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Socioeconomic inequalities in school-aged children's anthropometrics in post-war Syria: a cross-sectional study

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Socioeconomic inequalities in school-aged children's anthropometrics in post-war Syria: a cross-sectional study

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Abstract

Background: Studies aimed at exploring the effect of extreme socioeconomic inequalities on children's anthropometrics are limited. This study explored the differences in height, weight, BMI, and MUAC among three different socioeconomic segments, taking place in an impoverished setting which is post-war Syria.

Methodology: This cross-sectional study included 1052 participating children aged 6 to 12, taken from 3 different socioeconomic status (SES). Anthropometric outcomes were standardized using WHO Z-scores in order to compare socioeconomic groups regardless of age and sex.

Results: Children from the lower SES group were 1.7 times more likely to be stunted compared to the higher SES group, while children from the higher SES group were taller than children from the middle and lower SES groups by approximately $Z = 0.36$, $Z = 0.42$, respectively. Obesity is approximately 1.5 times more common in the higher SES group compared to the lower SES group, while all groups averaged above $Z = 0$, the higher SES group had higher BMI values compared to the lower SES group.

Conclusion: Lower socioeconomic status was associated with a negative effect on children's height, while children from a higher socioeconomic background were more prone to overweight and obesity. Early interventions are needed to limit the effects of socioeconomic factors.

Keywords: Anthropometrics, Height, Weight, BMI, MUAC, Socioeconomic, Inequalities.

1. Background

Socioeconomic differences result in nutritional, environmental, and behavioral variations, which combined can impact the weight, height, and BMI of a child[1]. A study in China showed that growth trajectories for children from higher socioeconomic status (SES) were above those from lower SES by approximately 3 cm on average[2]. These differences can be further studied by looking into countries where socioeconomic differences have become more dispersed and more notable over time, which is clear in Syria[3].

Beyond direct health outcomes, socioeconomic disparities influence children's education[4], sanitation[5], and healthcare[6], all of which contribute to a child's long term physical development[7-10]. Previous studies have shown that children from low-income households are at a higher risk of malnutrition and stunted growth due to poverty[11-13] or limited dietary diversity[14]. Research suggests that in many settings, these social determinants can outweigh genetic factors or healthcare access in influencing health outcomes[15], showing the deep relation between poverty and children's development.

In Syria, and throughout the 14 years of war, socioeconomic inequalities have become more prominent[3]. The collapse of healthcare systems and widespread food insecurity have left more than 9 million people, nearly half of the population, without reliable access to food[16]. According to 2023 UNICEF estimates, more than 609,900 children under the age of five are stunted in Syria, and more than 3.75 million children require nutritional assistance across the country[17]. Stunting results from chronic undernutrition and causes irreversible damage to children. Similar situations relating to socioeconomic inequality have been shown in other socioeconomically diverse countries such as India[18] or Ethiopia[19], which suggests that Syria is part of a larger pattern.

Education pathways often mirror broader social and financial conditions, as families in higher socioeconomic positions are more likely to access private schooling[20,21]. This shows that an effective way to evaluate inequalities in children's development is by examining the differences between students in public and private schools.

The increase in polarization of socioeconomic groups in Syria leaves us with a unique opportunity to isolate and study the effects of severe socioeconomic inequalities on children's health and growth. Understanding how these disparities manifest in the Syrian context could contribute to developing region-specific strategies for reducing nutritional inequities, strengthening healthcare resilience, and mitigating the intergenerational impacts of poverty[22,23], especially since other developing countries like Brazil and Peru were able to reduce child stunting by up to 48%[24] and 20%[25], respectively, by narrowing the income and services gap between different socioeconomic groups and improving socioeconomic determinants.

This study conducted in Damascus, Syria, aims to determine the effects of extreme socioeconomic differences on school-aged children (6-12 years old), regarding children's height, weight, BMI, and MUAC, using schooling pathways as a proxy for socioeconomic background.

2. Methodology

2.1 Study design, timeline, and participants

In January of 2026, a cross-sectional study was conducted among 6 schools in Damascus, Syria. The study included 1052 students aged between 6 and 12 years (after disqualifying participants whose data statistically indicated a measurement error, identified as any Z-value greater than 6 or less than -6).

Participants were drawn from three groups:

A: Public schools, representing the lower socioeconomic group.

B: Public schools with tuition fees, representing the middle socioeconomic group.

C: Private schools, representing the higher socioeconomic group.

Normal public schools have no tuition fees, public schools with tuition fees require parents to pay $70 USD a year, whereas private schools require parents to pay approximately $1000 USD a year. Public schooling is the pathway taken by the majority of the students.

Religious schools, special education schools, and excellence schools were not included in this study since they do not represent a distinct socioeconomic group. Individuals with clear physical disabilities were excluded from this study. The characteristics of the study participants are presented in Table 1.

Table 1: Characteristics of participants included in this study

Characteristics	**Count**	**Percentage**
Total participants	1052	100%
Male	557	52.9%
Female	495	47.1%
Higher SES	297	28.2%
Middle SES	381	36.2%
Lower SES	374	35.6%

2.2 Data collection

Each participant had their age (in years) and sex registered, then their weight, height, and MUAC were measured and linked to their socioeconomic group (represented by school type). After that, they were asked about their daily school allowance. The results were recorded and subsequently analyzed for documentation purposes. In order to compare anthropometrics between different socioeconomic groups using data collected from participants from all ages and both sexes, Z-values (Z-scores) were used throughout this study to compose the results[26,27]. Z-scores give a single number that reflects the status of the measurement compared to other children from the same sex at the same age. Z-scores represent the number of standard deviations a measurement deviates from the median of a reference population of the same age and sex. HAZ, WAZ, BAZ, MUAZ refer to height for age Z-score, weight for age Z-score, BMI for age Z-score, MUAC for age Z-score, respectively. The school tuition for each school was provided by the schools. Daily allowance and school tuitions were recorded in Syrian Pounds (SYP) then converted to their United States Dollar (USD) equivalent at the time of data collection. (SYP to USD conversion rate of 11100:1)

2.3 Research instruments

Height: Standing height was measured to the nearest 0.5 cm using a wall height flexible acrylic chart. Participants were measured without shoes, with their heels together, back straight, and looking straight ahead.

Weight: Body weight was measured to the nearest 0.01 kg using a calibrated digital scale. The scale was recalibrated before each measurement session. Children were weighed while wearing

light indoor clothing and no shoes, we subtracted 50g for every underwear piece and 100g for every piece of outer clothes.

Middle-Upper Arm Circumference (MUAC): MUAC was measured to the nearest 0.1 cm at the midpoint of the left upper arm. The midpoint was determined as the point halfway between the acromion process of the scapula and the olecranon process of the ulna. Non-stretchable, flexible MUAC measuring tapes were used, ensuring they were snug but not compressing the underlying soft tissue. All measurements were taken while the child's arm hung relaxed at their side.

2.4 Statistical analysis[I]

Anthropometric Z-scores for height for age (HAZ), weight for age (WAZ), and BMI for age (BAZ) were generated using the anthroplus package in R[28]. Z-scores for MUAC for age (MUAZ) were calculated using the methodology outlined by Myatt and Guevarra using the zscorer package in R[29,30]. All Z-scores used the 2007 World Health Organization growth reference standards for children and adolescents[26]. The assumption of normality was assessed using the Shapiro-Wilk test, and homogeneity was assessed using the Levene test [see Table S1 in Additional file 1]. The Shapiro-Wilk test for the variables WAZ and HAZ showed a normal distribution, while the BAZ and MUAZ variables showed slight exceptions. However, due to the large sample size ($n > 30$) in the group, the ANOVA analysis remains robust despite these exceptions, especially with the inclusion of Levene's homogeneity of variance test. Afterwards, a one-way ANOVA was performed to compare the three groups. A confidence interval of 95% ($P = 0.05$) has been selected to identify statistical significance. A statistically significant difference ($p < 0.05$) was detected in all four variables. After that, each pair of groups was compared using the Tukey post-hoc test to

[I] Age was converted from years to months (by multiplying the number of years by 12) in order to calculate Z-scores.

identify the specific groups that were different from each other. Effect sizes were calculated using eta-squared (η^2) and based on Cohen's criteria: small (0.01), medium (0.06), or large (0.14). A two-way ANOVA was then conducted to examine the main effects of school type and sex, as well as their interaction, on all anthropometric Z-scores. To explore age specific differences between the higher and lower SES groups, and given the unequal sample sizes and variances between groups, Z-score differences for each measurement at each age group were assessed using Welch's t-test. And as no specific result was hypothesized for the age specific differences, the 21 comparisons (3 Z-scores × 7 age categories) were treated as an exploratory analysis to characterize the age patterns of SES-related differences, therefore to adjust for multiple testing the Benjamini-Hochberg procedure was applied to control the false discovery rate (FDR) across this set. To explore the relationship between daily allowance and anthropometrics, Spearman's rank correlation coefficient was calculated. Stunting, Thinness, Overweight, and Obesity were calculated for each school type according to WHO definitions (HAZ < -2 SD, BAZ < -2 SD, BAZ > +1 SD, BAZ > +2 SD, respectively). Graphical illustrations were generated using R, figure 3 underwent external color editing to ensure legibility. R version 4.5.3[31] was used for all analyses.

3. Results

The prevalence of the different anthropometric indicators and the mean values of the measurements are summarized in Tables 2 and 3, respectively.

