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# The case for investment in nutritional interventions to prevent and reduce childhood and adolescent overweight and obesity in Peru: a modelling study

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## Abstract

**Background** Between 2006 and 2016 the prevalence of overweight and obesity among children and adolescents aged 5–19 years in Peru increased from 22.7 to 27.0%. This investment case quantifies the economic impacts of childhood and adolescent overweight and obesity in Peru. It identifies and quantifies the potential impact of a set of new or expanded interventions that can strengthen current national efforts to prevent and reduce child and adolescent overweight and obesity.

**Methods** A deterministic Markov cohort model with a societal cost perspective estimated reductions in mortality and morbidity from implementing interventions to prevent and reduce child and adolescent overweight and obesity and the impact in savings in healthcare costs and gains in wages and productivity. Interventions identified through a review of published literature includes a school-based social marketing campaign, exclusive breastfeeding promotion and support, a healthy food and drink policy for school premises, and a 20% subsidy on fruits and vegetables for people living below the national poverty line. The return on investment (ROI) was calculated along with the estimated cost savings associated with the interventions. Analysis was conducted to test ROI sensitivity to changes in the key parameters and assumptions.

**Results** Between 2025 and 2092, the expected combined direct and indirect healthcare costs attributable to child and adolescent overweight and obesity in Peru are 210.6 billion USD. The direct healthcare costs are 1.8 billion USD, and the indirect costs are 208.8 billion USD. Expected savings for all interventions combined is 13.9 billion USD with a per-person savings of 12,089.8 USD. The expected ROI of the four interventions combined is 39.3 USD (30-years), 64.6 USD (50-years), and 164.1 USD (66-years) per one USD invested.

**Conclusions** The overweight and obesity epidemic among children and adolescents in Peru requires wide-ranging and expanded implementation of policies to achieve long-term reductions in prevalence. This study's findings show

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that the four priority interventions have high ROIs and can be used to guide policy to address the complex interplay of factors that contribute to the obesogenic environment.

**Keywords** Obesity, Overweight, Economics, Peru, Adolescents, Children, Interventions, Investment

## Background

Between 2006 and 2016 the prevalence of overweight and obesity among children and adolescents aged 5–19 years in Peru increased by from 22.7 to 27.0% [1]. Children and adolescents who are affected by overweight and obesity are at increased risk of developing high blood pressure, high cholesterol, type 2 diabetes, asthma, joint problems, gallstones, anxiety, and depression [2–5]. They tend to miss more school days and are at an increased risk of psychosocial difficulties while at school [6, 7]. Children and adolescents living with overweight and obesity are at increased risk of maintaining that status into adulthood [8]. Overweight and obesity in adulthood is also associated with increased risk for multiple non-communicable diseases (NCDs), such as cancer, cardiovascular disease (CVD), diabetes, Alzheimer's disease, and asthma [9]. These overweight and obesity-attributable diseases account for 9% of premature deaths globally [10, 11]. In addition to the healthcare costs associated with treating these overweight and obesity-attributable diseases, economic impacts of overweight and obesity result from increased absenteeism (missed days of work), presenteeism (reduced productivity while at work), hiring discrimination, unemployment, lower income, disability, and premature death [12–14].

In middle-income countries (MICs), like Peru, that continue to deal with infectious diseases and undernutrition, the growing prevalence of overweight and obesity adds a double burden of malnutrition [15]. Moreover, the health and economic burdens are not equitably distributed within the population, with people in lower socio-economic groups being at increased risk for overweight and obesity and related NCDs such as cancer and CVD [16]. The health and economic impacts of overweight and obesity are substantial at both the individual and societal level and represent an important health equity issue.

As children and adolescents aged 0–19 years are projected to make up 32% of Peru's population in 2025—approximately 10.9 million children and adolescents [17], the Government of Peru has developed policies to address the factors that contribute to overweight and obesity among children and adolescents. In 2013, the government passed the Healthy Eating Promotion Law (Law No. 30021), which included a suite of interventions such as nutritional education and physical activity in schools, recommendations to provide healthy meals in school cafeterias and health centers, front-of-pack nutrition labeling, and restricted marketing of unhealthy foods [18]. However, rules for implementing the law were

not approved until 2017 and the subsequent implementation of the law by the government has been slow [19, 20]. Further legislation in 2018 enacted tiered sugar-sweetened beverage (SSB) taxation, which was modified in 2021 to the current level of 25% for SSBs with more than five grams of sugar per 100 ml and 17% tax for SSBs with sugar content between 0.5 and five grams per 100 ml [21]. This tiered design incentivized the beverage industry to reduce the sugar content of SSBs [22]. Even so, overweight and obesity prevalence among children has continued to rise in Peru, increasing in children under 5 years from 6.4% in 2019 to 7.8% in 2021, demonstrating that further measures are necessary to address the obesogenic environment and reduce the prevalence of overweight and obesity and their sequelae [23].

