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EdWorkingPaper No. 24-1106

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Since the onset of COVID-19 pandemic, there has been a significant rise in student absenteeism in the US and elsewhere. Meanwhile, food insecurity remains a persistent issue across the globe, including in the US. Food insecurity shapes students' immediate and wider contexts and may worsen school attendance. Applying ecological systems theory, we examined the relationship between food insecurity and student absence globally. We used multi-level zero-inflated Poisson regression to analyze novel, individual-level data of about half a million students from the Program for International Student Assessment (PISA) 2022. We found a universal and important relationship between food insecurity and student absence, which remains robust after accounting for student and school characteristics. Results suggest that the US should prioritize addressing food insecurity due to its higher levels of both food insecurity and student absenteeism compared to many other developed nations. We conclude that food security plays a key role in ensuring equal educational access globally.

VERSION: December 2024

Suggested citation: Canbolat, Yusuf, Leslie Rutkowski, and David Rutkowski. (2024). Empty Plates, Empty Seats: Food Insecurity and Student Absence in the US and Across the Globe. (EdWorkingPaper: 24 -1106). Retrieved from Annenberg Institute at Brown University: https://doi.org/10.26300/nzy0-jy50

Empty Plates, Empty Seats:
Food Insecurity and Student Absence in the US and Across the Globe

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Abstract

Since the onset of COVID-19 pandemic, there has been a significant rise in student absenteeism in the US and elsewhere. Meanwhile, food insecurity remains a persistent issue across the globe, including in the US. Food insecurity shapes students' immediate and wider contexts and may worsen school attendance. Applying ecological systems theory, we examined the relationship between food insecurity and student absence globally. We used multi-level zero-inflated Poisson regression to analyze novel, individual-level data of about half a million students from the Program for International Student Assessment (PISA) 2022. We found a universal and important relationship between food insecurity and student absence, which remains robust after accounting for student and school characteristics. Results suggest that the US should prioritize addressing food insecurity due to its higher levels of both food insecurity and student absenteeism compared to many other developed nations. We conclude that food security plays a key role in ensuring equal educational access globally.

Introduction

Chronic student absenteeism—defined as missing 10 percent or more of school for any reason—has doubled in the US since the pandemic, with a disproportionate increase among low-income students (Chang, Balfanz, and Byrnes 2022; Dee 2024). Similarly, absenteeism has significantly increased in various other nations, including Australia, Canada, Japan, and the UK (Bennet, 2024; Hare, 2023; Long & Roberts, 2024). Meanwhile, food insecurity—the difficulty of accessing food due to limited resources—continued as a persistent issue worldwide. Globally, more than two billion people are food insecure, with a sharp increase in recent years (Food and Agriculture Organization of the United Nations (FAO), 2023). In the US, food insecurity affects 44 million people with an upward trend in the last years as pandemic-era support programs expire. The percentage of households with children experiencing food insecurity reached 17%, with a disproportionate impact observed among minority and single-parent households (Godoy 2023; USDA 2024).

Food insecurity influences both the immediate and broader contexts of students, potentially worsening attendance through a large set of factors such as illness, worsened school engagement, and behavioral issues (Alaimo, Olson, and Frongillo 2001; Ashiabi 2005; Canbolat, Rutkowski, and Rutkowski 2023; Gundersen and Ziliak 2015). However, the relationship between food insecurity and student absenteeism has received limited attention. It is known that several factors including transportation, school climate, student and family characteristics, health, and environmental issues substantially shape absenteeism (e.g., Gottfried & Gee, 2017; Persico et al., 2022; Singer et al., 2021) but little is known about the role of food insecurity (Bartfeld, 2020; Coughenour et al., 2021).

In this study, we seek to fill this gap by utilizing data from the Program for International Student Assessment (PISA) 2022, which encompasses approximately half a million students

from 65 countries across the world. The estimation and comparison of the relationship between food insecurity and student absence offer an opportunity to see patterns across countries and, concurrently, validate the consistency of the analysis. PISA data allow us to capture students' individual food insecurity experiences, overcoming possible limitations of parent-reported information (Ashiabi 2005) and census-level food insecurity measures (Coughenour et al. 2021). The study contributes to broader student absenteeism literature (Gottfried and Gee 2017; Kearney, Childs, and Burke 2022; Singer et al. 2021). Also, it expands the evidence on the impact of school meal programs on attendance (Gordanier et al. 2020; Imberman and Kugler 2012) since we focus on a more holistic meaning of food insecurity beyond accessing food during school time.