Table 2: Summary of the prevalence of different anthropometric indicators

SES Group	Stunting	Thinness	Overweight	Obesity
Population	4.66%	1.14%	35.27%	13.78%
Higher SES	3.37%	1.35%	42.09%	17.51%
Middle SES	4.46%	0.79%	34.65%	13.12%
Lower SES	5.88%	1.34%	30.48%	11.5%

Table 3: Summary of measurements included in the study

SES Group	Mean HAZ (SD)	Mean WAZ (SD)	Mean BAZ (SD)	Mean MUAZ (SD)
Population	-0.10 (1.14)	0.36 (1.22)	0.60 (1.22)	0.04 (1.03)
Higher SES	0.18 (1.13)	0.71 (1.18)	0.81 (1.25)	0.29 (1.01)
Middle SES	-0.18 (1.06)	0.28 (1.24)	0.60 (1.2)	0.03 (1.05)
Lower SES	-0.25 (1.18)	0.15 (1.18)	0.45 (1.19)	-0.13 (0.98)

3.1 Height

Epidemiology: The prevalence of stunting (HAZ < -2) within the population is 4.7%. Children from the lower SES group are 1.7 times more likely to be stunted compared to the higher SES group (Figure 1).

Comparison: Children from the higher SES group were on average above Z = 0 by 0.18, while children from middle and lower SES groups were below Z = 0 by 0.18 and 0.25, respectively, making children from the higher SES group taller than children from the middle and lower SES groups by approximately Z = 0.36 and Z = 0.42, respectively (95% CI: 0.15 to 0.56, $p < 0.001$ comparing the higher to the middle SES group. And 95% CI: 0.22 to 0.63, $p < 0.001$ comparing the higher to the lower SES group, with a small effect size of $\eta^2 = 0.025$). No statistically significant differences were found comparing height between children from the middle SES group and children from the lower SES group ($p = 0.693$) (Figure 2). [see Table S2 in Additional file 1]

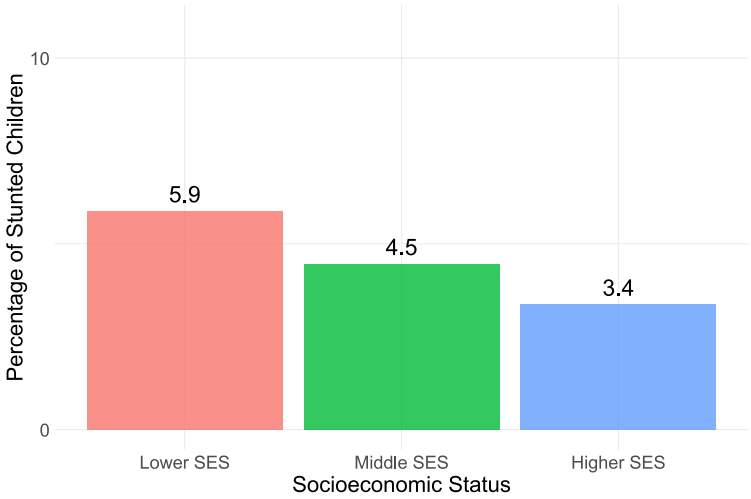


Figure 1: Stunting prevalence among different socioeconomic groups

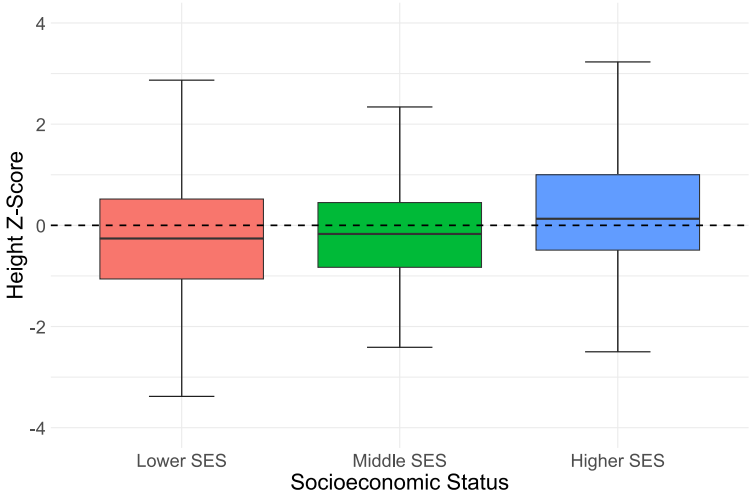


Figure 2: Height Z-Score (HAZ) distribution by socioeconomic status

3.2 BMI

Epidemiology: 13.8% of the population is obese (BAZ > 2), 35.3% of the population is overweight (BAZ > 1), and 1.1% of the population is thin (BAZ < -2). Overweight and obesity are 1.4 and 1.5 times more common in the higher SES group compared to the lower SES group, respectively (Figure 3).

Comparison: All SES groups averaged above Z = 0. (Higher SES by 0.81, middle SES by 0.6, lower SES by 0.45) The higher SES group had higher BAZ values compared to the lower SES group by Z = 0.36 on average (95% CI: 0.14 to 0.58, $p < 0.001$, with a small effect size of $\eta^2 = 0.014$) (Figure 4). [see Table S2 in Additional file 1]

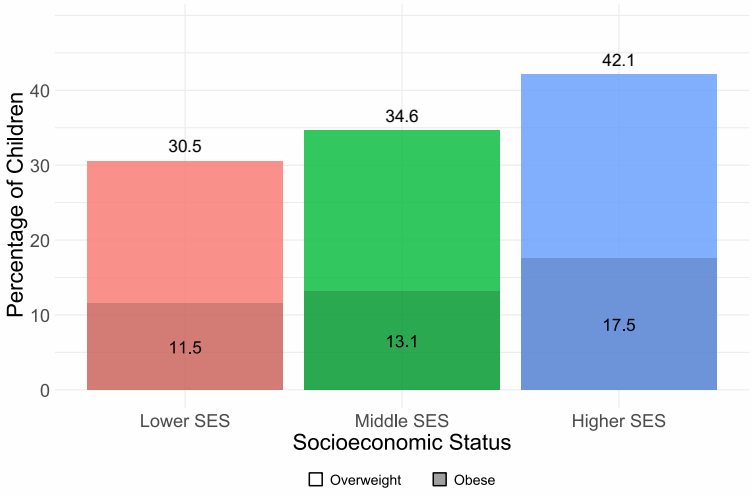


Figure 3: Overweight and obesity prevalence among different socioeconomic groups

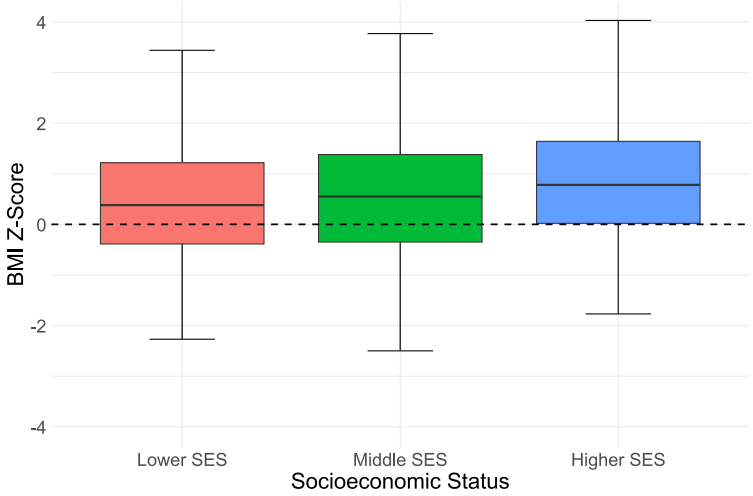


Figure 4: BMI Z-Score (BAZ) distribution by socioeconomic status

3.3 Middle Upper Arm Circumference

Children from the lower SES group were on average below Z = 0 by 0.13, while children from the higher and middle SES groups were above Z = 0 by 0.29 and 0.03, respectively. The higher SES group had higher MUAZ values compared to both the middle and lower SES groups by Z = 0.26 and Z = 0.42, respectively (95% CI: 0.077 to 0.45, p = 0.002 comparing the higher to the middle SES group. And 95% CI: 0.23 to 0.61, p < 0.001 comparing the higher to the lower SES group, with a small effect size of $\eta^2 = 0.026$).

No statistically significant differences were found comparing MUAZ between children from the middle SES group and the lower SES group (p = 0.08) (Figure 5). [see Table S2 in Additional file 1]

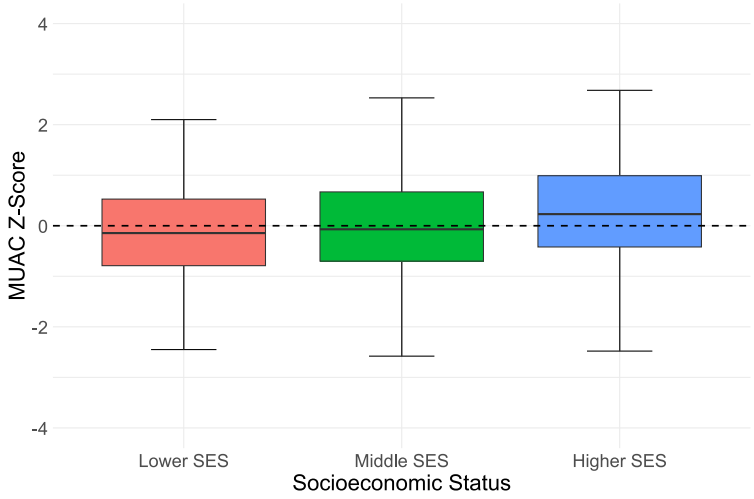


Figure 5: MUAC Z-Score (MUAZ) distribution by socioeconomic status

3.4 Daily allowance

Daily allowance showed statistically significant but very weak correlations with anthropometric indicators and therefore had limited practical significance (Figures 6 and 7).[II] [see Table S3 in Additional file 1]

