of family meals.[22] Higher quality nutritional and physical education at school also encourages children to have a healthier diet and to be more active.[23] However, little is known so far about the relationship between gross public social spending on children and childhood obesity.

To bridge this knowledge gap, in this study, we sought to answer the following questions using data from the Organization for Economic Cooperation and Development (OECD) countries. First, is social spending on children associated with the prevalence of childhood obesity? Second, if so, which types of social spending contribute to this association? In this study, we

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focus on between-country differences, considering gross social spending as a macrosocial indicator. The mechanisms via which social spending may influence childhood obesity are numerous and, at the individual level, childhood obesity is likely better predicted by individual circumstance. To estimate the impact of macro-economic policies, we report on differences at this level.

METHODS

Study design and sample

We conducted a panel data analysis of 35 OECD countries using the NCD Risk Factor Collaboration (NCD-RisC) database,[24] which provides trends of childhood obesity during 1975−2016 in 200 countries. We examined social spending on children using (1) the OECD Social Expenditure Database (SOCX) [25] and (2) the OECD educational finance indicators dataset.[26] The SOCX database includes internationally comparable statistics on public social spending ("public" means "by the central, state, or local government" [20]) across 35 OECD countries. The spending is categorised into "old age," "survivors," "incapacity related," "family," "active labour market program," "unemployment," "housing," and "other social policy areas." We focused on the category "family" because this category is most likely to measure direct benefits to children.[27] Although we anticipate that children will benefit from indirect spending on, for example, unemployment programs and housing, including these categories would overestimate the sums reaching families with children. We did not include private social spending ("private" means that it came from other sources than the general government) because it was not available for most countries in the SOCX dataset. Although education is considered as an essential aspect of social spending,[19] spending on school education is not included in the

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SOCX datasets (early childhood education and care [ECEC] is included). Thus, we obtained information on public social spending on school education from the OECD's educational finance indicators dataset. Furthermore, we examined several country-level sociodemographic variables, including the population of children aged < 20 years, the gross domestic product [GDP] per capita, unemployment rate, and poverty rate, using the OECD.Stat database.[28] We examined data during 2000−2015, for which reliable data on both childhood obesity and social spending were available. We excluded Lithuania from all analyses due to missing data in most years.

Measures

Outcome variable: Prevalence of childhood obesity

We used the age-standardised prevalence (%) of childhood obesity among children aged 5 to 19 years (standardised to the WHO standard population), which has been estimated by sex using a Bayesian hierarchical model based on the measured height and weight on 31.5 million children.[24] Childhood obesity was defined as more than two standard deviations above the age and sex-specific WHO growth reference median.[29]

Exposure variable: Social spending on children

Our primary exposure variable was total social spending on children, which was defined as the sum of (1) public social spending on family, which includes benefits on family allowance, maternal and parental leave, ECEC, and others (the components are shown in **online supplemental table Table S1**),[25] and (2) public social spending on school education (primary to post-secondary non-tertiary). Specifically, public social spending on family includes (a) Child-related cash transfers to families with children, including income-tested child allowances, public

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income support payments during periods of parental leave, and income support for single-parent families; (b) public spending on services for families with children, including the direct subsidisation of childcare and ECEC facilities, public childcare support through earmarked payments to parents, and home help services for families; (c) financial support for families via the tax system, including child tax allowances and tax credits.[30] Public social spending on school education includes direct expenditure on educational institutions (e.g., public spending on instruction services, university research, and ancillary services such as meals and transport to schools) as well as education-related public subsidies given to households and administered by educational institutions.[26,31] Social spending on children was expressed as the purchasing power parity (PPP)-adjusted United States (US) dollars (fixed price, 2010 as the baseline year) per child aged < 20 years.

Our secondary exposure variables were five dimensions of social spending on children (family allowance, maternal and parental leave, ECEC, school education, and other benefits). This disaggregation of social spending on children was conducted following the OECD's datasets to examine which dimensions of social spending contributed to the relationship between the social spending on children and childhood obesity.

Adjustment variables

We adjusted for countries' demographics and the "baseline" prevalence of childhood obesity in 2000. Demographics consisted of three economic indicators (GDP per capita, unemployment rate and poverty rate) and the percentage of children aged < 20 years, because these factors could affect both the social spending on children [19] and the prevalence of childhood obesity. The

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"baseline" prevalence of childhood obesity was also included as countries that had suffered from high obesity prevalence in the past may invest more in social programs to mitigate against childhood obesity.

Statistical analysis

Basic social characteristics derived across the included OECD countries in 2015 were: GDP per capita (PPP-adjusted US dollars), unemployment rate (for the total population), poverty rate (the ratio of the number of people aged 18−65 years whose income falls below half the median household income of the total population, before tax and transfer), and children aged < 20 years as a percentage of total population.

Next, we cross-sectionally investigated the relationship between total social spending on children and childhood obesity across OECD countries, using 2015 data. We plotted the prevalence of childhood obesity against social spending on children and estimated the correlation between them using a Pearson's correlation. We also examined the association between them, by using a multivariable linear regression model that adjusted for the demographic indicators (GDP per capita, unemployment rate, poverty rate, and percentage of children aged < 20 years) in 2015, and the prevalence of childhood obesity in 2000. The analyses were separately conducted for each sex here (and hereafter) because the pattern of childhood obesity varied by sex across countries.[1] In this analysis, we substituted the latest year data for Denmark, Poland, Netherlands, and New Zealand, for which 2015 data on social spending were unavailable.

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Then, to effectively investigate the association between social spending on children and childhood obesity within the same country, we examined the longitudinal trends in total social spending on children and childhood obesity during the period 2000−2015. To account for the difference in economic growth by countries, we first estimated the average annual growth in social spending on children adjusted by the growth in GDP per capita for each country using linear regression (**online supplemental method S1**). Next, we illustrated the association between the growth in social spending and childhood obesity by plotting the absolute change in the prevalence of childhood obesity from 2000 to 2015 against the average annual change in social spending on children for countries and estimating the correlation between them using a Pearson's correlation. We then investigated the association between them, by using a multivariable linear regression model that adjusted for the changes in demographic indicators (unemployment rate, poverty rate, and percentage of children aged < 20 years) from 2000 to 2015 and the prevalence of childhood obesity in 2000. In this longitudinal analysis, we substituted the latest year data/the earliest year data when the 2015/2000 data were unavailable.