By establishing a robust link between student absenteeism and food insecurity, this study aims to highlight the importance of addressing food insecurity not only as a social welfare issue but also as a crucial strategy for improving educational outcomes. This is in light of a growing body of research suggesting that student absenteeism is linked to broader societal inequalities (Gottfried and Gee 2017; Singer et al. 2021). While school-level efforts such as early warning systems alone do not always significantly improve attendance because of structural barriers (Canbolat 2024) mitigating poverty-related barriers such as food insecurity and housing can boost student attendance (Covelli, Engberg, and Opper 2022; Johnston et al. 2020). This underscores the need for comprehensive policy responses that encompass all levels of the educational system and extend to other social sectors within public policy (Childs and Lofton 2021). The connection between food insecurity and absence can provide a compelling rationale for policymakers to prioritize food security initiatives as part of educational interventions,

ensuring that efforts to enhance student attendance and success are informed by an understanding of the broader socio-economic context.

The motivation for incorporating international comparisons in this study stems from the need to understand variations in this relationship across diverse educational systems and social settings. Notably, not all countries have universal school meal programs (Global Child Nutrition Foundation 2022), and examining the relationship in such a large context avoids conflating the relationship between school meal programs and attendance (Gordanier et al. 2020). In addition, a cross-cultural comparison provides an international perspective of understanding where commonalities exist and highlights the unique factors influencing the effectiveness of these programs in different contexts. This approach enables a deeper appreciation of how cultural, economic, and policy differences are associated with outcomes, ultimately contributing to more informed understandings.

For example, in our analysis we found that the US has relatively larger food insecurity and student absence rates than most developed countries (see Appendix). Our multilevel zero-inflated Poisson regression results indicate a consistent and important relationship between food insecurity and absence in the US and internationally beyond controlling for several factors including student and school socioeconomic status. In particular, a one unit increase in the food insecurity scale is associated with 8% higher student absence in the US. At the extreme, this relationship suggests a 40% difference in student absence between food-secure students and their peers who face the highest level of food insecurity. Globally, absenteeism reaches 75%. These results can inform the ongoing discussion around policies to ensure equal educational access in the US and elsewhere. The next two sections discuss the theoretical framework and existing

evidence on the issue, respectively. Then, we present the methods and findings followed by a discussion.

Ecological Systems Theory to Explain Food Insecurity and Student Absence

Bronfenbrenner's ecological systems theory (1979) offers a useful conceptual framework for understanding how food insecurity can shape student absenteeism. The theory suggests that multiple interconnected systems shape human development. At the microsystem level, an individual's immediate surroundings—such as family, peers, and school—play a crucial role. The mesosystem considers how these microsystems interact and influence each other. Moving outward, the exosystem encompasses external environments that indirectly affect an individual such as community services. The broader socio-cultural context, including cultural norms and historical factors, falls under the macrosystem. Lastly, the chronosystem recognizes changes over time, both personal life transitions and historical events, shaping an individual's development. Educational outcomes such as attendance stem from those systemic, structural elements and environmental influences. These factors intertwine with the personal experiences of students within their communities and educational institutions (Lenhoff et al. 2022).

Food insecurity directly affects children within their immediate environment (*microsystem*). In a food-insecure household, children may lack access to regular, nutritious meals, leading to hunger, which can cause chronic illness, physical discomfort, fatigue, and difficulty concentrating (Gundersen and Ziliak 2015; Olson 1999; Weinreb et al. 2002), creating barriers to regular school attendance. Also, the stress and anxiety associated with food insecurity can contribute to emotional and behavioral issues that further impede school attendance (Alaimo, Olson, and Frongillo 2001; Ashiabi 2005).

The relationship between family and school (*mesosystem*) can also influence attendance (Gottfried & Gee, 2017). Food-insecure households may face obstacles to effective communication and collaboration with schools due to the family's preoccupation with meeting basic needs, increased risk of mental health issues among parents (Whitaker, Phillips, and Orzol 2006), and worsened family well-being (Johnson and Markowitz 2018). This depressed engagement between families and schools can result in missed opportunities for support and intervention, prolonging chronic absenteeism (Childs and Grooms 2018). Factors outside the immediate family and school environment, such as community resources and social support networks (e*xosystem*), play a role in shaping experiences of food insecurity. Communities with limited access to affordable and nutritious food options may exacerbate food insecurity among families. Additionally, economic instability, unemployment, and inadequate social safety nets can contribute to persistent food insecurity (Long et al., 2020; USDA, 2024), further impacting school attendance among children in affected households (Kearney, Childs, and Burke 2022; Singer et al. 2021).