This paper reports the results of an investment case for childhood and adolescent overweight and obesity in Peru. We aim to quantify the health and economic impacts of childhood and adolescent overweight and obesity in Peru and the potential gains from a set of new or expanded interventions. The investment case identifies which interventions will generate the largest health and economic returns with the goal of supporting resource allocation and prioritization to efficiently respond to the increasing challenge of childhood and adolescent overweight and obesity.

## Methods

This investment case applies a methodology that was developed and piloted in Mexico to assess the health and economic impact of child and adolescent overweight and obesity prevention and reduction interventions [24]. The model is a deterministic Markov cohort combining the Assessing Cost-Effectiveness in Obesity (ACE-Obesity) and the Early Prevention of Obesity in Childhood (EPOCH) models [25, 26]. We estimated reductions in mortality and morbidity from interventions and the resulting economic impact in terms of averted mortality, savings in healthcare costs, and gains in wages and productivity. The model applies a societal cost perspective that includes all costs and health effects regardless of the payer or beneficiary, providing insight into the impact interventions will have on the wider economy and society [27, 28]. The model cohort includes children and adolescents aged 0–19 years in 2025 and estimates impacts until 2092, when the mean age of the cohort will be 77 years – the current Peruvian life expectancy [17]. 2025 was selected as the base year to allow time to prepare and implement interventions. Results are presented

in 2020 USD dollars (USD) and Peruvian sol (SOL) using exchange rate and consumer price index data from the World Bank. The analysis was conducted in Microsoft Excel according to the Consolidated Health Economic Evaluation Reporting Standards' practice guidelines (Table S1) [29]. In the absence of similar studies to validate the model against, the model's code was reviewed by an analyst who was not involved in creating the model. A summary is provided in the sub-sections below with additional details in the **Supplementary Materials**.

### Baseline scenario

The baseline scenario estimated the health and economic outcomes attributable to overweight and obesity in children and adolescents aged 0–19 years in 2025 (the model cohort) throughout their lifetime. We assumed that current trends in mortality, morbidity, and risk factors in Peru remain unchanged and projected future mean BMI and overweight and obesity prevalence, disaggregated by age and sex.

The projected prevalence of overweight and obesity was used to calculate future health and economic impacts. First, we estimated the years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs) attributable to overweight and obesity in the model cohort. We discounted the effects at 3% annually, the standard discount rate for global health economics research [28, 30, 31], and used the standard discounting formula to calculate the all-cause YLLs for age group by year to reflect the social preference of a healthy year now rather than in the future [32]. Future overweight and obesity-attributable YLLs were estimated using the same proportion of all-cause YLLs due to overweight and obesity-attributable diseases or conditions [33, 34] obtained from projected all-cause and cause-specific mortality rates from 2026 to 2092 using an autoregressive integrated moving average (ARIMA) model [35]. The analysis uses Peru's gross domestic product (GDP) per capita (6,064 USD in 2020) as a proxy for the value of a life year to capture economic losses from premature mortality [31]. We then calculated the YLDs for each overweight and obesity-attributable condition within the 5-year age groups [11, 36]. Finally, the economic impact of children and adolescents affected by overweight and obesity was estimated at baseline by the combination of healthcare costs attributable to obesity (excluding overweight) during childhood and adulthood, and the impact that overweight and obesity has on future labor productivity.

### Obesity-attributable healthcare cost

Data on additional healthcare costs is only available for children and adolescents affected by obesity; therefore, the analysis includes only the additional healthcare costs

of obesity (excluding overweight). To obtain obesity-attributable healthcare costs, we multiplied the number of individuals affected by obesity, by age group, by the incremental annual healthcare expenditure for a person affected by obesity. Annual healthcare expenditure was calculated by multiplying the average annual healthcare expenditure per person by the incremental percentage of higher healthcare expenditure paid by individuals affected by obesity (as compared to those of healthy weight), disaggregated by age [37, 38]. Average annual healthcare expenditure in Peru was obtained from the WHO Global Health Expenditure Database [39]. All costs were inflated to 2020 Peruvian Sol values using the consumer price index (CPI) [30, 31, 40].