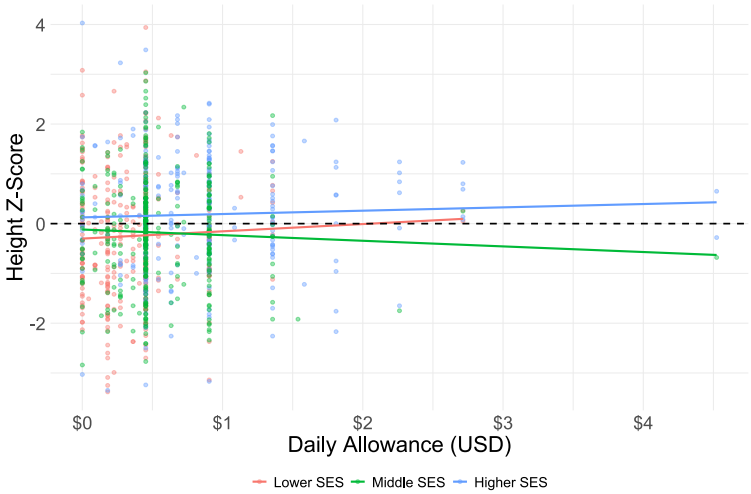


Figure 6: The effect of daily allowance on height Z-Scores

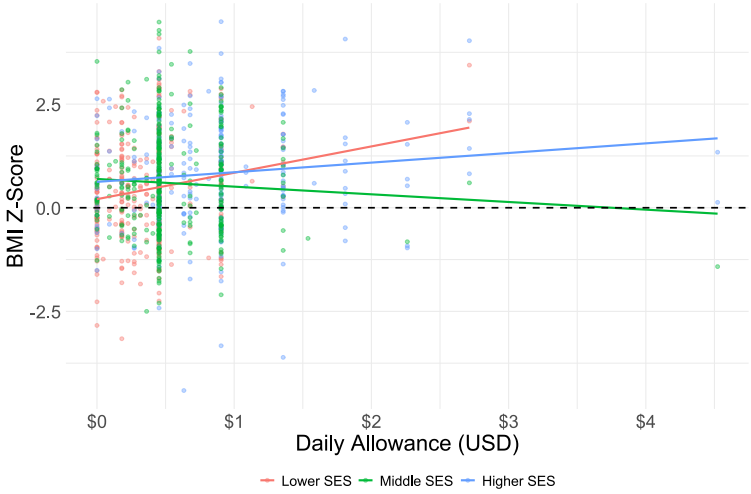


Figure 7: The effect of daily allowance on BMI Z-Scores

[II] According to Spearman's rank correlation coefficient there were weak positive correlations across all indicators ($\rho = 0.09$ for HAZ, $\rho = 0.15$ for WAZ, $\rho = 0.13$ for BAZ and $\rho = 0.13$ for MUAZ), despite being statistically significant ($p = 0.003$ for HAZ and $p < 0.001$ for other variables), meaning daily allowance does not meaningfully result in variations in anthropometrics.

3.5 Age

Comparing HAZ, BAZ, and MUAZ at the same age between the higher and lower SES groups, and after applying the Benjamini-Hochberg (FDR) correction, a statistically significant difference in HAZ was found from 8 to 10 years, peaking at 10 years old (mean difference = 0.884, 95% CI: 0.463 to 1.305, FDR-adjusted p = 0.001) (Figure 8). In BAZ the statistically significant difference remained only at 9 years old (mean difference = 0.604, 95% CI: 0.171 to 1.037, FDR-adjusted p = 0.024) (Figure 9). In MUAZ the findings were similar to HAZ and BAZ, where a statistically significant difference in MUAZ was found at 8 and 9 years old, peaking at 9 years old (mean difference = 0.673, 95% CI: 0.284 to 1.061, FDR-adjusted p = 0.006) (Figure 10). [see Table S4 in Additional file 1]

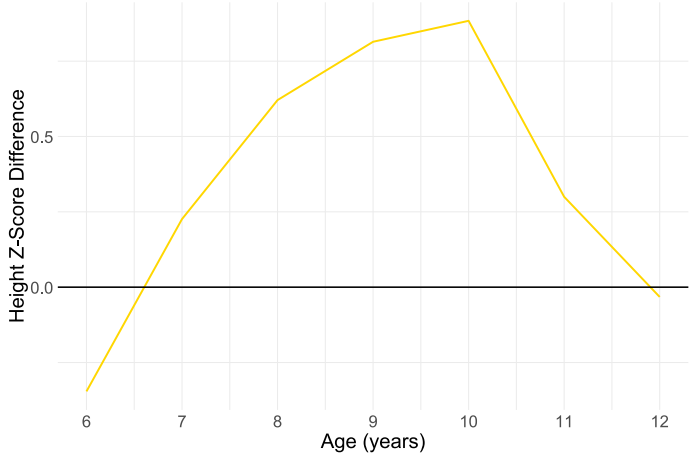


Figure 8: The difference in height Z-Score (HAZ) between the higher and the lower SES groups at each age

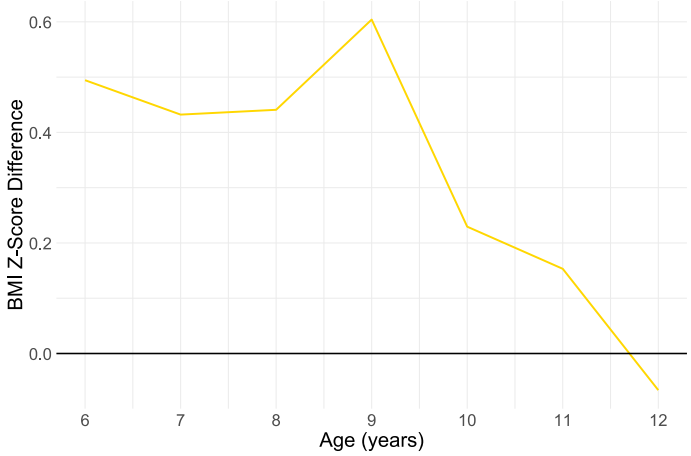


Figure 9: The difference in BMI Z-Score (BAZ) between the higher and the lower SES groups at each age

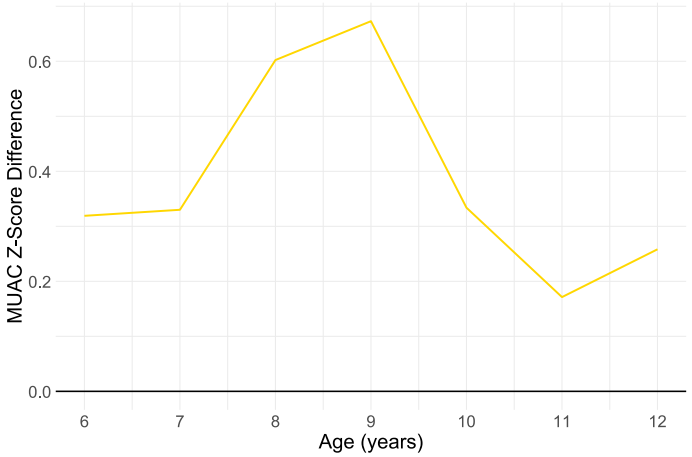


Figure 10: The difference in MUAC Z-Score (MUAZ) between the higher and the lower SES groups at each age

3.6 Sex

No statistically significant differences in HAZ, BAZ, nor in MUAZ were observed between males and females within the same SES group in two-way ANOVA tests, suggesting no gender-based inequalities in these regards ($F(2, 1046) = 1.76$, $p = 0.172$ for HAZ. $F(2,1046) = 1.46$, $p = 0.232$ for BAZ. $F(2, 1046) = 1.55$, $p = 0.212$ for MUAZ). Nor were there differences comparing males and females in the population as a whole after correcting the values for age and sex ($F(1, 1046) = 0.03$, $p = 0.862$ for HAZ. $F(1,1046) = 2.79$, $p = 0.095$ for BAZ. $F(1, 1046) = 3.82$, $p = 0.051$ for MUAZ) (Figures 11, 12, 13). [see Table S5 in Additional file 1]

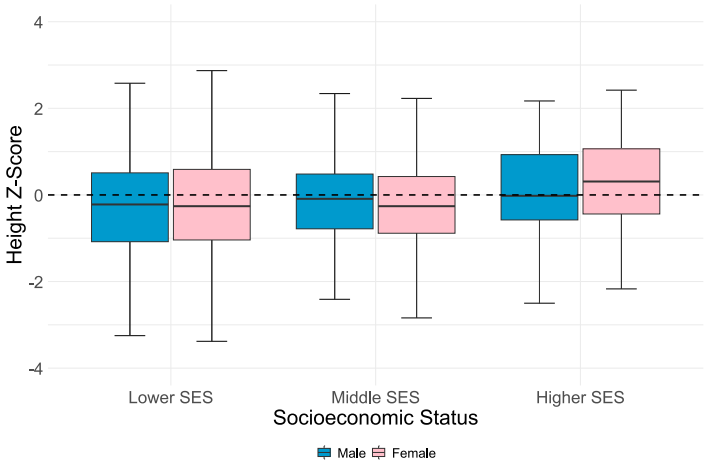


Figure 11: Height Z-score (HAZ) inequalities between males and females in each SES group

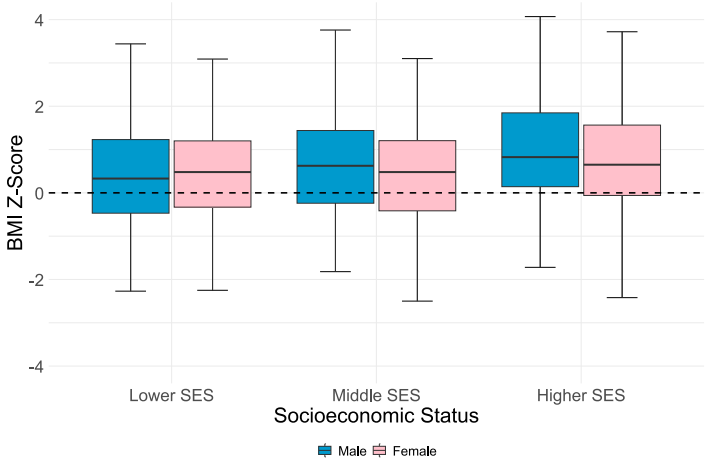


Figure 12: BMI Z-score inequalities between males and females

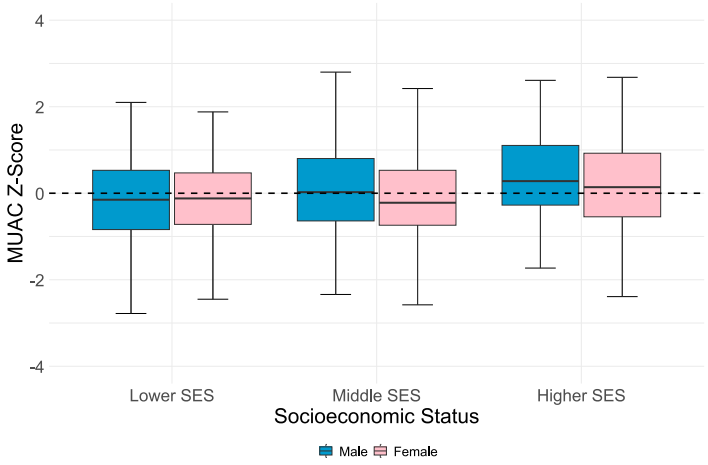


Figure 13: MUAC Z-Score (MUAZ) inequalities between males and females in each SES group