The broader cultural, societal, and economic influences (*macrosystem*) also contribute to food insecurity and its effects on chronic school absence. Societal factors such as poverty, income inequality, and food distribution policies can perpetuate cycles of food insecurity, disproportionately affecting marginalized communities (Long et al., 2020). Finally, food insecurity can be episodic or chronic (*chronosystem*), depending on various temporal factors such as economic fluctuations, pandemics like COVID-19, family circumstances, or policy changes. Chronic food insecurity can lead to long-term stress, health issues, and disruptions in educational continuity, ultimately contributing to patterns of chronic school absence over time (Alaimo, Olson, and Frongillo 2001; Ashiabi 2005). Additionally, the cumulative effects of

chronic absenteeism can further exacerbate educational disparities and perpetuate cycles of poverty and food insecurity across generations (Chilton, Knowles, and Bloom 2017).

Evidence on the Interplay of Food Insecurity and Student Absenteeism

Despite extant literature on food insecurity and student absenteeism, the link between these two pressing issues is not well understood. While researchers have paid greater attention to the relationship between food insecurity and other important phenomena such as health, cognitive and psychosocial development (Alaimo, Olson, and Frongillo 2001; Grineski et al. 2018; Gundersen and Ziliak 2015), fewer studies have examined its relationship with school attendance. Coughenour et al.'s (2021) examination in a disadvantaged Nevada school district underscores a positive relationship between catchment area food insecurity and catchment-level absence rates, suggesting that a 10% increase in food insecurity correlates with a 2% rise in absence rates. However, their catchment area food insecurity measure obscures the variation between students. Using Global School-Based Health Survey data from 2003 and 2005, Rahman et al., (2023) examined the prevalence and correlates of chronic student absence across countries. They found that students who report the highest level of food insecurity have a 22% higher likelihood of chronic absence. However, the authors note that they are unable to control school-level factors since such information is not available in the data. Also, the data does not cover the recent increase in student absences since COVID-19 (Bennet 2024; Dee 2024; Hare 2023).

Although a direct relationship between food insecurity and student absence has not been well-examined, several studies unpacked the link between food insecurity and the important causes of absence such as health, engagement, and well-being (Gottfried and Gee 2017). For instance, Ashiabi's (2005) analysis of data from the National Survey of American Families reveals that food insecurity significantly predicts poor health status and emotional well-being in

children, while also detrimentally affecting school engagement. Moreover, mediation analyses suggest that food insecurity indirectly affects emotional well-being and school engagement through its influence on health status. Similarly, Howard's (2011) longitudinal study using the Early Childhood Longitudinal Study-K (ECLS-K) data further highlights the enduring impact of food insecurity on non-cognitive skills, persisting from early grades to later years, with implications for classroom behavior.

Evaluation of school meal programs offers insight into the association between food insecurity and absence because those programs potentially improve food security to a certain level (Bartfeld & Men, 2017). While the provision of free breakfast and lunch yielded a modest increase in attendance in some programs, others indicated no significant effect. For instance, using administrative data in Milwaukee between 2009-2014, Bartfeld et al. (2019) examined the impact of free breakfast on student attendance. They found the provision of free breakfast for all students reduced the odds of chronic absence by 3.5 percentage points. Bartfeld and her colleagues also examined the impact of universal access to school meal programs through community eligibility provision (CEP) on student attendance in Wisconsin. Exploiting the difference in difference and using comprehensive administrative attendance data, they found a modest decrease in student absence among economically disadvantaged students after the first year (Bartfeld, 2020). Likewise, Gordanier et al. (2020) examined the impact of free lunch through CEP on educational outcomes in South Carolina and found a 3% decrease in absence rates. On the other hand, in their experimental study, Bernstein et al., (2004) evaluated federally funded breakfast programs implemented in six districts across the country and found no significant effect on attendance. Exploiting the timing of breakfast offerings in the classroom and using a difference in differences approach, Imberman & Kugler (2012) found a weak impact on

attendance in a large US school district. Unpacking the mechanism behind the modest—and sometimes null—impact of school meal programs on attendance warrants a more comprehensive discussion. However, an important limitation of school meal studies for understanding the relationship between food insecurity and student absence is that school meal programs address food insecurity only during school. Thus, results from even a carefully implemented free school meal program have important limitations to uncover the complete picture of the link between food insecurity and student absence. In this study, we leverage student survey data from PISA to capture a more comprehensive state of food insecurity to contribute to those findings.