### Impact on labor productivity

Productivity losses due to childhood and adolescent overweight and obesity were modeled for lifetime wage loss due to lower education attainment and productivity loss due to absenteeism and presenteeism [41]. To estimate the impact on educational attainment, the number of individuals affected by overweight and obesity at age 17 (the age when individuals in Peru complete secondary education to begin tertiary education) and the proportion of the Peruvian population aged 25–34 with tertiary education, were used to estimate the number of individuals who would not attain tertiary education due to overweight and obesity [42]. We accounted for the wages earned during the five additional years that individuals who do not attend tertiary school may have worked (since tertiary education lasts for five years in Peru) and assumed that every individual who attained tertiary education and participates in the workforce would enter the workforce at age 22 and exit at age 65, the legal retirement age under the Peruvian pension system [43].

### Intervention scenario

To identify and select priority interventions we focused not only on the costs and cost-effectiveness of interventions aimed at preventing and reducing childhood and adolescent overweight and obesity, but also on the cultural and policy environment in Peru. We conducted Peru-specific and global literature reviews of the costs and cost-effectiveness of interventions for childhood and adolescent overweight and obesity. The search also identified baseline coverage levels of selected interventions from published and grey literature sources. Additionally, we used purposive sampling to identify key informants ( $n=4$ ) from the Peruvian government, academia, research institutes, and civil society working in the areas of nutrition, public policy, and addressing overweight and obesity. Utilizing a semi-structured interview guide (see Supplementary Exhibit S1), semi-structured interviews were conducted in Spanish and English. Content analysis

was employed to distil interviewees' views regarding the interventions they considered most valuable and applicable to the Peru context [44, 45].

The following four priority interventions were identified [46, 47]. First, implementing a social marketing campaign focused on behavioral nudges in schools focused on healthy diets and physical activity with the involvement of parents and caregivers. Second, as Peru's exclusive breastfeeding rate for infants under six months was 68.4% in 2020, promoting and providing support for exclusive breastfeeding in the first six months via individual counseling, group education, breastfeeding support at delivery, and lactation management in antenatal and prenatal care, hospitals, and delivery centers [48]. This would also entail wider community-based group counseling and education. Third, scaling up the policy only allowing healthy food and drink on school premises policy currently in place in Lima to the rest of the country, as well as raising awareness among staff, managers, parents,

and students [49]. Last is the introduction of a 20% fruit and vegetable subsidy for people living below the national poverty line. The subsidy on fruit and vegetables, social marketing in schools, and breastfeeding promotion and support have not been previously implemented in Peru, while the healthy school food environment interventions have previously only been implemented in Lima. Evidence on the effect sizes in terms of BMI or overweight and obesity prevalence reduction, as well as the unit costs associated with each of the interventions were obtained from the literature (Table 1). Due to limited Peru-specific data and studies, the analysis applies evidence from wider Latin American countries and the global literature.

The costs of implementing the interventions were applied from 2025 to 2044, the year when the last subcohort would turn 19 years old. We used a baseline coverage of 0% for interventions not previously implemented in Peru (social marketing interventions in schools, breastfeeding promotion and support, and the subsidy on

**Table 1** Baseline level of interventions in Peru and Effect size and cost data to Reach Target goals

Intervention	Target population	Baseline coverage	Target coverage	Effect size (95% CI)	Effect size source	Unit cost (cost per child, 2020 USD)	Cost components	Unit cost source
Social marketing in schools	Children and adolescents aged 6–16 years	0%	80% of target population	-0.25 (-0.45, -0.04) BMI reduction	Aceves-Martins et al. (2016) [66]	USD 1.04	Program organization costs, training of teachers and food service staff, extra teaching, and additional curricular activities, such as brochures and books	Cecchini et al. (2010) [67]
Breastfeeding promotion at health centers	Mothers of infants aged 6 months or less	0%	85% of the target population	Average 5.2% (3.5%, 6.5%) reduction in obesity prevalence at age 5	Rollins (2016)[53] and Holla-Bhar (2015)[68]	USD 21.57	Health education to mothers and training health workers and community volunteers	Rollins (2016) [53] and Bhutta et al. (2013) [69]
Healthy school food environment	Children and adolescents aged 6–16 years	3.38%	80% of target population	Boys: 5.1% (0.9%, 9.3%) reduction in overweight prevalence Girls: 1.8% (-2.8%, 6.4%) reduction in overweight prevalence (Not significant)	Levasseur (2021) [70]	USD 0.19	Basic administration, planning, enforcement, preparation and distribution of posters, and monitoring	Sassi (2010) [71]
Targeted 20% food subsidy for population under the national poverty line	Children and adolescents aged 0–19 years	0%	20.2% of national population (Figure based on proportion of children and adolescents living below the poverty line).	-0.08 (-0.16, 0.00) BMI reduction	Afshin et al. (2017)[65]	USD 0.02	Planning and development, operations, administration, and monitoring	Sassi (2010) [71]