4. Discussion

In this study, children from a higher SES are more prone to overweight and obesity while children from a lower SES are more prone to stunting. The findings of this study in Syria are similar to global patterns of socioeconomic inequality and childhood growth. However, it is common for studies conducted in other nations to reach other conclusions. As an example, Mekonnen and colleagues' work in Norway[32] showed that parents with less education often have children who have a higher BMI and gain weight more quickly, but in Norway there are no differences in height based on parental education. Syria is possibly different because of a more extreme gap between socioeconomic segments, reflecting a nutritional transition compressed into a conflict zone. That arrangement fits the broader double burden of malnutrition seen across low- and middle-income settings, where stunting remains concentrated in disadvantaged households while overweight rises with wealth[33]. This pattern is also regionally consistent in MENA (Middle East and North Africa) although the exact gradient varies by country and transition stage[34]. In Syria, this gradient likely reflects both conflict-related deprivation and ongoing nutrition transition, since conflict disrupts food access and livelihoods, while limited food diversity and reduced physical activity increase overweight risk[33,35].

The discussion about the significance of MUAC over the ages of 5 is still progressing, this study helps academics reach a broader conclusion about the role of MUAC in predicating the nutrition status in children older than 5 years. In this study higher MUAZ values were consistent with the higher BAZ values shown in the higher SES group, while lower MUAZ values were consistent with the lower BAZ values shown in the lower SES group. Similar to our results, data from India

show MUAC values in low SES settings were below reference standards across ages, suggesting moderate undernutrition and potential muscle mass deficiency[36].

Daily allowance should be interpreted because it reflects the child's immediate and independent purchasing power. Our findings align with other evidence that suggests allowance alone is not a meaningful determinant while other household resources such as parental education, income, and food payment patterns are more significant[37,38].

Studying the variation of effect across ages, Aurino and colleagues recently synthesized data from 73 low- and middle-income countries and documented an inverted U-shape in SES-height gradients[39]. Our data show a similar pattern, with the largest differences between groups being at 10 years of age for height and 9 years for BMI, but we cannot observe whether normal pubertal catch-up occurs or not. Moreover, because of Syria's 14 years of conflict, food insecurity affecting 9 million people (with UNICEF reporting that 85% of households struggle to make ends meet and seven in ten families are food insecure) and a collapsed healthcare infrastructure where only 59% of hospitals are fully functional[40], we believe that catch-up may be impaired.

Educational pathways can be used as a proxy for socioeconomic status. A study by Piovesan and colleagues showed that the type of school is a "feasible predictor" for health outcomes when other individual-level SES data are unavailable[41]. This is particularly fitting in Syrian context. The difference in tuition fees between educational pathways reflects large economic inequalities that have widened during the war. While acknowledging that educational pathways do not tell the whole story about socioeconomic status, like household income or parental education, it might be the only available proxy for socioeconomic status given the absence of accessible databases in post-war Syria and the lack of cooperation from parents disclosing their household income. This limitation is further mitigated by the results, where differences in anthropometrics and

anthropometric indicators are observed between the educational pathways, partially validating the use of this classification.

4.1 Strengths and Limitations

The main strength of this study is the severity of the economic setting, and the unique window it offers to examine the effects SES factors have on children's growth. However, for lack of better available indicators we were circumscribed by using educational pathways as a proxy for socioeconomic situations which makes for the main limitation. Other limitations include: the self-reported age and daily allowance from children, the measurement of age in years rather than months, restriction of the study to Damascus (while Damascus includes displaced individuals from all states, a thorough investigation including samples from multiple states would have been more accurate), lack of data concerning physical activity and dietary patterns, not accounting for sexual maturity. The study follows a cross-sectional design whereas a cohort study would provide more information, the study only includes children who have access to schooling, leaving the most vulnerable segment who do not have access to schooling outside of the research.

4.2 Implications

Reduced HAZ scores among children from lower socioeconomic groups likely reflect chronic exposure to food insecurity and poor dietary diversity. These early inequalities may track into adulthood. The absence of an association between daily school allowance and anthropometric status in this study suggests that structural household and community conditions are more influential for linear growth than children's short-term purchasing power. Evidence from developing countries indicates that early interventions such as school feeding programs, routine growth monitoring, and age-appropriate nutrition education for children and caregivers can

improve anthropometrics[42,43]. We encourage further investigation to monitor the improvement in children's anthropometric data during the upcoming economic recovery period in Syria.

5. Conclusions

Lower socioeconomic status was associated with a negative effect on children's height, while children from a higher socioeconomic background were more prone to overweight and obesity.

6. Declaration

6.1 Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Committee of Damascus University (Ethical Approval ID number: MD-261125-557). This study was conducted in accordance with the 1964 Declaration of Helsinki and its later amendments. All data collection was conducted through arrangements with Damascus Education Directorate, The Ministry of Education in Syria. Research was conducted while taking into account the voluntary involvement of participants, obtaining signed parental informed consent for each child, maintaining the anonymity and confidentiality of all measurements and data.

6.2 Consent for publication

Not applicable.

6.3 Availability of data and materials

The dataset supporting the conclusions of this article is in the Zenodo repository, https://doi.org/10.5281/zenodo.22793147. However, the dataset is not publicly available in order to protect children's data. Researchers aiming to replicate this study should request access to the dataset through the DOI hyperlink above.

6.4 Competing interests

The authors declare that they have no competing interests.

6.5 Funding

This research was funded by the authors, no funding from any entity was received.

6.6 Authors' contributions

Munir Al Homsh: Project administration, Conceptualization, Methodology, Investigation, Data curation, Writing: original draft, Writing: review and editing.

Mohammed Omar Alkheja: Visualization, Investigation, Data curation, Writing: original draft, Writing: review and editing.

Mohammad Oklah: Formal analysis, Validation, Investigation, Data curation, Writing: original draft, Writing: review and editing.

Danial Takieddin: Investigation, Data curation, Writing: original draft, Writing: review and editing.

Omar Zewani: Investigation, Data curation, Writing: original draft.

Dr. Diana Alasmar: Supervision.

6.7 Acknowledgements

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List of abbreviations

SES: Socioeconomic status. BMI: Body mass index. MUAC: Middle upper arm circumference. HAZ: Height for age Z-score. WAZ: Weight for age Z-score. BAZ: BMI for age Z-score. MUAZ: Middle upper arm circumference Z-score

Additional Files

File name: Additional file 1

File format: .xlsx

Title of data: Statistical Analyses

Description of data: The complete results of the statistical analysis done for this research.

References

1. Bann D, Johnson W, Li L, Kuh D, Hardy R. Socioeconomic inequalities in childhood and adolescent body-mass index, weight, and height from 1953 to 2015: an analysis of four longitudinal, observational, British birth cohort studies. Lancet Public Health. 2018 Apr;3(4):e194-e203. doi: 10.1016/S2468-2667(18)30045-8. Epub 2018 Mar 21. PMID: 29571937; PMCID: PMC5887082.
2. Gao M, Wells JCK, Johnson W, Li L. Socio-economic disparities in child-to-adolescent growth trajectories in China: Findings from the China Health and Nutrition Survey 1991-2015. Lancet Reg Health West Pac. 2022 Feb 26;21:100399. doi: 10.1016/j.lanwpc.2022.100399. PMID: 35540561; PMCID: PMC9079352.
3. World Inequality Database [Internet]. Syrian Arab Republic. [cited 2026 Jun 17]. Available from: https://wid.world/country/syrian-arab-republic
4. Morgan PL, Farkas G, Hillemeier MM, Maczuga S. Risk factors for learning-related behavior problems at 24 months of age: population-based estimates. J Abnorm Child Psychol. 2009 Apr;37(3):401-13. doi: 10.1007/s10802-008-9279-8. PMID: 19057886; PMCID: PMC3085132.
5. Kumar P, Hasan N, Rajak R. Socio-economic disparities in the utilization of improved sanitation facilities among Indian households. Sci Rep. 2024 Dec 30;14(1):31659. doi: 10.1038/s41598-024-80949-3. PMID: 39738319; PMCID: PMC11685393.
6. McMaughan DJ, Oloruntoba O, Smith ML. Socioeconomic Status and Access to Healthcare: Interrelated Drivers for Healthy Aging. Front Public Health. 2020 Jun 18;8:231. doi: 10.3389/fpubh.2020.00231. PMID: 32626678; PMCID: PMC7314918.
7. Raghupathi V, Raghupathi W. The influence of education on health: an empirical assessment of OECD countries for the period 1995-2015. Arch Public Health. 2020 Apr 6;78:20. doi: 10.1186/s13690-020-00402-5. PMID: 32280462; PMCID: PMC7133023.
8. World Health Organization [Internet]. Sanitation. Geneva: WHO; c2026 [cited 2026 Mar 17]. Available from: https://www.who.int/news-room/fact-sheets/detail/sanitation
9. Agency for Healthcare Research and Quality (US). 2021 National Healthcare Quality and Disparities Report [Internet]. Rockville (MD): AHRQ; 2021 Dec. Access to Healthcare and Disparities in Access. Available from: https://www.ahrq.gov/research/findings/nhqrdr/index.html