Methods

Data

To address our research questions, we used data from PISA 2022 questionnaires which have the most recent measures of both food insecurity and student absence internationally, explained subsequently. PISA 2022 was administered in 81 countries. However, either food insecurity or student absence items were not available in the data for 16 countries. Therefore, the PISA sample in this study consists of 442, 622 students from 16,560 schools in 65 countries. PISA is a triennial international survey conducted by the Organization for Economic Co-operation and Development (OECD) since 2000 that aims to assess 15-year-old students' knowledge and skills to participate in social and economic life. PISA employs a two-stage stratified sampling design. First, schools with potential 15-year-old students were selected with probabilities based on the estimated size of their eligible student population. At least 150 schools were chosen per country. In the second stage, students within sampled schools were selected, with 42 students chosen from each school list, or all eligible students if fewer than 42 were enrolled (OECD 2023b).

Measures

Student absence: Students reported the frequency of whole school day absence in the last two weeks on a four-point Likert scale: Never (0), one or two times (1), three or four times (2), or five or more times (3) with higher values indicating more frequent absence. As a justification of the validity of the measure for the US sample, this item is the same as the student absence item in The National Assessment of Educational Progress (NAEP) (National Center for Education Statistics 2022).

Food insecurity: PISA introduced a novel food insecurity measure in its 2022 cycle, marking the first time this aspect was included. This measure provided a unique opportunity to explore its correlation with student academic performance (OECD 2023a). National datasets such as NAEP do not survey food insecurity (National Center for Education Statistics 2022). Also, some national surveys such as ECLS-K (Howard 2011), and international surveys such as the Food Insecurity Experience Scale (FIES) (FAO 2021) estimate food insecurity among children through parent surveys. Unlike those studies, PISA directly examines details of the issue at the individual student level. Further, it includes explicit inquiries about why students might have skipped meals. While previous surveys like the Trends in Mathematics and Science Study (TIMSS) 2019 asked students about their hunger levels upon arriving at school they did not delve into the reasons behind the hunger (Martin, Von Davier, and Mullis 2020). This leaves uncertainties regarding whether students arrive at school hungry due to the availability of school breakfast programs or because they bring their own breakfast from home (Canbolat, Rutkowski, and Rutkowski 2023). The food insecurity item in PISA 2022 asked, “In the past 30 days, how often did you not eat because there was not enough money to buy food?” on a five-point Likert scale: Never or almost never (0), about once a week (1), 2 to 3 times a week (2), 4 to 5 times a

week (3), every day or almost every day (4). Higher values indicate higher levels of food insecurity.

Control variables: We used several control variables that are correlated with food insecurity and student absence to account for student and school characteristics. We selected those variables based on the relevant literature, available data, and empirical results. Prior studies suggested that parental income, and education, immigration status, sex, family structure and school location are associated with absenteeism and food insecurity (Baiden et al. 2020; FAO 2021; Gottfried 2014; Gottfried and Gee 2017; Rahman et al. 2023; Singer et al. 2021). Table 1 reports that socioeconomic status, immigrant, sex, number of siblings, and school locale are correlated with student absence and food insecurity. Therefore, we accounted for those variables to mitigate potential bias We use the PISA Index of Economic, Social, and Cultural Status (ESCS) to control students' socioeconomic status. The ESCS is a composite score constructed using parental education, parental occupation, and home possessions, which encompassed factors like the presence of books in the home. We benefit from the school's means of ESCS to account for school demographics. In addition, we control for sex (female=0, male=1), number of siblings (1=none, 2=one, 3=two, 4=three or more), immigration status (native student=1, second-generation student=2, first-generation student=3), and school location (village, hamlet or rural area=1, small town=2, town=3, city=4, large city=5, megacity=6). Descriptive statistics and correlation between variables at the international level are reported in Table 1.