Finally, we used the secondary exposure variables, by replacing total social spending on children with five dimensions of social spending on children (family allowance, maternal and parental leave, ECEC, school education, and other benefits), and repeated multivariable linear regressions.[16] In this analysis, we examined 29 OECD countries for which information on all the dimensions of social spending on children were available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States were excluded). All analyses were conducted using Stata version 15 (College Station, TX; StataCorp LLC.). $P<0.05$ was considered as statistically significant.

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Post-hoc analyses

To investigate potential heterogeneous effects according to economic development, we divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group (i.e., countries with lower vs countries with upper GDP per capita).

Patient and public involvement

The current study involved secondary use of publicly available aggregated data. The study did not involve patients and the public in any way and did not require ethics review.

RESULTS

Basic characteristics across OECD countries

PPP-adjusted GDP per capita varied across OECD countries in 2015, ranging from $16,660 in Mexico to $87,825 in Luxembourg (**Table 1**). The unemployment rate was 7.9% on average, ranging from 3.4% in Japan to 24.9% in Greece. The poverty rate was 20.0% on average, ranging from 8.8% in Switzerland to 29.9% in Ireland. Children aged < 20 years accounted for 23.1% of the total population on average, ranging from 17.3% in Japan to 37.2% in Mexico.

Cross-sectional analysis of social spending and childhood obesity

The prevalence of childhood obesity varied across OECD countries in 2015, lowest in Japan (1.7% for girls and 5.0% for boys) and highest in New Zealand (14.7% and 17.1%) with the US as an outlier (19.3% and 23.0%) (**Figure 1**). There was considerable variation in PPP-adjusted social spending on children. Luxemburg was the highest spender, with social spending on

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children amounting to $24,350 per child. The lowest spender was Mexico, which spent $1,901 per child. When splitting countries into two groups (the upper versus lower half of the population proportion of children) and comparing social spending on children in 2015, there was no substantial difference (mean $10,785 versus $8,586; p=0.18 in Brunner-Munzel test). The relationship between social spending on children and the prevalence of childhood obesity was moderate and inverse for girls (Pearson's r=−0.32; p=0.06) and boys (r=−0.35; p=0.04). Since the US appeared to be an outlier for childhood obesity, we conducted a post-hoc estimation of correlation coefficients by excluding the US data, but the associations were qualitatively unchanged (r=−0.37; p=0.03 for girls and r=−0.40; p=0.02 for boys). After we adjusted for potential confounders (**Table 2**), we found that countries with higher total social spending on children experienced lower prevalence of childhood obesity ($\beta = -0.3 \times 10^{-3}$; $p = 0.01$ for girls and $\beta = -0.4 \times 10^{-3}$; $p = 0.02$ for boys).

Longitudinal analysis of social spending and childhood obesity

During the period 2000−2015, all countries experienced increases in the prevalence of childhood obesity, with the exception of girls in Denmark (**Figure 2**). When we examined the changes in social spending adjusted by the growth in GDP per capita and changes in the prevalence of childhood obesity, we observed a moderate inverse association between these variables for girls (Pearson's r=−0.49; p< 0.01) and a weak inverse association for boys (r=−0.28; p=0.10). After we adjusted for potential confounders (**Table 3**), we found that countries with greater increases in total social spending on children also had smaller increases in the prevalence of childhood obesity ($\beta = -0.6 \times 10^{-2}$; $p = 0.007$ for girls and $\beta = -0.7 \times 10^{-2}$; $p = 0.04$ for boys). These estimates indicate that a 100 US dollars average annual increase (adjusted by PPP and GDP per

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capita) per child was associated with a decline in childhood obesity between 2000 and 2015 by 0.6% for girls and 0.7% for boys.

Disaggregated social spending and childhood obesity

Patterns of spending on specific dimensions within the gross social spending figure varied considerably between countries (**online supplemental figure S1)**. On average, 14.5% of social spending on children was used for family allowance, 6.4% for maternal and parental leave, 12.4% for ECEC, 56.2% for school education, and 10.4% for other benefits in 2015. When we focused on the specific dimensions of social spending in cross-sectional analyses (**Table 2**), we found no evidence that either dimension of social spending on children was associated with the prevalence of childhood obesity. However, when we focused on the changes over time (**Table 3**), we found an inverse association between the change in spending on ECEC and in the prevalence of childhood obesity for girls ($\beta = -1.2 \times 10^{-2}$; $p = 0.045$) and boys ($\beta = -2.1 \times 10^{-2}$; $p = 0.049$). We also found an inverse relationship between the change in spending on school education and the growth in childhood obesity for girls ($\beta = -1.1 \times 10^{-2}$; $p = 0.01$), but not for boys ($\beta = -0.5 \times 10^{-2}$; $p = 0.43$). The change in social spending on family allowance, maternal leave and other benefits were not associated with the growth in the prevalence of childhood obesity for either sex.

Post-hoc analyses

In the stratified analyses according to GDP per capita in 2000, the cross-sectional inverse relationship between total social spending on children and prevalence of childhood obesity was observed among countries with higher GDP per capita ($p = 0.03$ for girls and $p = 0.04$ for boys)

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(**online supplemental table S2**). When focusing on disaggregated social spending, we found a cross-sectional inverse association between social spending on maternal and parental leave and prevalence of childhood obesity for boys among countries with lower GDP per capita ($p = 0.02$). In longitudinal analyses, the coefficients for the association between the changes in total social spending and changes in the prevalence of childhood obesity remained negative; however, they did not reach statistical significance regardless of the level of GDP per capita and sex (**online supplemental table S3**).

DISCUSSION

Among OECD countries, we found an inverse association between the growth in social spending on children and childhood obesity, after accounting for the underlying difference in social factors that could drive social spending and childhood obesity. What contributed most to this association was social spending on education: ECEC for both sexes, and social spending on school education also contributed notably for girls. These results suggest that OECD countries whose social spending on children increase more tend to experience smaller increases in childhood obesity prevalence in a context where all countries except Denmark showed increasing prevalence in childhood obesity. These findings may highlight the importance of social protection programs as macrosocial determinants of childhood obesity.