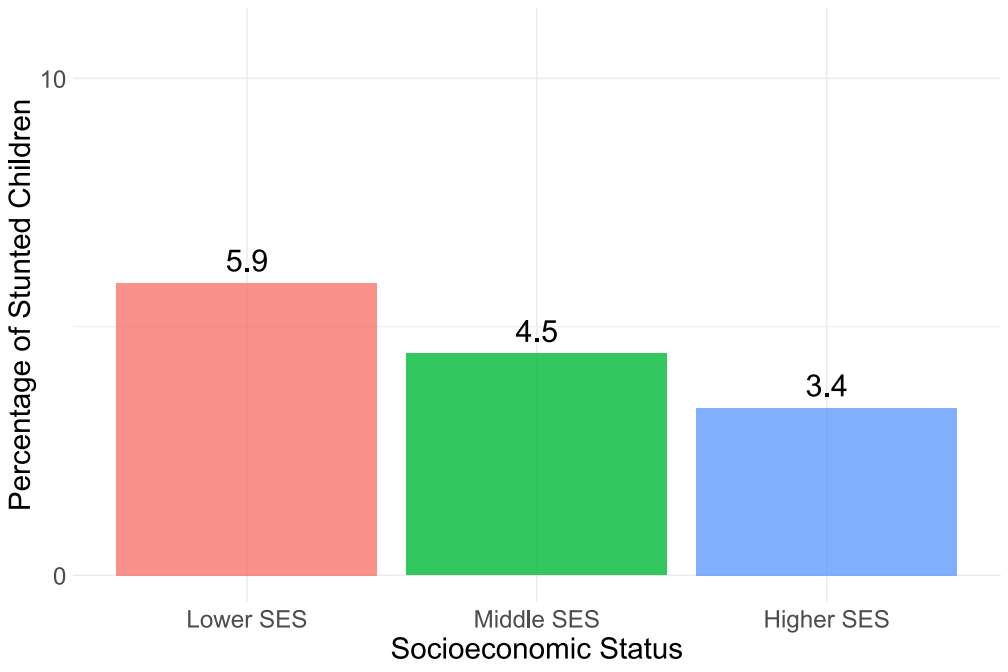
10. American SPCC [Internet]. How Health Challenges Impact Childhood Development and Well-Being: Key Effects and Solutions. [cited 2026 Mar 17]. Available from: https://americanspcc.org/how-health-challenges-impact-childhood-development-and-well-being-key-effects-and-solutions/
11. Siddiqui F, Salam RA, Lassi ZS, Das JK. The Intertwined Relationship Between Malnutrition and Poverty. Front Public Health. 2020 Aug 28;8:453. doi: 10.3389/fpubh.2020.00453. PMID: 32984245; PMCID: PMC7485412.
12. Lu C, Black MM, Richter LM. Risk of poor development in young children in low-income and middle-income countries: an estimation and analysis at the global, regional, and country level. Lancet Glob Health. 2016 Dec;4(12):e916-e922. doi: 10.1016/S2214-109X(16)30266-2. Epub 2016 Oct 4. PMID: 27717632; PMCID: PMC5881401.
13. Nwosu CO, Ataguba JE. Explaining changes in wealth inequalities in child health: The case of stunting and wasting in Nigeria. PLoS One. 2020 Sep 14;15(9):e0238191. doi: 10.1371/journal.pone.0238191. PMID: 32925960; PMCID: PMC7489558.
14. Paramashanti BA, Dibley MJ, Alam A, Huda TM. Wealth- and education-related inequalities in minimum dietary diversity among Indonesian infants and young children: a decomposition analysis. Glob Health Action. 2022 Dec 31;15(1):2040152. doi: 10.1080/16549716.2022.2040152. PMID: 35389332; PMCID: PMC9004518.
15. World Health Organization [Internet]. Social Determinants of Health. Geneva: WHO; c2026 [cited 2026 Jun 17]. Available from: https://www.who.int/health-topics/social-determinants-of-health
16. World Food Programme [Internet]. Syrian Arab Republic. [cited 2026 Mar 17]. Available from: https://www.wfp.org/countries/syrian-arab-republic
17. UNICEF Syria [Internet]. UNICEF warns of looming child nutrition crisis in Syria amid 12 years of conflict and deadly earthquakes. 2023 Mar 15 [cited 2026 Mar 17]. Available from: https://www.unicef.org/syria/press-releases/unicef-warns-looming-child-nutrition-crisis-syria-amid-12-years-conflict-and-deadly
18. Singh S, Srivastava S, Upadhyay AK. Socio-economic inequality in malnutrition among children in India: an analysis of 640 districts from National Family Health Survey (2015-16). Int J Equity Health. 2019 Dec 27;18(1):203. doi: 10.1186/s12939-019-1093-0. PMID: 31881899; PMCID: PMC6935164.
19. Bekele T, Rawstorne P, Rahman B. Socioeconomic inequalities in child growth failure in Ethiopia: findings from the 2000 and 2016 Demographic and Health Surveys. BMJ Open. 2021 Dec 14;11(12):e051304. doi: 10.1136/bmjopen-2021-051304. PMID: 34907054; PMCID: PMC8672003.

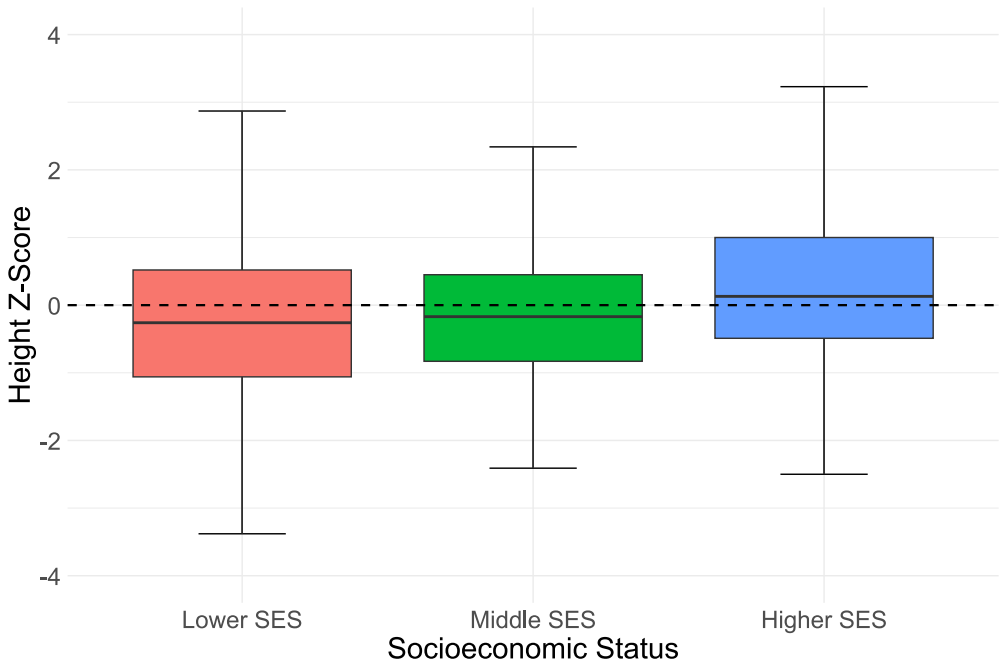
20. Claes E, Moulin L. Private vs. Public Schooling: The role of school composition. Int J Educ Res. 2026;135:102863. doi: 10.1016/j.ijer.2025.102863.
21. OECD. Public and Private Schools: How Management and Funding Relate to their Socio-economic Profile. Paris: OECD Publishing; 2012. doi: 10.1787/9789264175006-en.
22. Marmot M. The Health Gap: The Challenge of an Unequal World: the argument. Int J Epidemiol. 2017 Aug 1;46(4):1312-1318. doi: 10.1093/ije/dyx163. PMID: 28938756; PMCID: PMC5837404
23. UNICEF Syria. Syria Nutrition Fact Sheet [Internet]. Damascus: UNICEF; 2023 Oct [cited 2026 Mar 17]. Available from: https://www.unicef.org/syria/media/13906/file/Syria-nutrition-fact-sheet-Oct-2023.pdf
24. Monteiro CA, Benicio MH, Conde WL, Konno S, Lovadino AL, Barros AJ, Victora CG. Narrowing socioeconomic inequality in child stunting: the Brazilian experience, 1974-2007. Bull World Health Organ. 2010 Apr;88(4):305-11. doi: 10.2471/BLT.09.069195. Epub 2009 Dec 8. PMID: 20431795; PMCID: PMC2855601.
25. Huicho L, Vidal-Cárdenas E, Akseer N, Brar S, Conway K, Islam M, Juarez E, Rappaport A, Tasic H, Vaivada T, Wigle J, Bhutta ZA. Drivers of stunting reduction in Peru: a country case study. Am J Clin Nutr. 2020 Sep 14;112(Suppl 2):816S-829S. doi: 10.1093/ajcn/nqaa164. Erratum in: Am J Clin Nutr. 2021 Jan 4;113(1):246. doi: 10.1093/ajcn/nqaa356. PMID: 32860403; PMCID: PMC7487430.
26. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85(9):660-7. doi: 10.2471/blt.07.043497.
27. Wang Y, Chen HJ. Use of Percentiles and Z -Scores in Anthropometry. In Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease. Springer New York. 2012. p. 29-48 doi: 10.1007/978-1-4419-1788-1_2
28. Schumacher D. anthroplus: Computation of the WHO 2007 References for School-Age Children and Adolescents (5 to 19 Years) [Internet]. R package version 1.1.0. 2026. doi: 10.32614/CRAN.package.anthroplus. Available from: https://CRAN.R-project.org/package=anthroplus
29. Myatt M, Guevarra E. zscorer: Child Anthropometry z-Score Calculator [Internet]. R package version 0.3.1. 2019. doi: 10.32614/CRAN.package.zscorer. Available from: https://CRAN.R-project.org/package=zscorer
30. Mramba L, Ngari M, Mwangome M, Muchai L, Bauni E, Walker AS, Gibb DM, Fegan G, Berkley JA. A growth reference for mid upper arm circumference for age among school age children and adolescents, and validation for