fruits and vegetables). While the prevalence of exclusive breastfeeding in Peru is currently 68.4% and individual breastfeeding promotion efforts exist throughout the country, we modeled a coordinated national breastfeeding promotion policy to improve the design, implementation, and coverage of Baby Friendly Hospital Initiative (BFHI) and breastfeeding promotion through community health workers. For the national baseline coverage of the healthy school food environment, we first calculated the number of students in primary school (aged 6–11) and secondary school (aged 12–16) in Lima by multiplying the population of primary school and secondary school age in Peru by the school enrollment ratio for primary and secondary schools, respectively, and the proportion of the population of Peru living in Lima. Population, by sex, in Peru was obtained from the United Nations' World Population Prospects (WPP) [17], school enrollment ratio was obtained from the World Bank's World Development Indicators database [50], and the proportion of the Peruvian population living in Lima was based on the 2017 Peru census [51].

The target coverage level was set at 80% for the school-based social marketing and the healthy school food environment and 20.2% for the fruit and vegetable subsidy, which is the percentage of the population in Peru that lives under the national poverty line. For breastfeeding promotion and support, we aimed to increase the prevalence of exclusive breastfeeding from birth to six months from the current 68.4–85% [52]. To estimate the coverage level for BFHI and community intervention required to reach the target exclusive breastfeeding prevalence of 85%, we used the relative risks (RR) of exclusive breastfeeding from birth to six months with health systems and community interventions from Rollins et al., 2016 [53]. Based on this RR, we set the target coverage level for BFHI and community intervention at 16%. For the target population, we selected children and adolescents aged 0–19 years for the fruit and vegetable subsidy (the subsidy would go to the head[s] of household), children and

adolescents 6–16 years (primary and secondary school age in Peru) for the school-based social marketing and healthy school food environment interventions, and children aged under one year in 2025 for the breastfeeding promotion intervention.

We assumed that intervention effects are realized one year after implementation [54]. We then estimated the impact of the interventions on YLLs, YLDs, and DALYs saved, healthcare costs averted, productivity gained, and lifetime wages gained due to increased educational attainment. We calculated the effect of each intervention on baseline BMI of the model cohort for each age and sex group. We assumed that the change in BMI was maintained into adulthood and estimated the resulting reduction in projected overweight and obesity prevalence by sex and age using the potential impact fraction (PIF) to calculate the reductions in mortality and morbidity [24].

#### Indicator

The investment case examines the efficiency of the interventions through a return-on-investment (ROI) analysis. The ROI (or benefit-cost ratio) is calculated by dividing the total economic value gained from the interventions by the cost to implement the interventions. The ROI analysis compares the cost of implementation to all economic benefits – averted mortality, healthcare costs averted, and wages and productivity gained. The analysis reviews this indicator of efficiency over 30 years, 50 years, and lifetime horizons in order to capture medium and long term costs and benefits of the intervention [53].