Table 1 about here

Analysis

In deciding on the most appropriate analytical approach to analyze the data, we considered three factors. First, student absence can take a limited integer value from 0 to 3. Second, given the near-universal nature of school attendance in a population of 15-year olds, a substantial share of students attend school regularly, leading to excess zeros in the data. In other words, more students than would be expected in a typical ordinal distribution report never missing class. Therefore, student absence is reasonably approximated by a zero-inflated Poisson distribution (Figure 1; although the absence variable is not strictly a count variable, the ordered frequency nature of the variable is reasonably modeled via a Poisson distribution). Third, given the sampling structure of PISA in which students are nested within schools and schools are nested within countries, we employed a three-level multilevel approach. As a justification, the interclass correlation coefficient (ICC) suggested that 80% of the variance in student absence is observed between countries. To address these three requirements, we used multilevel zero-inflated Poisson (M-ZIP) regression which has an important strength over standard Poisson regression since it is better suited for estimating zeros and counts through two separate processes (Lambert 1992).

To examine the relationship between food insecurity and student absence globally, we fit two nested M-ZIP models. In Model 1, we tested the relationship without controlling for any other variables. In Model 2, we expanded Model 1 to examine the extent to which the relationship between food insecurity and student absence is robust against potentially confounding factors that are correlated with food insecurity and absence. Thus, Model 2 controlled for students and school socioeconomic status, gender, number of siblings, immigration status, and school location and can be expressed as follows:

The logistic part $\text{logit}(p_{ijk}) = \alpha_0$

The Poisson part

Level 1(Student): $log(\lambda_{ijk}) = \beta_{0jk} + \beta_{1k}X_{ijk} + \sum_{c=2}^{5}\beta_c Z_{cijk} + r_{ijk}$

Level 2 (School): $\beta_{ojk} = \gamma_{10} + \sum_{c=6}^{7}\gamma_{0c}Z_{cjk} + u_{jk}$

$\beta_{1k} = \gamma_{20}$

$\beta_c = \gamma_{3c}\ for\ c = 2,3,4\ or\ 5$

Level 3(Country): $\gamma_{10} = \theta_{10} + \varphi_k$

$\gamma_{20} = \theta_{20} + \omega_k$

$\gamma_{c0} = \theta_{c0}\ for\ c = 6\ or\ 7$

In the above equation, *i, j,* and *k* index student, school, and country, respectively. Because our research question focuses on the count of the absences and there is flexibility to fit separate models to estimate zeros and counts (Lambert 1992), we fit an intercept-only model on the logistic part of the M-ZIP where α_0 is the log odds of some absence. Thus, $\frac{\exp(\alpha_0)}{1+\exp(\alpha_0)}$ is the probability of missing at least a school day. The Poisson part has a random intercept and random slope structure. $log(\lambda_{ijk})$ is the logarithm of the mean of the Poisson distribution, denoted by λ_{ijk}. β_{0jk} is the random intercept that varies across schools and countries with $var(u_{jk})$ and var (φ_k) respectively. X_{ijk} expresses food insecurity and β_{1k} is our variable of interest, which is free to vary across countries by $var(\omega_k)$. Z_{cijk} is a vector of student level covariates that consist of students' socioeconomic status, gender, number of siblings, and immigration status (i.e., $c = 2,3,4\ or\ 5$). Z_{cjk} is a vector of school level covariates that include the school mean of socioeconomic status and location indexed with c =6 and 7, respectively.

Given a diverse set of educational systems that participate in PISA and our interest in country-specific estimates of the relationship between food insecurity and student absence, we

estimated the country-specific coefficients from the above random slope model using the empirical Bayes approach, which enables the derivation of distinct system-level estimates for randomly varying relationships. Additionally, it permits the calculation of standard errors for these estimates, facilitating comparisons between individual systems and international average estimates. This method is preferred over fitting 65 separate two-level models, as it enables the estimation of the international model and each educational system's unique effects simultaneously (Raudenbush and Bryk 2002; L. Rutkowski, Rutkowski, and Engel 2013).

Similar to other international large-scale assessments, PISA uses sampling weights since students do not have the same selection probabilities. We used non-response adjusted student weights to take into account selection probabilities. We scaled the weight to make the sum of the student weights equal to the number of students in each country (Asparouhov 2006). We used the *glmmTMB* package (Brooks et al. 2023) in *R* (R Core Team 2021) to fit the ML-ZIP models to the data.