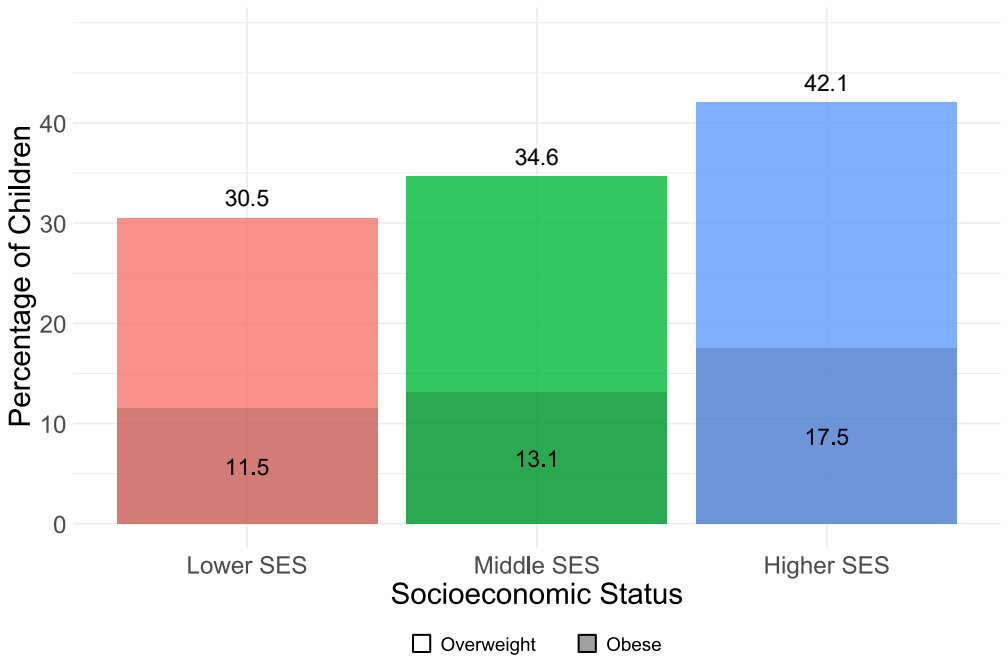
mortality: growth curve construction and longitudinal cohort study. BMJ. 2017 Aug 3;358:j3423. doi: 10.1136/bmj.j3423. PMID: 28774873; PMCID: PMC5541507.

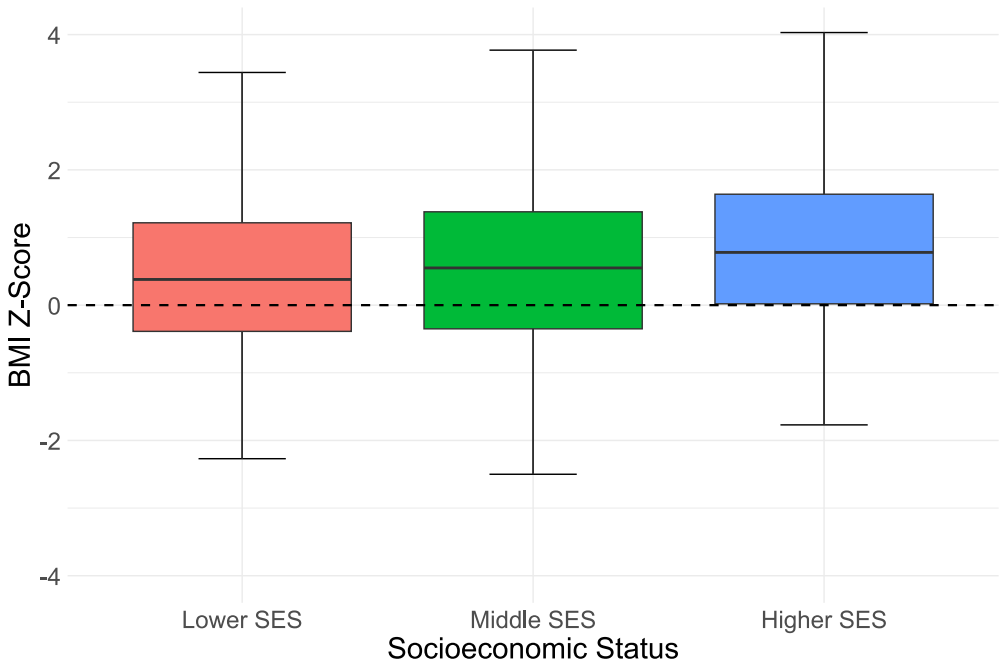
31. R Core Team. R: A Language and Environment for Statistical Computing [Internet]. Vienna, Austria: R Foundation for Statistical Computing; 2026. Available from: https://www.R-project.org/
32. Mekonnen T, Papadopoulou E, Arah OA, Brantsæter AL, Lien N, Gebremariam MK. Socioeconomic inequalities in children's weight, height and BMI trajectories in Norway. Sci Rep. 2021 Mar 2;11(1):4979. doi: 10.1038/s41598-021-84615-w. PMID: 33654136; PMCID: PMC7925535.
33. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. Lancet. 2020 Jan 4;395(10217):65-74. doi: 10.1016/S0140-6736(19)32497-3. Epub 2019 Dec 15. PMID: 31852602; PMCID: PMC7179702.
34. Ghattas H, Acharya Y, Jamaluddine Z, Assi M, El Asmar K, Jones AD. Child-level double burden of malnutrition in the MENA and LAC regions: Prevalence and social determinants. Matern Child Nutr. 2020 Apr;16(2):e12923. doi: 10.1111/mcn.12923. Epub 2019 Dec 11. PMID: 31828957; PMCID: PMC7083402.
35. Azanaw MM, Anley DT, Anteneh RM, Arage G, Muche AA. Effects of armed conflicts on childhood undernutrition in Africa: a systematic review and meta-analysis. Syst Rev. 2023 Mar 15;12(1):46. doi: 10.1186/s13643-023-02206-4. PMID: 36922839; PMCID: PMC10015806.
36. Badaik S. Evaluating the nutritional and growth indicators among rural school-aged children through anthropometric measurements. Int J Multidiscip Res. 2025;7(4). doi:10.36948/IJFMR.2025.V07I04.51907.
37. Hao L, Yeung WJ. Parental Spending on School-Age Children: Structural Stratification and Parental Expectation. Demography. 2015 Jun;52(3):835-60. doi: 10.1007/s13524-015-0386-1. PMID: 25933638; PMCID: PMC4466087.
38. Humphries DL, Dearden KA, Crookston BT, Woldehanna T, Penny ME, Behrman JR; Young Lives Determinants Consequences of Child Growth Project team. Household food group expenditure patterns are associated with child anthropometry at ages 5, 8 and 12 years in Ethiopia, India, Peru and Vietnam. Econ Hum Biol. 2017 Aug;26:30-41. doi: 10.1016/j.ehb.2017.02.001. Epub 2017 Feb 14. PMID: 28222325; PMCID: PMC5555831.
39. Aurino E, Lleras-Muney A, Tarozzi A, Tinoco B. The rise and fall of SES gradients in heights around the world. J Health Econ. 2023 Sep;91:102797. doi: 10.1016/j.jhealeco.2023.102797. Epub 2023 Aug 5. PMID: 37549519; PMCID: PMC11111217.

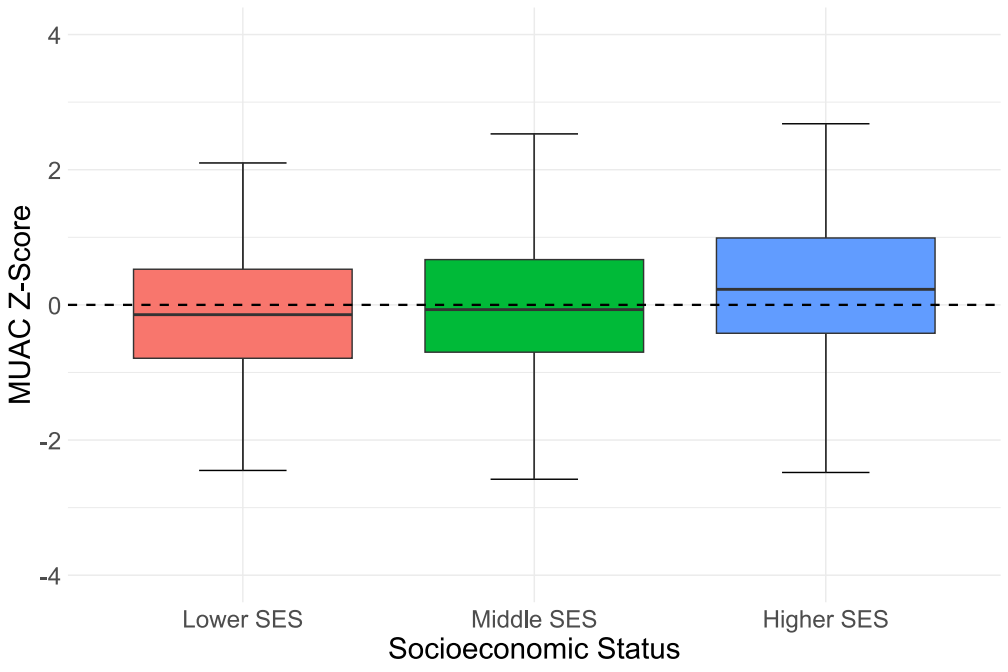
40. UNICEF Syria. Humanitarian situation report: 1 January to 31 December 2023 [Internet]. Damascus: UNICEF; 2023 Dec 31 [cited 2026 Mar 19]. Available from: https://www.unicef.org/syria/reports/humanitarian-situation-report-1-january-31-december-2023
41. Piovesan C, Pádua MC, Ardenghi TM, Mendes FM, Bonini GC. Can type of school be used as an alternative indicator of socioeconomic status in dental caries studies? A cross-sectional study. BMC Med Res Methodol. 2011 Apr 2;11:37. doi: 10.1186/1471-2288-11-37. PMID: 21457574; PMCID: PMC3080355.
42. Nuraini DL, Ramadianti DT, Syukrina F. Effects of Integrated Nutrition-Specific and Nutrition-Sensitive Interventions on Child Growth Outcomes in Low- and Middle-Income Countries: A Systematic Review. Proceedings Book of the International Conference and Exhibition on the Indonesian Medical Education Research Institute. 2026;9:92-106. doi:10.69951/proceedingsbookoficeonimeri.v9i-.307.
43. Panjwani A, Heidkamp R. Complementary Feeding Interventions Have a Small but Significant Impact on Linear and Ponderal Growth of Children in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. J Nutr. 2017 Nov;147(11):2169S-2178S. doi: 10.3945/jn.116.243857. Epub 2017 Sep 13. PMID: 28904113.