It is not clear why the inverse association between social spending and childhood obesity exist, but the finding that the relationship between social spending on children and childhood obesity varies by dimensions of social spending may help to determine the possible mechanisms of this association. Notably, social spending on ECEC was associated with reduced obesity growth rates

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for both girls and boys. Moreover, school education was associated with reduced growth of obesity among girls. Spending on these education categories may enrich nutritional and physical activity environments that protect against obesity, such as higher quality school meals,[32,33] limited access to energy-dense competitive foods and beverages at school,[34,35] and better access to playing fields.[36] Conversely, schools under financial pressures may adopt unhealthy food policy (sales or advertising of snack foods) in schools or cancel gym classes in order to improve school budgets.[37] If the high-quality educational environment is protective against childhood obesity, we might predict that public ECEC spending would have a particularly important role since it will increase both quality (e.g. through increasing staff-to-child ratios) and uptake (in a context where ECEC is not mandatory in most OECD countries). For example, Norway is the highest ECEC spender, has mandatory subsidized childcare from 1 year, and provides the highest quality of ECEC among developed countries;[35] and has low growth in obesity rates within the OECD. This relationship with public ECEC spending is particularly interesting since maternal employment and use of childcare in the earliest years (largely financed privately) have been associated with higher rates of obesity.[38–40] Our finding supports the view that the reason early childcare is associated with obesity is that it is often lower quality and highly constrained,[40] suggesting the importance of public spending on high quality care for reducing childhood obesity. In contrast, in the context of universal provision of school education, the school environment may be more important for girls than boys in influencing levels of physical activity.[41] However, this mechanism may depend on the social context; another study in the US showed that the protective effect of increased physical education on obesity was concentrated among boys because girls substituted physical education for other activities.[42] Other possible mechanisms may be through children's health literacy and socioeconomic

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conditions in the future resulting from public investments in education.[43] However, without further breakdown of categories of social spending, we can only provide plausible suggestions for what might account for these observed associations.

Comparison with other studies

Our findings add to a body of work that has explored the relationship between social protection, especially social spending as its indicator, and population health outcomes. Bradley and colleagues demonstrated a link between public social spending and better population health measures in terms of life expectancy, infant mortality rate, and low birth weight across OECD countries.[18] They also found similar associations in the US between social spending and better health outcomes, including the lower prevalence of adult obesity.[21] A study by Shim further found that social spending on children, especially spending on the family allowance, was associated with reduced infant mortality in OECD 19 countries.[27] In Canada, Ng and Muntaner found that indicators of welfare generosity, including social spending on postsecondary education, were associated with reduced mortality.[44] There is also a growing literature on the effect of social programmes and education on adult obesity.[15–17] Our study extends these previous studies by further focusing on childhood obesity, one of the top public health issues in the modern context, and therefore reinforces the key roles of social protection policies and social spending as their indicator in population health.

Strengths and limitations of this study

This is the first study that has investigated the relationship between social spending on children and childhood obesity. We further focused on which dimensions of public social spending

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contributed most to these relationships. Moreover, we tested the association between social spending and childhood obesity more robustly by examining the association between longitudinal changes as well as cross-sectional relationships. This would have helped to adjust for unobserved country-specific characteristics. For example, the fact that the US was a clear outlier in the cross-sectional analysis might be due to the country's traditional food and agricultural policies that encourages overconsumption.[45] These factors would have been effectively controlled for in the longitudinal analysis but not in the cross-sectional analysis.

Our study has limitations. First, as in any ecological study unmeasured confounding will have influenced our findings. For example, countries that spend more of social spending for families, may also spend more on public health activities for the prevention of childhood obesity (e.g., food labelling and sugar tax) or other social protection programs that can be protective against childhood obesity at the population level (e.g., housing and labour market programs).[46,47] Second, we analysed only 35 countries at most, which limits the number of possible adjustment variables that could be included in the regression analyses. Third, our study was unable to identify the exact mechanisms through which social spending was inversely associated with childhood obesity, even though we broke down social spending into several dimensions. We did not have information on individual social policies (e.g., child care quality and availability or free school meals), and it was difficult to isolate the effect of individual social policies. Nevertheless, our findings suggest that public social spending in the broadest sense may be an important macro-level indicator of child health and wellbeing, such as childhood obesity. Future work should focus more directly on the impact of individual social policies on childhood obesity. Fourth, the change in social spending on children does not appear to explain all the variation of

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the growth in the prevalence of childhood obesity. For example, Japan, Belgium, and Denmark had a smaller growth in childhood obesity compared to the fitted lines, while several countries, including Hungary, Mexico, and Turkey, experienced a larger growth. Therefore, even when this association is causal, the effect of increasing social spending on children on the prevalence of childhood obesity in an individual country may differ by the country's characteristics such as economic inequalities and cultural factors related to food and physical activity. Fifth, our study captures obesity across a wide age range (5-19 years), while many of these policies are age dependent (e.g. school impacts are likely to be cumulative after school starting age). Finally, our analysis did not include private social spending. Private social spending may act to partially counter the redistributive impact of public social spending.[48] Further studies on how changes in the public and private mix in social spending may affect childhood obesity may be required.

Although our sample includes both high- and higher middle-income countries, findings were based on OECD countries' data and might not be generalizable to countries outside of this group.

CONCLUSIONS

In summary, we found that OECD countries with larger increases in social spending on children between 2000 and 2015 tended to experience a smaller increase in childhood obesity over the same period. This association appeared to be explained mainly by the change in social spending on early childhood education and care and school education. Our findings may highlight the importance of social spending as a macrosocial indicator in childhood obesity.

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AUTHOR CONTRIBUSTIONS

A.M. and C.E. conceived the study design. A.M. analysed data. A.M., C.E., P.L., and Y.K. interpreted the data. All authors contributed to the draft manuscript and have approved the final version.

DATA STATEMENT

The datasets are available from the following websites: NCD-RisC datasets (http://ncdrisc.org), OECD SOCX datasets (https://www.oecd.org/social/expenditure.htm), and the public spending on education datasets (https://www.oecd-ilibrary.org/education/public-spending-on-education/indicator/english_f99b45d0-en).

CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

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Table 1. Characteristics of Organization for Economic Cooperation and Development 35 countries in 2015

Country	GDP per capita (US dollars)	Unemployment rate (%)	Poverty rate (%)	Children aged < 20 (% of population)
Australia	45,584	6.1	18.6	25.1
Austria	42,906	5.7	20.9	19.7
Belgium	40,900	8.5	24.5	22.6
Canada	42,498	6.9	20.0	22.0
Chile	20,789	6.2	14.5	28.0
Czech Republic	29,874	5.0	17.3	19.7
Denmark	44,760	6.2	18.7	23.1
Estonia	26,023	6.2	20.0	20.6
Finland	38,272	9.4	23.5	21.9
France	36,902	10.4	26.2	24.6
Germany	42,503	4.6	20.0	18.4
Greece	23,649	24.9	28.9	19.4
Hungary	24,254	6.8	24.0	19.7
Iceland	43,726	4.0	11.5	27.0
Ireland	58,229	9.9	29.9	27.7
Israel	31,221	5.2	18.8	36.4
Italy	33,164	11.9	23.9	18.4
Japan	37,036	3.4	18.4	17.3
Latvia	22,237	9.9	19.9	19.4
Luxembourg	87,825	6.7	25.0	22.6
Mexico	16,660	4.3	16.6	37.2
Netherlands	45,855	6.9	20.1	22.6
New Zealand	33,981	5.4	15.2	26.8
Norway	59,430	4.3	18.1	24.4
Poland	24,170	7.5	21.2	20.4
Portugal	26,677	12.4	22.9	19.6
Slovakia	28,423	11.5	16.8	20.7
Slovenia	28,203	9.0	21.4	19.4
South Korea	34,193	3.6	13.5	20.1
Spain	31,753	22.1	28.8	19.8
Sweden	44,832	7.4	14.5	22.8
Switzerland	54,453	4.8	8.8	20.3
Turkey	22,709	10.2	15.3	32.7
United Kingdom	38,723	5.3	20.8	23.7
United States (US)	52,105	5.3	19.8	25.7
OECD 35 average	37,558	7.9	20.0	23.1

GDP: gross domestic product. The GDP per capita was measured as purchasing power parity adjusted US dollars (fixed price, 2010 as the baseline year). Poverty rate show the ratio of the number of people aged 18−65 whose income falls below half the median household income of the total population, before tax and transfer.

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Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's $r = -0.32$; $p = 0.06$ for girls and $r = -0.35$; $p = 0.04$ for boys).

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Table 2. Association between total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%): Cross sectional analyses in 2015

Types of social spending	Coefficients	95% CI		P value	R squared
		Lower	Upper		
		Girls			
Total social spending [a]	-0.3×10^{-3}	-0.5×10^{-3}	-0.1×10^{-3}	0.01	0.92
By dimension [b]					0.89
Family allowance	-0.2×10^{-3}	-0.9×10^{-3}	0.4×10^{-3}	0.43	
Maternal and parental leave	0.7×10^{-3}	-0.6×10^{-3}	1.9×10^{-3}	0.28	
ECEC	-0.5×10^{-3}	-1.5×10^{-3}	0.5×10^{-3}	0.32	
Education	-0.5×10^{-3}	-1.1×10^{-3}	0.04×10^{-3}	0.07	
Others	0.1×10^{-3}	-0.7×10^{-3}	0.9×10^{-3}	0.79	
		Boys			
Total social spending [a]	-0.4×10^{-3}	-0.7×10^{-3}	-0.1×10^{-3}	0.02	0.83
By dimension [b]					0.79
Family allowance	-0.1×10^{-3}	-1.0×10^{-3}	0.8×10^{-3}	0.79	
Maternal and parental leave	1.3×10^{-3}	-0.5×10^{-3}	3.1×10^{-3}	0.14	
ECEC	-0.7×10^{-3}	-2.1×10^{-3}	0.8×10^{-3}	0.37	
Education	-0.7×10^{-3}	-1.5×10^{-3}	0.1×10^{-3}	0.07	
Others	0.1×10^{-3}	-1.0×10^{-3}	1.1×10^{-3}	0.87	

CI: Confidence interval. ECEC: Early childhood education and care.

For each sex, we examined the association between social spending on children (PPP-adjusted US dollars) and prevalence of childhood obesity (%) by using a multivariable linear regression model that adjusted for the countries' demographics (employment rate, poverty rate, and percentage of children aged < 20 years) in 2015 and the prevalence of childhood obesity in 2000. We reported the coefficient. For example, our results indicated that among girls, a 1000 US dollar difference in total social spending per children was associated with a 0.3 percentage points lower prevalence of childhood obesity.

[a] We regressed the prevalence of childhood obesity on total social spending on children. These analyses were conducted for all the 35 countries.
[b] We regressed the prevalence of childhood obesity on five dimensions of social spending on children. These analyses were conducted for 33 countries. Mexico and United States of America were excluded because either dimension of social spending is not available.

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Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's $r = -0.49$; $p < 0.01$ for girls and $r = -0.28$; $p = 0.10$ for boys).

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Table 3. Association between changes in total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%): Longitudinal analyses from 2000 to 2015

Types of social spending	Coefficients	95% CI		P value	R squared
		Lower	Upper		
		Girls			
Total social spending [a]	-0.6×10^{-2}	-1.0×10^{-2}	-0.2×10^{-2}	0.007	0.65
By dimension [b]					0.72
Family allowance	-0.8×10^{-2}	-2.0×10^{-2}	0.5×10^{-2}	0.20	
Maternal and parental leave	1.0×10^{-2}	-1.5×10^{-2}	3.5×10^{-2}	0.42	
ECEC	-1.2×10^{-2}	-2.4×10^{-2}	0.03×10^{-2}	0.045	
Education	-1.1×10^{-2}	-1.9×10^{-2}	0.3×10^{-2}	0.01	
Others	0.4×10^{-2}	-0.5×10^{-2}	1.3×10^{-2}	0.35	
		Boys			
Total social spending [a]	-0.7×10^{-2}	-1.3×10^{-2}	-0.03×10^{-2}	0.04	0.55
By dimension [b]					0.57
Family allowance	-1.2×10^{-2}	-3.4×10^{-2}	0.9×10^{-2}	0.26	
Maternal and parental leave	0.1×10^{-2}	-3.9×10^{-2}	4.1×10^{-2}	0.96	
ECEC	-2.1×10^{-2}	-4.1×10^{-2}	-0.01×10^{-2}	0.049	
Education	-0.5×10^{-2}	-2.0×10^{-2}	0.9×10^{-2}	0.43	
Others	0.2×10^{-2}	-1.3×10^{-2}	1.7×10^{-2}	0.79	

CI: Confidence interval. ECEC: Early childhood education and care.