#### Sensitivity analysis

Additional analyses were conducted to test the sensitivity of the results to changes in the assumptions. First, a 95% confidence interval (95% CI) for the ROI estimates was derived by utilizing the upper and lower limits of the intervention effect size reported in the literature (Table 2). Second, the effects of interventions were modelled to be realized two years after implementation

**Table 2** Economic gains resulting from the four interventions, 2026–2092

Intervention	Healthcare cost savings	Gains from increased wages	Productivity gained from averted work absenteeism and presenteeism	Economic value of life years gained (YLLs only)	Total savings	Total savings per person affected by overweight or obesity
	UDS millions					USD
Social marketing in schools	93.4 (14.9, 168.2)	112.7 (18.0, 202.8)	250.0 (40.0, 450.0)	955.5 (152.9, 1,719.8)	1,411.5 (225.8, 2,540.8)	9,329.9 (9,035.9, 9,609.9)
Breastfeeding promotion at health centers	33.9 (22.9, 42.6)	49.8 (33.7, 62.6)	83.9 (56.8, 105.5)	278.0 (188.3, 349.7)	445.6 (301.8, 560.5)	4,355.8 (4,323.0, 4,382.1)
Healthy school food environment	845.3 (683.6, 1,007.0)	784.0 (645.9, 922.2)	2,449.9 (1,989.9, 2,910.0)	7,823.8 (6,506.2, 9,141.4)	11,903.1 (9,825.7, 13,980.5)	11,775.7 (10,860.4, 12,583.2)
20% food subsidy	5.3 (0.0, 16.2)	6.0 (0.0, 18.5)	14.0 (0.0, 43.2)	54.0 (0.0, 166.2)	79.3 (0.0, 244.1)	5,273.7 (0.0, 5,314.7)
All four combined	977.8 (721.5, 1,233.9)	952.5 (697.7, 1,206.1)	2,797.9 (2,086.7, 3,508.7)	9,111.3 (6,847.4, 11,377.1)	13,839.5 (10,353.3, 17,325.9)	12,089.8 (10,895.3, 13,135.4)

**Table 3** Implementation costs

Implementation cost	SOL (millions)	USD (millions)
Social marketing in schools	256.93	73.51
Breastfeeding promotion at health centers	3.90	1.12
Healthy school food environment	32.25	9.23
20% food subsidy	0.76	0.22
All four combined	293.84	84.08

**Table 4** Health outcomes for the model cohort in the base-case scenario, 2026–2092

	Years of life lost (YLLs)	Years of healthy life lost due to disability (YLDs)	Disability adjusted-life years (DALYs)
Males	8,169,214	3,292,040	11,461,254
Females	7,020,499	3,179,563	10,200,061
Total	15,189,712	6,471,603	21,661,315

instead of one year after implementation (Supplementary Table S3). Third, the impact of childhood and adolescent obesity on education attainment were varied such that obesity in childhood has been associated with a 43% lower likelihood of not completing 12 or more years of education [42, 55]. Fourth, sensitivity analyses were conducted to consider how changes in national income (GDP per capita) impact upon the value of these changes in mortality or life expectancy. As such, the valuation of a life year was increased by independently multiplying GDP per capita by a global GDP multiplier of 1.6 and a regional GDP multiplier for Latin America of 1.4 [12, 56]. An additional sensitivity analysis substituted annual discount rate of 3% with 5% to illustrate a preference for receiving benefits earlier [57]. Finally, as the main analysis estimates the combined ROI of implementing the four interventions by assuming the impact of each intervention is additive and independent, a sensitivity analysis was conducted to examine the ROI results of a less-than-additive impact and a more-than-additive impact by estimating the ROI of the combined intervention package if each intervention's impact was reduced by 50% and increased by 10% [24].

## Results

Table 3 shows the cost of implementation for each intervention independently and combined.

In Table 4 the base-case scenario health outcomes for the model cohort are given in lost YLLs, YLDs, and DALYs attributable to childhood and adolescent overweight and obesity. Overall, childhood and adolescent overweight and obesity in Peru causes 15.2 million YLLs, 6.5 million YLDs, and 21.7 million DALYs from 2026 to 2092. These results differ by sex, with more YLLs, YLDs,

**Table 5** Direct and indirect costs attributable to childhood and adolescent overweight and obesity, 2026–2090 total

	Total cost USD (billions)	Total cost SOL (billions)	Average lifetime cost per child affected by overweight or obesity (USD)
Direct healthcare costs (obesity only)			
During childhood	0.2	0.6	190.8
During adulthood	1.7	5.8	1,981.3
Total direct	1.8	6.3	2,172.1
healthcare costs			
Indirect costs			
Loss in lifetime wages	0.9	3.2	332.5
Productivity loss	16.9	59.2	20,277.0
Mortality costs	190.9	667.3	69,942.9
Total indirect	208.8	729.7	76,481.4
costs			
Total costs (direct and indirect)	210.6	736.0	77,146.2

**Table 6** Impact of interventions on DALY reductions during the lifetime of the model cohort

Intervention	Lifetime reduction DALYs (95% CI, thousands)
Social marketing in schools	124.6 (19.9, 224.3)
Breastfeeding promotion at health centers	38.0 (25.7, 47.9)
Healthy school food environment	942.9 (783.6, 1,102.3)
20% food subsidy	7.0 (0.0, 21.7)
All four combined	1,112.7 (829.3, 1,396.2)

and DALYs resulting from childhood and adolescent overweight and obesity among males than females.