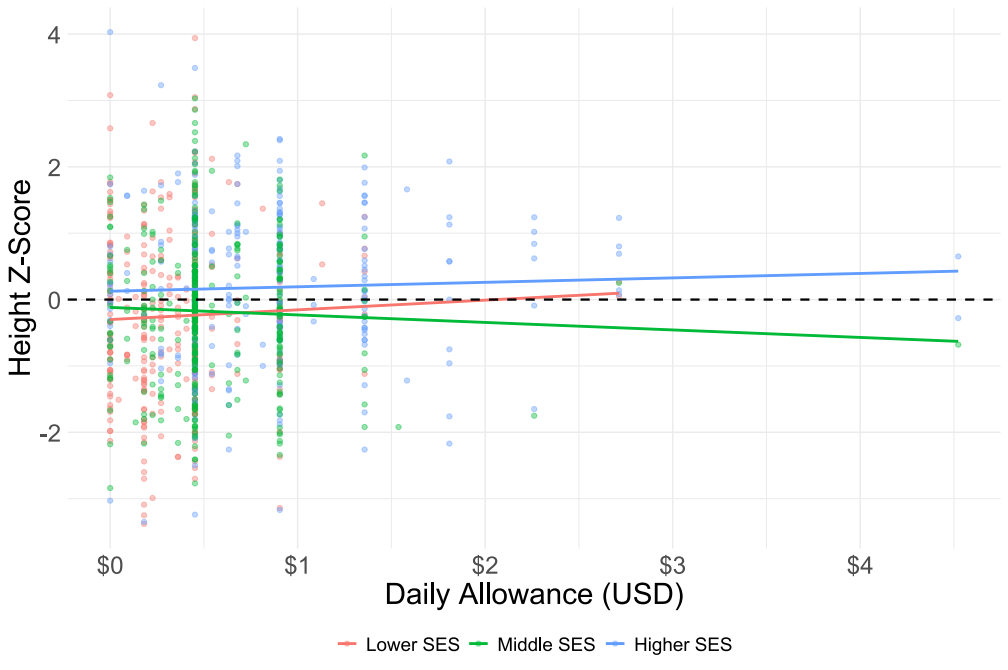

10
0
Percentage of Stunted Children
5.9
4.5
3.4
Lower SES
Middle SES
Higher SES
Socioeconomic Status

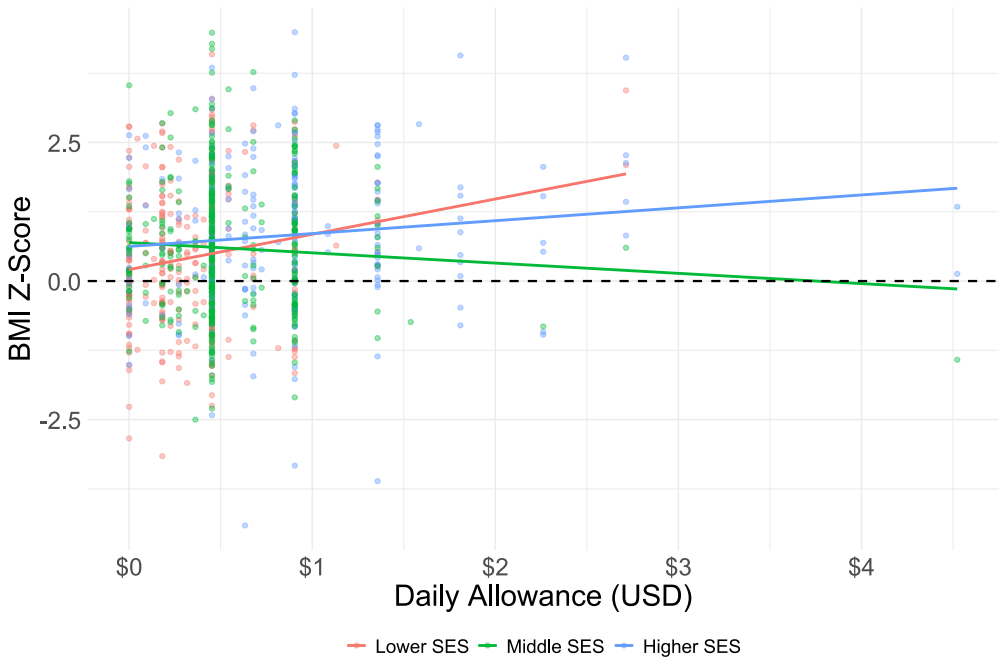

4
2
0
-2
-4
Height Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status

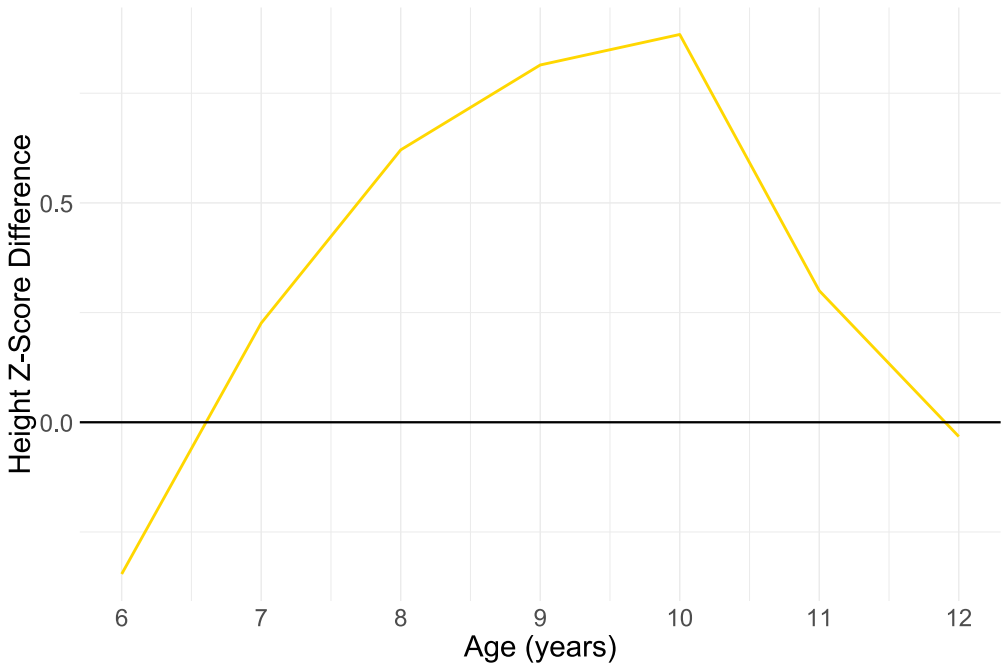

Percentage of Children
0
10
20
30
40
30.5
34.6
42.1
11.5
13.1
17.5
Lower SES
Middle SES
Higher SES
Socioeconomic Status
Overweight
Obese