For each sex, we examined the association between the changes in social spending on children (PPP-adjusted US dollars) and the prevalence of childhood obesity (%) from 2000 to 2015, by using a multivariable linear regression model that adjusted for average annual changes in employment rate and poverty rate, changes in the percentage of children aged < 20 years, and the "baseline" prevalence of childhood obesity in 2000. We reported the coefficient. For example, our results indicated that among girls, a 100 US dollar average annual increase in total social spending per child was associated with a 0.6 percentage points decrease in the prevalence of childhood obesity between 2000 and 2015.

[a] We regressed the change in the prevalence of childhood obesity on the change in total social spending on children. The analyses were conducted for 33 countries. South Korea and Luxembourg were excluded because the average annual change in unemployment rate or poverty rate cannot be calculated (data for more than two years are not available).

[b] We regressed the change in the prevalence of childhood obesity on the changes in five dimensions of social spending on children. The analyses were conducted for 31 countries. South Korea, Luxembourg, Mexico, and United States of America were excluded because the average annual change in either dimension of social spending or the average annual change in unemployment rate or poverty rate cannot be calculated (data for more than two years are not available).

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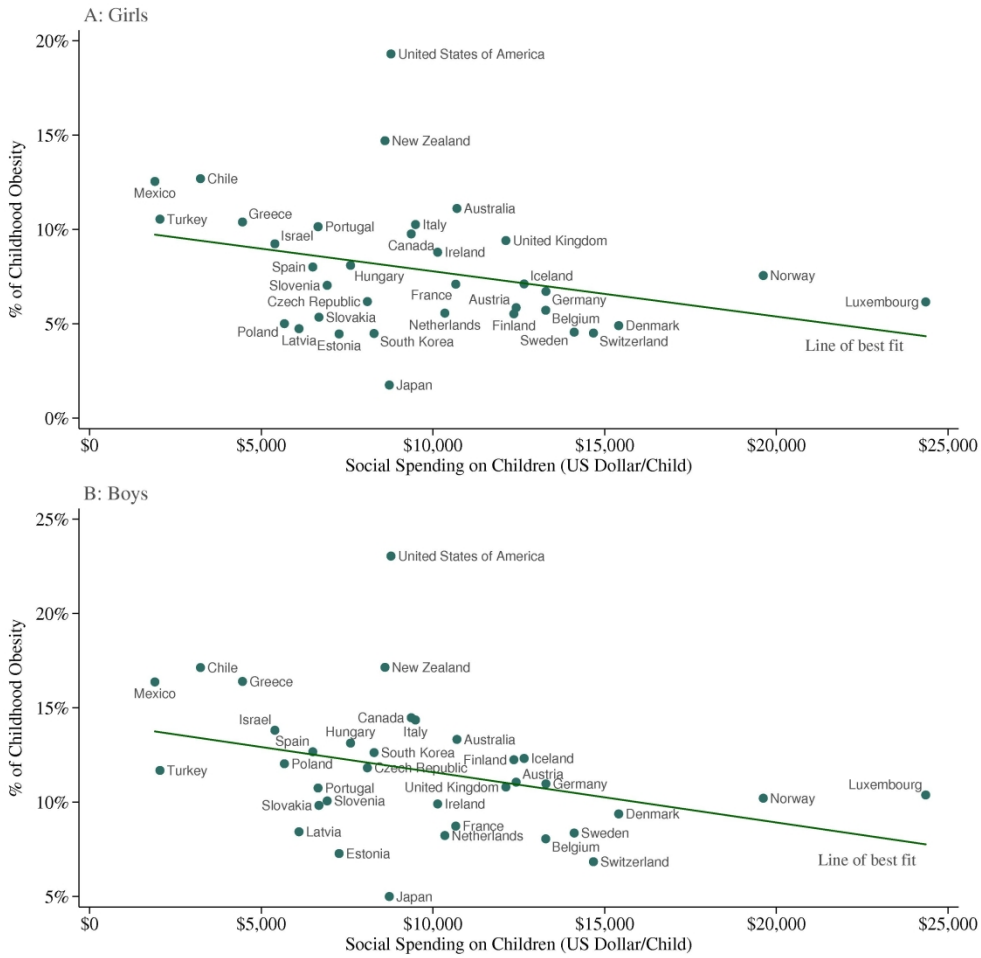

Figure 1. Social spending on children and prevalence of childhood obesity by sex in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: Data are from 2015 for all countries apart from Denmark (2014), Poland (2014), Netherlands (2011), or New Zealand (2011). The x-axis shows the country-level social spending on children (including cash benefits and tax breaks for families with children, expenditure on childcare or other benefits in kind, and expenditure on primary and secondary education), measured as purchasing power parity (PPP)-adjusted US dollars (fixed price, 2010 as the baseline year) per child aged under 20 years. The y-axis indicates the country-level prevalence (%) of children aged 5−19 years categorized as obesity (body mass index > 2 standard deviations above the WHO growth reference for children). The lines of best fit show that countries whose governments spend more money on children tend to experience smaller percentages of childhood obesity for both sexes (Pearson's r = −0.32; p = 0.06 for girls and r = −0.35; p = 0.04 for boys).