The total combined direct healthcare costs and indirect costs attributable to child and adolescent overweight and obesity in Peru are 210.6 billion USD (736.0 billion SOL) (Table 5). Direct healthcare costs account for just 1% of the total cost (1.8 billion USD), while indirect costs are the large majority of costs (208.8 billion USD). Indirect costs include loss in lifetime wages of 0.9 billion USD, productivity loss of 16.9 billion USD, and mortality costs of 190.9 billion USD.

The lifetime reduction of DALYs attributable to the interventions are 124.6 thousand for the social marketing intervention in schools, 38.0 thousand for breastfeeding promotion and support at health centers, 942.9 thousand for the healthy school food environment intervention, 7.0 thousand for the food subsidy, and 1.1 million for all four interventions combined (Table 6).

Total lifetime savings for all four interventions combined is 13.8 billion USD with a per-person savings of 12,089.8 USD (Table 2). The economic benefits were expected to equal the implementation costs 18 years after implementing the combined interventions. The economic gains resulting from the four interventions come

from healthcare cost savings of (977.8 million USD, gains from increased wages (952.5 million USD), productivity gained from averted work absenteeism and presenteeism (2.8 billion USD), and economic value of life years gained (9.1 billion USD). The disaggregated total savings by intervention are 1.4 billion USD from the social marketing intervention in schools, 445.6 million USD from breastfeeding promotion and support at health centers, 11.9 billion USD from the healthy school food environment intervention, and 79.3 million USD from the food subsidy.

Table 7 shows the return-on-investment (ROI) of the four interventions independently and combined. The ROI of the four interventions combined is 39.2 USD (30 years), 64.4 USD (50 years), and 163.6 USD (lifetime) per one USD invested. The healthy school food environment intervention would have the greatest ROI across all three-time horizons with an ROI of 325.1 USD (30 years), 518.1 USD (50 years), and 1,289.1 USD (66 years; lifetime).

Table S3 shows the ROIs from the sensitivity analyses. The interventions' effects being realized two years after implementation, as opposed to one year, resulted in moderately lower ROIs for all interventions except the healthy school food environment intervention which was significantly decreased. In this conservative scenario, the 20% subsidy had the highest ROI. Using an annual discounting rate of 5% resulted in lower ROIs across all time horizons and interventions. Increasing the impact of childhood and adolescent obesity on education attainment, valuing one life-year as GDP per capita times the global GDP multiplier (1.6), valuing one life-year as GDP per capita times the regional GDP multiplier for Latin America (1.4), and assuming the combined package of interventions had a more-than-additive impact all slightly increased the ROIs across all time horizons and interventions. If the intervention package had a less-than-additive

impact, the package of interventions would still offer Peru a positive ROI within a 30-year time horizon.

## Discussion

This analysis identified the significant health and economic impacts (direct and indirect) of child and adolescent overweight and obesity in Peru. The estimated lifetime costs from child and adolescent overweight and obesity included in this analysis is 24.3 times greater than Peru's annual government health spending in 2020 [58]. The four interventions examined in the investment case—a social marketing campaign in schools, promotion and support for breastfeeding at health centers, a policy advocating for a healthy food environment in schools, a 20% food subsidy—all yield positive returns on investment. Of the interventions, the policy mandating availability of only healthy food and drinks for students at school demonstrates the highest ROI. Together the interventions provide economic gains of 13.8 billion USD over a 66-year period, or an annual average gain of 209.7 million USD, equivalent to 2.4% of Peru's annual government health spending in 2020 [58]. Savings incurred by implementing all four interventions over a lifetime are equal to 1.6 times Peru's government health expenditure in 2020 [58].