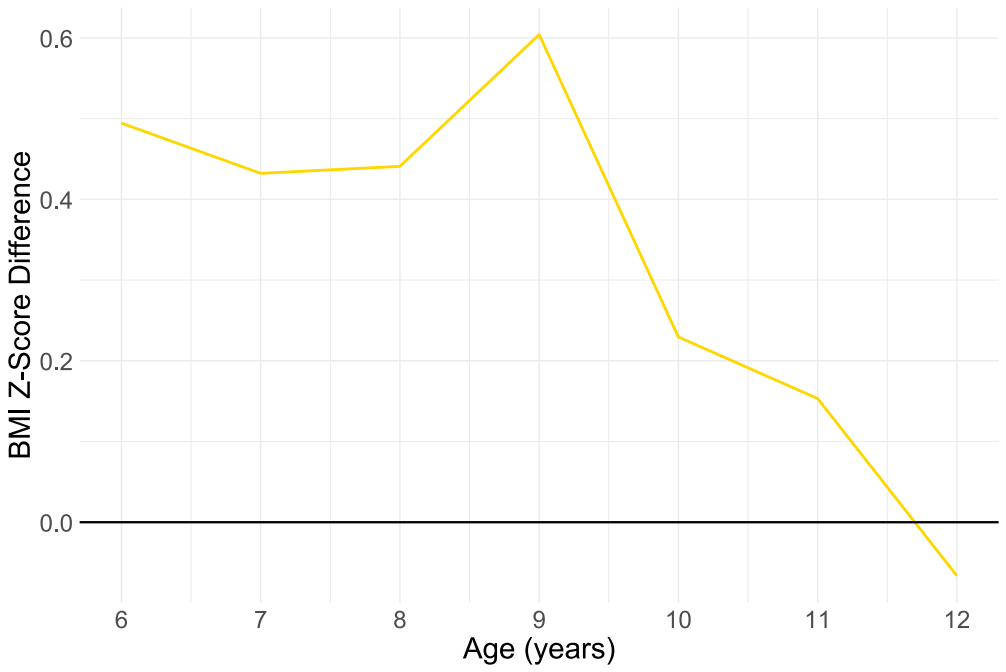

4
2
0
-2
-4
BMI Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status

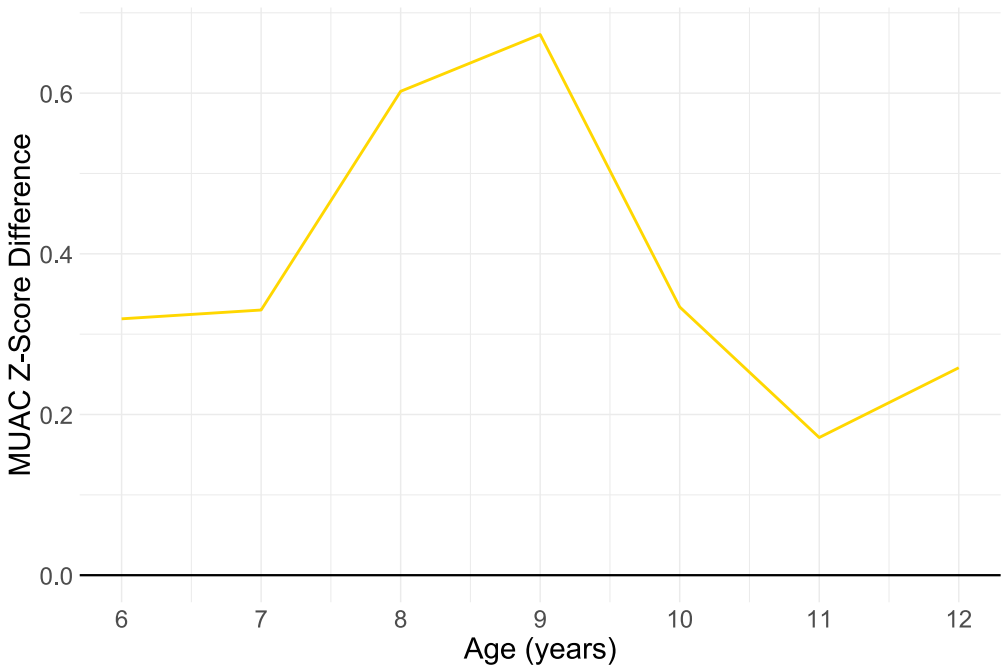

4
2
0
-2
-4
MUAC Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status

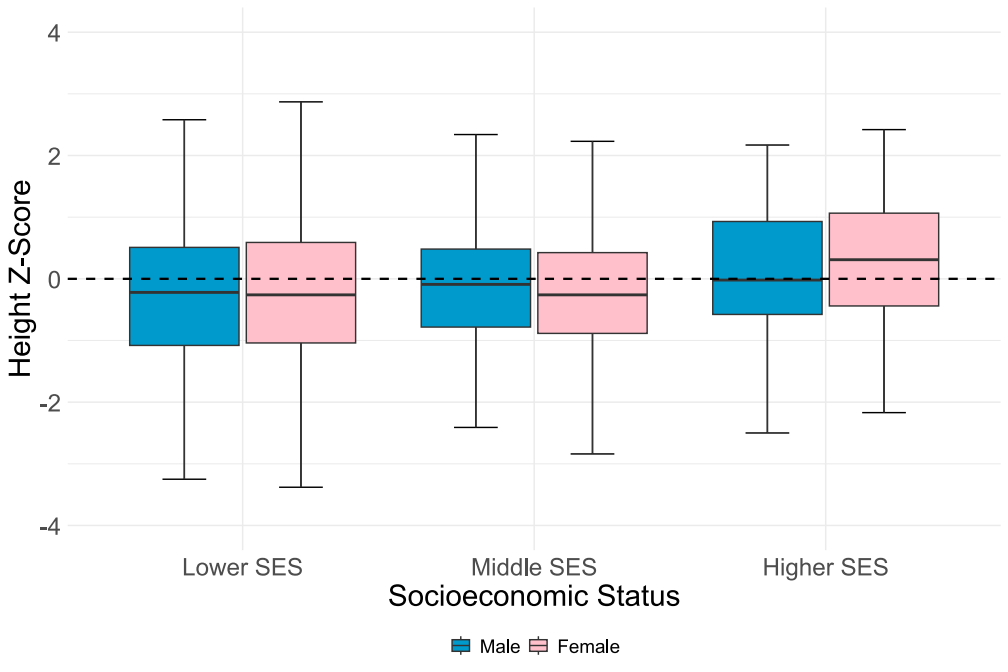

4
2
0
-2
Height Z-Score
$0
$1
$2
$3
$4
Daily Allowance (USD)
Lower SES
Middle SES
Higher SES

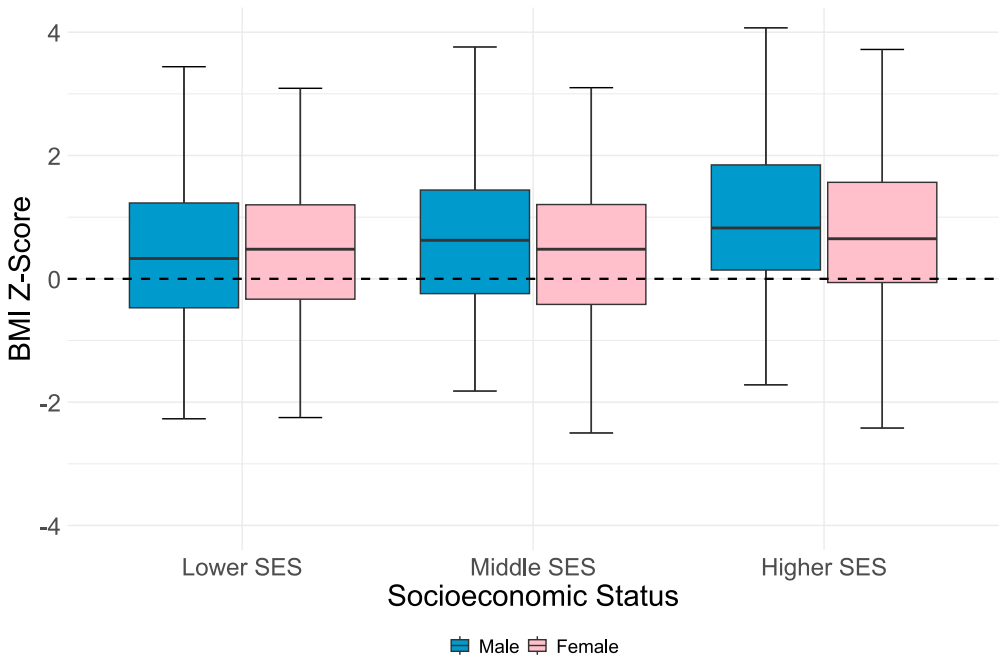

BMI Z-Score
2.5
0.0
-2.5
$0
$1
$2
$3
$4
Daily Allowance (USD)
Lower SES
Middle SES
Higher SES

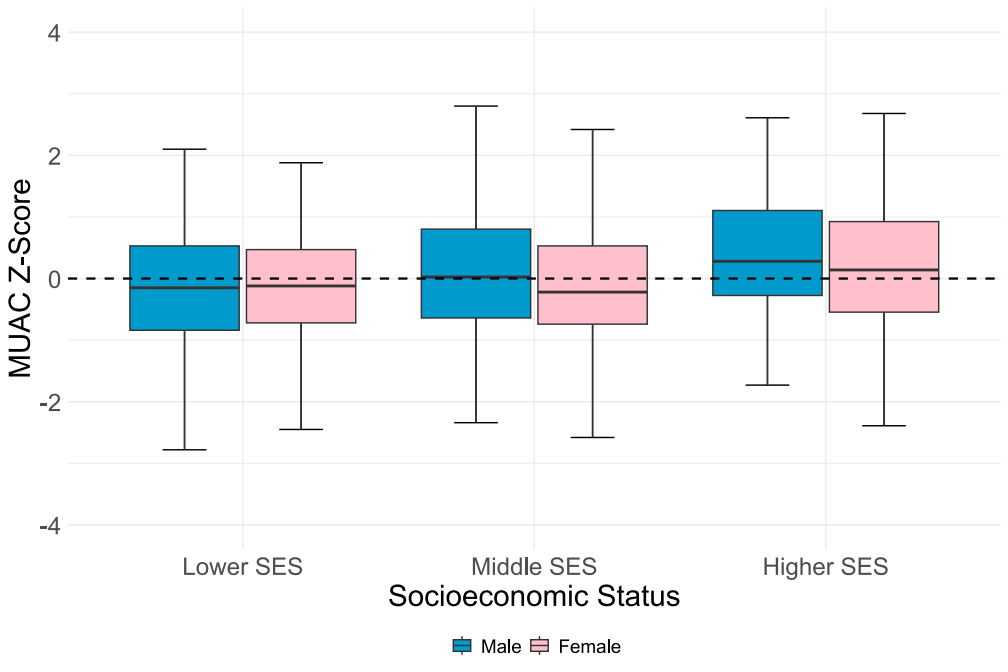

Height Z-Score Difference
0.5
0.0
6
7
8
9
10
11
12
Age (years)


0.6
0.4
0.2
0.0
BMI Z-Score Difference
6
7
8
9
10
11
12
Age (years)


MUAC Z-Score Difference
0.0
0.2
0.4
0.6
6
7
8
9
10
11
12
Age (years)


4
2
0
-2
-4
Height Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status
Male
Female


4
2
0
-2
-4
BMI Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status
Male
Female


4
2
0
-2
-4
MUAC Z-Score
Lower SES
Middle SES
Higher SES
Socioeconomic Status
Male
Female

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