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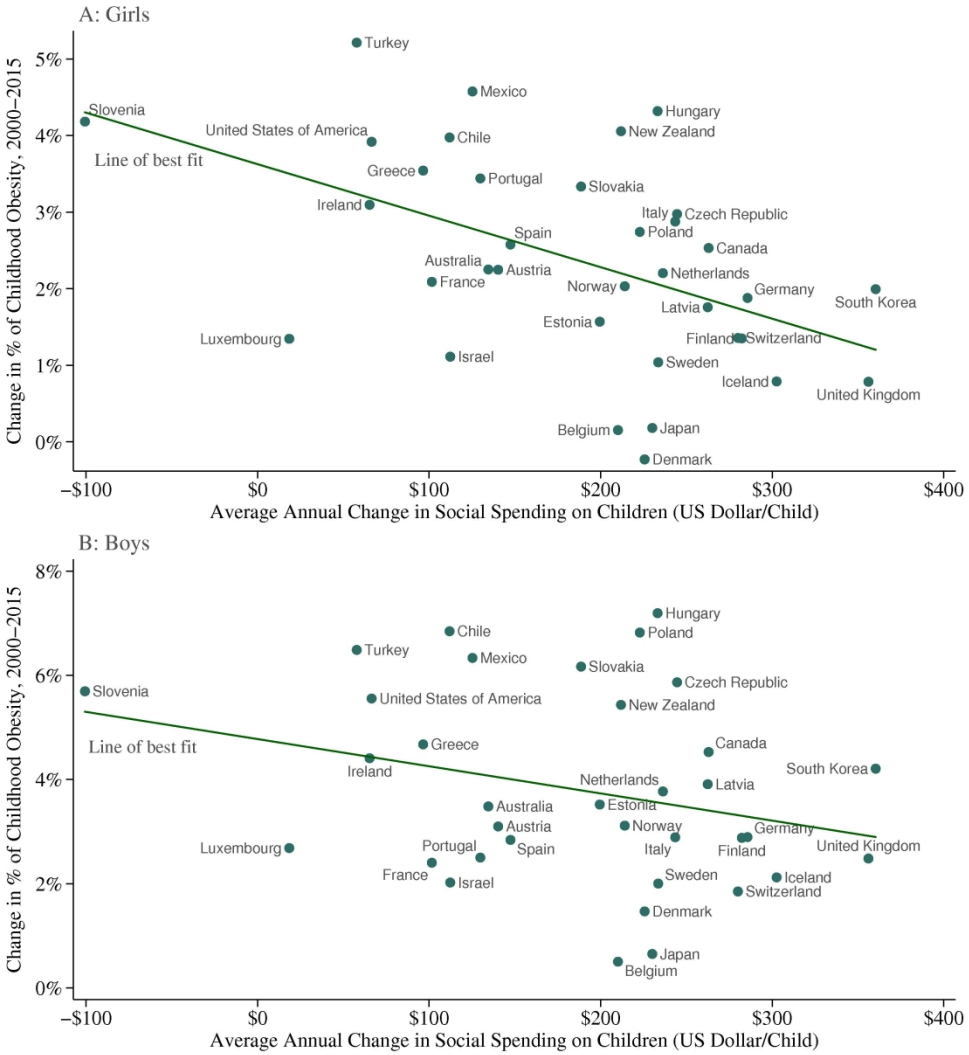

Figure 2. Changes in social spending on children and in the prevalence of childhood obesity from 2000 to 2015 in the Organization for Economic Cooperation and Development (OECD) countries

Source: Authors' analysis of data from OECD's Social Expenditure Database (SOCX), OECD Education statistics database, and NCD Risk Factor Collaboration (NCD-RisC) database.
Notes: The x-axis shows the average annual change in social spending on children (PPP-adjusted US dollars per child) adjusted by the growth in GDP per capita during 2000−2015. The y-axis indicates the absolute change in the prevalence of childhood obesity from 2000 to 2015. The lines of best fit show that changes in social spending on children and the percentage of childhood obesity are inversely associated for both sexes (Pearson's r = −0.49; p <0.01 for girls and r = −0.28; p = 0.10 for boys).

127x139mm (600 x 600 DPI)

Supplementary Material

Relationships between Social Spending and Childhood Obesity in OECD Countries: An Ecological Study

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Table S1. Details of each dimension in social spending on family

Dimensions	Details
Family allowances (Cash benefits / Tax break)	Family allowance
	Family income supplement
	Family allowance supplement
	Basic family payment
	Additional family payment
	Home child care allowance
	Family tax payment
	Family tax benefit (Part A and B)
	More help for families–one-off payments
	Parenting payment (Single and Partnered)
	Single Income Family Bonus (2008)
	Back to School Bonus (2008)
	Economic Security Strategy (2008)
	Single Income Family Supplement
	Schoolkids Bonus
Maternity and parental leave (Cash benefits / Tax break)	Maternity allowances
	Maternity immunization allowance
	Baby Bonus (previously Maternity payment)
	Parental Leave Pay
	Dad and Partner Pay
	Stillborn Baby Payment
Early childhood education and care (ECEC) (Benefits in kind)	National Partnerships on Early Childhood Education and Care - National Occasional Care
	Support for the Child Care System - Child Care Communications Campaign
	Child care support
	Child care for eligible parents undergoing training
	Support for child care
	Support for child care: specific purpose payment
	Child care benefit
	Child care (pre-primary education)
	Child care (pre-primary education - 4-5yo)
	Child Care Tax Rebate
	Support for the Child Care System - Child Care Services Support
	Support for the Child Care System - Job Education and Training
	Child Care Fee Assistance - Child Care Benefit
	Child Care Fee Assistance - Child Care Rebate
	National Partnerships on Early Childhood Education and Care - Indigenous Early Childhood Development Children and Family Centers
	National Partnerships on Early Childhood Education and Care - TAFE Fee Waivers for Child Care Qualifications
	National Partnerships on Early Childhood Education and Care - National Quality Agenda
	State/Territory Child Care Expenditure
	National Partnership on Universal Access to Early Childhood Education
	Early Childhood Education - 4 and 5 year olds in ISCED 1 (Primary school)

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Others (Cash benefits / Tax break)	Supporting parent's benefit
	Sole parents pension
	Partner allowance (pension)
	Parenting allowance
	Assistance for Isolated Children
Others (Benefits in kind)	Home help / Accommodation
	Parenting
	Family support services scheme
	Child abuse prevention
	Family violence partnership
	Family violence regional activities
	Grants to family relationship support organizations
	Indigenous parenting and family well-being
	National illicit drug strategy
	Services for families with children
	Stronger families and communities strategy: families initiative
	Services for families with children: specific purpose payment
	Pre-school education
	Family and child welfare - State and Territory
	Child protection and out-of-home care services - State and Territory
	Family Support
	Find and Connect
	Families and Children

Source: OECD's Social Expenditure Database (SOCX).

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Method S1. Technical appendix

I regressed the average annual growth in social spending on the average annual growth in GDP per capita and calculated the residuals. Then, I calibrated them by adding the average of annual growth in social spending so that "cross-national mean of adjusted average annual growth in social spending" = "cross-national mean of unadjusted average annual growth in social spending."