The high economic gains from implementing the interventions are likely due to the interventions altering the obesogenic environment, rather than relying solely on education or awareness-raising alone [59]. The intervention that independently has the highest lifetime health gains and ROI is the national healthy school food environment intervention to implement a policy requiring that only healthy food and drinks are available to students at school. Traditional school-based interventions have been shown to be limited in their capacity to improve health and economic outcomes when they focus solely on education [25]. The findings from this analysis shed light on how the impact that school-based interventions can have may be magnified by addressing part of the obesogenic environment within schools by ensuring only healthy food and drinks are available. The healthy school food environment intervention would expand Lima's municipal law requiring schools to provide only healthy food and drinks in and around schools to the whole country, thereby broadening the scope of the national Health Eating Promotion Law [49]. An evaluation of the current compliance with the policy in Lima schools found that participating schools had less than 40% compliance [60]. Hence the proposed national scale-up of the local policy would also include awareness-raising with school staff, managers, parents, and students, as well as enforcement. Specific consideration to enforcement and education will likely require the most attention in order to ensure successful implementation.

**Table 7** Return-on-investment (ROI) of selected childhood and adolescent obesity interventions over a 30-year, 50-year, and lifetime time horizon

Intervention	ROI (USD)		
	Over 30 years	Over 50 years	Over lifetime
Social marketing in schools	2.9 (-0.4, 6.1)	6.3 (0.2, 12.1)	18.2 (2.1, 33.6)
Breastfeeding promotion at health centers	53.8 (36.1, 67.9)	130.0 (87.7, 163.8)	397.8 (269.2, 500.8)
Healthy school food environment	325.1 (275.3, 374.8)	518.1 (437.2, 599.1)	1,289.1 (1,063.9, 1,514.2)
20% food subsidy	81.5 (-12.1, 176.6)	154.2 (-21.9, 333.3)	380.6 (-52.4, 820.9)
All four combined	39.3 (30.4, 48.0)	64.6 (49.3, 79.6)	164.1 (122.1, 205.1)

The breastfeeding promotion and support intervention offers the second highest ROI with a lifetime ROI of 397.8. This intervention will complement the existing national 'Comprehensive Maternal Health Care' policy that recommends prenatal check-ups at primary care centers include vaccinations, vital measurements, blood tests, fetal imaging, and education about the six signs of pregnancy complications and six health and lifestyle topics (including breastfeeding) [61, 62]. It also complements Peru's implementation of the International Code of Marketing of Breast-Milk Substitutes. A recent evaluation of Peruvian prenatal care found that only about half of women who attend their prenatal visits currently receive information about breastfeeding [63]. Therefore, this intervention will provide additional support during prenatal visits to ensure women receive information about breastfeeding. It will also promote exclusive breastfeeding at hospitals, delivery centers, and in the community through a mix of counseling, group education, and mass media campaigns. As these components would be new to the Peruvian context at a national, coordinated level their implementation would likely benefit from a stakeholder readiness and capacity development assessment prior to scaling up the intervention's coverage.

The third highest ROI is for the 20% fruit and vegetable subsidy for people on low incomes. The positive ROI is consistent with previous findings from an investment case in Mexico that identified fiscal interventions (including both subsidies and taxes) as offering a high ROI for reducing childhood and adolescent overweight and obesity [24]. In the present analysis, the fruit and vegetable subsidy was included as a standalone policy, as the Peruvian government has already implemented a substantial SSB tax [21]. The proposed Peru subsidy additionally focused on a narrower subset of the population – people living under the national poverty line, based on evidence suggesting that this more focused subsidy would be best in the Peruvian context [64]. It should also be noted that there is uncertainty regarding the ROIs and the health and economic impact of the fruit and vegetable subsidy due to the zero- or negative lower limits of the 95% CI. These results reflect that there is some degree of uncertainty in the effect of food subsidies on overweight and obesity owing to the currently underdeveloped state of evidence across a wider range of countries; nonetheless we opted to include the targeted fruit and vegetable subsidy as a potential option given the positive indications from Afshin, et al.'s 2017 systematic review and meta-analysis of the impact of food pricing on improving dietary consumption and indication of interest from stakeholders [65]. As this subsidy does not currently exist in Peru, further research will be needed to develop an implementation plan capable of effectively targeting only populations living below the national poverty line.