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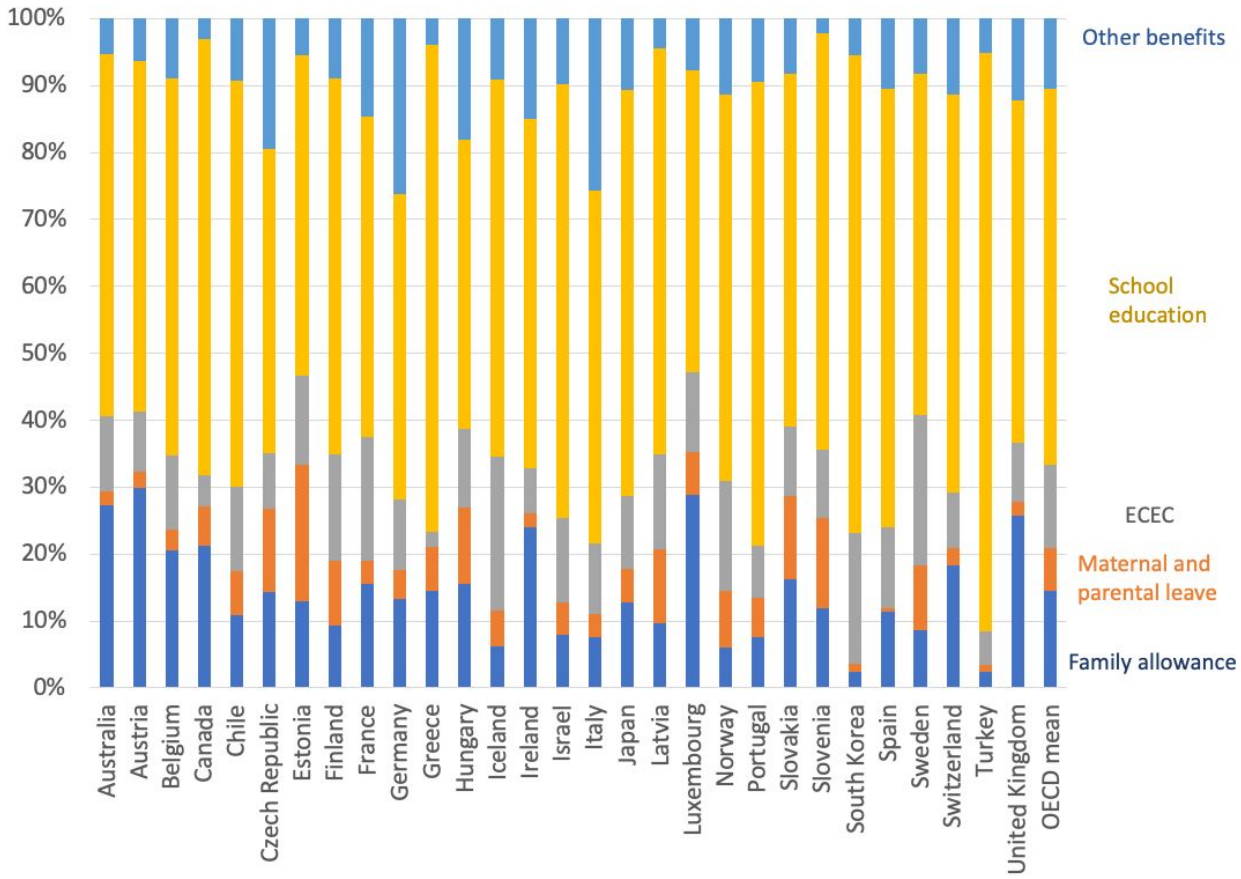
Figure S1. Specific dimensions of social spending on children in OECD countries compared with the OECD averages in 2015



Source: Authors' analysis of data from Organization for Economic Cooperation and Development (OECD) Social Expenditure Database (SOCX).

Notes: Specific dimensions of social spending on children are shown for 29 OECD countries for which the information on all the dimensions of social spending on children are available (Denmark, Mexico, Netherlands, New Zealand, Poland, and the United States are excluded). The OECD mean is calculated for these 29 countries. ECEC: Early childhood education and care.

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Table S2. Association between total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%) for countries with lower vs. higher gross domestic product (GDP) per capita: Cross sectional analyses in 2015

	Lower GDP per capita				Higher GDP per capita				P-for-interaction [a]
Types of social spending	Coefficients	95% CI		P value	Coefficients	95% CI		P value	
		Lower	Upper			Lower	Upper		
Girls									
Total social spending [b]	0.05×10^{-3}	-1.1×10^{-3}	1.2×10^{-3}	0.93	-0.2×10^{-3}	-0.4×10^{-3}	-0.02×10^{-3}	0.03	0.12
By dimension [c]									
Family allowance	2.4×10^{-3}	-1.6×10^{-3}	6.3×10^{-3}	0.19	-0.4×10^{-3}	-2.5×10^{-3}	1.8×10^{-3}	0.68	0.21
Maternal and parental leave	-2.6×10^{-3}	-6.8×10^{-3}	1.5×10^{-3}	0.17	0.5×10^{-3}	-7.3×10^{-3}	8.4×10^{-3}	0.87	0.33
ECEC	-2.0×10^{-3}	-5.9×10^{-3}	2.0×10^{-3}	0.27	-0.7×10^{-3}	-4.8×10^{-3}	3.5×10^{-3}	0.70	0.49
Education	-0.5×10^{-3}	-3.7×10^{-3}	2.8×10^{-3}	0.74	-0.3×10^{-3}	-1.1×10^{-3}	0.6×10^{-3}	0.49	0.61
Others	-0.5×10^{-3}	-3.1×10^{-3}	2.1×10^{-3}	0.67	-0.01×10^{-3}	-1.9×10^{-3}	1.9×10^{-3}	0.99	0.78
Boys									
Total social spending [b]	-0.1×10^{-3}	-1.5×10^{-3}	1.4×10^{-3}	0.92	-0.2×10^{-3}	-0.5×10^{-3}	-0.1×10^{-3}	0.04	0.07
By dimension [c]									
Family allowance	3.1×10^{-3}	-0.2×10^{-3}	6.3×10^{-3}	0.06	-0.4×10^{-3}	-2.0×10^{-3}	1.3×10^{-3}	0.58	0.33
Maternal and parental leave	-4.8×10^{-3}	-8.6×10^{-3}	-1.0×10^{-3}	0.02	1.3×10^{-3}	-5.4×10^{-3}	8.0×10^{-3}	0.64	0.41
ECEC	-2.3×10^{-3}	-5.7×10^{-3}	1.3×10^{-3}	0.17	-1.3×10^{-3}	-4.2×10^{-3}	1.7×10^{-3}	0.32	0.64
Education	-2.2×10^{-3}	-4.8×10^{-3}	0.4×10^{-3}	0.09	-0.3×10^{-3}	-1.2×10^{-3}	0.7×10^{-3}	0.54	0.35
Others	-1.3×10^{-3}	-3.5×10^{-3}	1.0×10^{-3}	0.22	0.1×10^{-3}	-1.5×10^{-3}	1.6×10^{-3}	0.92	0.99

We divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group. See Table 2 in the main text of the manuscript for more details.

[a] We formally tested the interaction between the level of GDP per capita in 2000 (lower vs. upper) and social spending on children using a Wald test.

[b] We regressed the prevalence of childhood obesity on total social spending on children. These analyses were conducted for 18 countries with lower GDP per capita in 2000 and 17 countries with higher GDP per capita in 2000.

[c] We regressed the prevalence of childhood obesity on five dimensions of social spending on children. These analyses were conducted for 17 countries with lower GDP per capita in 2000 and 16 countries with higher GDP per capita in 2000. Mexico and United States of America were excluded because either dimension of social spending is not available.

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Table S3. Association between changes in total or five dimensions of social spending on children (US dollars) and the prevalence of childhood obesity (%) for countries with lower vs. higher gross domestic product (GDP) per capita: Longitudinal analyses from 2000 to 2015

	Lower GDP per capita				Higher GDP per capita				P-for-interaction [a]
Types of social spending	Coefficients	95% CI		P value	Coefficients	95% CI		P value	
		Lower	Upper			Lower	Upper		
Girls									
Total social spending [b]	-0.3×10^{-2}	-0.9×10^{-2}	0.3×10^{-2}	0.30	-0.4×10^{-2}	-1.1×10^{-2}	0.3×10^{-2}	0.26	0.46
By dimension [c]									
Family allowance	-5.8×10^{-2}	-13.4×10^{-2}	1.7×10^{-2}	0.11	-0.7×10^{-2}	-3.1×10^{-2}	1.6×10^{-2}	0.46	0.38
Maternal and parental leave	1.7×10^{-2}	-3.1×10^{-2}	6.4×10^{-2}	0.42	-0.5×10^{-2}	-3.4×10^{-2}	2.4×10^{-2}	0.67	0.58
ECEC	1.2×10^{-2}	-4.9×10^{-2}	7.3×10^{-2}	0.65	1.6×10^{-2}	-4.2×10^{-2}	7.3×10^{-2}	0.52	0.11
Education	0.6×10^{-2}	-1.1×10^{-2}	2.4×10^{-2}	0.41	1.4×10^{-2}	-2.5×10^{-2}	5.3×10^{-2}	0.39	0.90
Others	-1.0×10^{-2}	-3.5×10^{-2}	1.4×10^{-2}	0.33	-1.3×10^{-2}	-4.0×10^{-2}	1.5×10^{-2}	0.29	0.91
Boys									
Total social spending [b]	-0.3×10^{-2}	-1.3×10^{-2}	0.7×10^{-2}	0.52	-0.2×10^{-2}	-1.3×10^{-2}	0.8×10^{-2}	0.64	0.36
By dimension [c]									
Family allowance	-5.5×10^{-2}	-19.7×10^{-2}	8.6×10^{-2}	0.38	-0.8×10^{-2}	-4.5×10^{-2}	3.0×10^{-2}	0.62	0.61
Maternal and parental leave	1.4×10^{-2}	-7.7×10^{-2}	10.4×10^{-2}	0.73	0.1×10^{-2}	-5.1×10^{-2}	5.2×10^{-2}	0.97	0.41
ECEC	0.7×10^{-2}	-9.2×10^{-2}	10.7×10^{-2}	0.86	1.1×10^{-2}	-8.8×10^{-2}	11.0×10^{-2}	0.78	0.29
Education	0.1×10^{-2}	-3.1×10^{-2}	3.3×10^{-2}	0.92	1.0×10^{-2}	-5.1×10^{-2}	7.1×10^{-2}	0.68	0.91
Others	-0.2×10^{-2}	-4.7×10^{-2}	4.4×10^{-2}	0.93	-0.7×10^{-2}	-5.7×10^{-2}	4.3×10^{-2}	0.74	0.44

We divided OECD countries in half according to GDP per capita in 2000 and repeated the regression analyses for each group. See Table 3 in the main text of the manuscript for more details.

[a] We formally tested the interaction between the level of GDP per capita in 2000 (lower vs. upper) and changes in social spending on children using a Wald test.

[b] We regressed the change in the prevalence of childhood obesity on the change in total social spending on children. The analyses were conducted for 17 countries with lower GDP per capita in 2000 and 16 countries with higher GDP per capita in 2000.

[c] We regressed the change in the prevalence of childhood obesity on the changes in five dimensions of social spending on children. The analyses were conducted for 16 countries with lower GDP per capita in 2000 and 15 countries with higher GDP per capita in 2000.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	#3	State specific objectives, including any prespecified hypotheses	7-8
Methods			
Study design	#4	Present key elements of study design early in the paper	8-9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of	8-9

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		recruitment, exposure, follow-up, and data collection	
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	8-9
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-9
Bias	#9	Describe any efforts to address potential sources of bias	10-11
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	11
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	11
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	11-12
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	N/A
Statistical methods	#12e	Describe any sensitivity analyses	13
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	12
Participants	#13b	Give reasons for non-participation at each stage	12
Participants	#13c	Consider use of a flow diagram	N/A

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Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	12
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	13
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	13-14
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-15
Main results	#16b	Report category boundaries when continuous variables were categorized	N/A
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	15-16
Discussion			
Key results	#18	Summarise key results with reference to study objectives	16
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	19-20
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	16-18
Generalisability	#21	Discuss the generalisability (external validity) of the study results	20
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

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