The sensitivity analysis scenario in which the interventions' effect size are not realized until two years after implementation (instead of one) found that the highest ROI was for the 20% fruit and vegetable food subsidy to those living below the national poverty line. This conservative scenario did not substantially change the ROI for the 20% fruit and vegetable food subsidy because the impact is across all age groups in both the main analysis and the sensitivity analysis, whereas the impact from the healthy school food environment intervention changes from being in effect from age 7 in the main analysis to being in effect from age 8 in the sensitivity analysis. Nonetheless, each intervention, individually or combined as part of a package, routinely demonstrates strong impacts across all seven sensitivity analyses and would bolster the existing Peruvian policies to mitigate the obesogenic environment by making healthy food more affordable (through the subsidy) and more available (through school-based healthy food requirements).

A primary strength of the present study is that it is the first investment case on childhood and adolescent overweight and obesity in South America. Additionally, the study entailed close collaboration with national nutrition policy experts and government officials, as well as UNICEF Peru to create a set of intervention recommendations that are uniquely suited to the Peruvian context. The model applied conservative assumptions and estimates based on peer-reviewed intervention literature and examined the result sensitivity to changes in the key parameters and assumptions.

There are several limitations that should be considered. First, the estimated costs attributable to childhood and adolescent overweight and obesity are only limited to the cohort modeled and would be lower than population-level costs. Second, the model assumes that the interventions permanently changed children and adolescents' BMI and longitudinal data would be needed to confirm this. Finally, the model assumes that intervention effect sizes are independent (the probability of one intervention does not impact the probability of another intervention occurring) and additive (the effect size of all four interventions combine is the sum of the four individual intervention effect sizes) as no data is currently available to indicate the potential interplay of multiple interventions being implemented simultaneously. However, as some interventions share implementation settings, such as the healthy school food environment and school-based social marketing campaign interventions, linking these interventions could potentially improve implementation cost efficiency.

In the face of persistent increases in overweight and obesity in Peru over recent years, it is likely that an expanded set of robust policy interventions will be necessary to achieve long-term progress in addressing the



overweight and obesity epidemic among children and adolescents. This study's findings can be used to guide policy and strategy to address the complex interplay of factors that contribute to the obesogenic environment.

## Conclusion

Without further intervention, child and adolescent overweight and obesity are expected to pose a significant burden on Peru's long-term health and economy. Addressing this epidemic will require wide-ranging and expanded implementation of policies to achieve long-term reductions in prevalence. This study's findings show that national interventions to establish healthy school food environments, support and promote breastfeeding, subsidize fruit and vegetable sales for low-income households, and implement social marketing campaigns with behavioral nudges in schools can offer Peru strong health and economic returns on investment, both individually and collectively. The high economic gains these interventions offer is likely due their ability to alter the obesogenic environment, rather than solely relying on education or awareness-raising alone. These findings offer an evidence-base to guide future policies and strategies to address child and adolescent overweight and obesity.

## Abbreviations

ARIMA	Autoregressive integrated moving average
BFHI	Baby Friendly Hospital Initiative
CI	Confidence interval
CPI	Consumer price index
CVD	Cardiovascular disease
DALY	Disability-adjusted life year
GDP	Gross domestic product
MIC	Middle income country
NCD	Noncommunicable disease
OR	Odds ratio
PIF	Potential impact fraction
ROI	Return-on-investment
RR	Relative risk
SSB	Sugar sweetened beverage
SOL	Peruvian sol
USD	US dollar
WPP	World Population Prospects
YLD	Year of healthy life lost due to disability
YLL	Year of life lost

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12966-024-01677-5>.

Supplementary Material 1

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## Author contributions

MEU – Investigation, Validation, Writing – review & editing. CM – Investigation, Project administration, Writing – review & editing. AMJM – Conceptualization, Funding acquisition, Supervision, Methodology, Writing – review & editing. DW – Methodology, Data curation, Formal Analysis, Writing – original draft. CR – Investigation, Validation. MJ – Investigation. COZZ – Investigation, Validation. EFLB – Investigation, Writing – original draft. DAW – Conceptualization, Funding acquisition. JJ – Conceptualization, Funding acquisition.

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## Data availability

The datasets used and/or analyzed during the current study are available in publicly accessible databases including the World Bank's World Development Indicators (<https://datatopics.worldbank.org/world-development-indicators/>), the International Labour Organization's ILOSTAT database (<https://ilostat.ilo.org/>), NCD Risk Factor Collaboration (<https://ncdrisc.org/data-downloads.html>), Global Burden of Disease Study (<https://www.healthdata.org/gbd>), and the UN World Population Prospects (<https://population.un.org/wpp/>).

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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