Results

Descriptive results

We first looked at descriptives of food insecurity and student absence. Thirteen percent of US students reported that they did not eat *at least once a week* in the last month because there was not enough money to buy food. This rate is lower than the international average (15.39%) but higher than many developed countries such as Canada (9.23%), Ireland (6.8%), Korea (3.79%), Netherlands (2.88%) and United Kingdom (9.92%). It is important to note that the proportion of students who report food insecurity every day or almost every day—the highest food insecurity category in PISA—is higher than the international average (5.24%) in the US where 6.28% of the students report the highest level of food insecurity. These rates suggest that

the US is an outlier among developed countries with its relatively higher food insecurity rates among students (Appendix 1).

In the US, the average student absence is higher than the international average. The percentage of students who report that they missed at least a whole school day in the last two weeks is 28.35% and 21.60% in the US and internationally, respectively. Among 65 countries, the US ranks 20th by this measure, with Jordan reporting the lowest absence at 12.33%. Further, it has one of the highest absence rates among the OECD countries along with Canada (27.15%), New Zealand (37.39%), and United Kingdom (29.54%). Most East Asian, and East European countries as well as Chile and Portugal have the lowest absence rates internationally (Appendix 2). Secondly, we explored the relationship between food insecurity and student absence descriptively. Figure 1 plots the distribution of student absence by food insecurity. This figure illustrates that students who are food secure have the lowest absence rates while their food insecure peers have the highest absence. For instance, among students who experience food insecurity never or almost never (black in the figure), approximately 80% had never missed a whole-day absence. Among students reporting food insecurity every day or almost every day about 72% had never missed a whole day of school. A similar pattern exists in other absence categories. For instance, 5% of the students who report the highest level of food insecurity missed a whole school day five or more times in the last two school weeks whereas less than 2% of their food-secure peers missed a whole school day five or more times. These descriptive results suggested that food insecurity is an important factor associated with higher levels of student absenteeism.

Figure 1 about here

Main results

We report the global estimates of the relationship between food insecurity and student absence in Table 2. The zero-inflation part of Model 1 reveals an intercept of -1.32 (SE = 0.02, p < .01). This means that internationally 21% of the students miss at least a whole school day within the last two weeks of the PISA 2022 survey ($\frac{\exp(-1.318)}{1+\exp(-1.318)} = 0.21$).

Table 2 about here

Fixed effects results from the Poisson regression part (i.e., the conditional model) indicate a positive and consistent relationship between food insecurity and student absence. Model 1 reveals an international regression coefficient of 0.17 (SE = 0.02, p < .01). The associated odds ratio (OR =1.18 (95% CI: [1.16– 1.20]) suggests that a one-unit increase in the food insecurity scale is linked to an increase in student absence of 18% on average. The positive coefficient of 0.14 (SE = 0.01, p < .01) for food insecurity in Model 2 that controls for student and school characteristics suggests a persistent and significant association between food insecurity and student absence. Specifically, for every one-unit increase in food insecurity, there is an associated increase in student absence by a factor of approximately 1.15 (95% CI: [1.13 – 1.16]). This indicates that an additional unit increase in food insecurity is linked to higher incidence of student absence by about 15%, holding other variables constant. These results suggest a substantial attendance gap between food-secure students and their peers who experience the highest level given that the food insecurity scale consists of five categories. Comparing the difference in the maximum and minimum values on the food insecurity scale and the 15%-point estimate suggests that absence among students who have the highest level of food insecurity is 75% greater than that of food-secure students.

Figure 2 provides country-specific estimates derived using empirical Bayes estimates, examining the relationship between food insecurity and student absence. Results suggest that most of the country-specific estimates statistically mirror the global estimate of 0.14 (SE = 0.01, $p < .01$) reported above. The relationship is positive in all countries but not statistically different from zero in 14 out of 65 countries. Notably, some East Asian countries such as Korea, Chinese Taipei, and Hong Kong (China) exhibit the highest coefficients with an estimate of larger than 0.30 indicating a particularly strong association between food insecurity and student absence. On the other hand, countries like Kosovo, Baku (Azerbaijan), and Qatar display the lowest coefficients, with an estimate of lower than 0.05, suggesting a relatively weaker relationship. These estimates highlight some variations in the relationship between food insecurity on student absence across different countries. Potential reasons for cross-country variation are discussed subsequently.

The regression coefficient for the US is 0.08 (0.02). The associated odds ratio (OR =1.08 (95% CI: [1.05– 1.12]) suggests that a one-unit increase in the food insecurity scale is linked to an 8% increase in student absence. In other words, controlling for student and school characteristics, absence among students who have the highest level of food insecurity is 40% greater than that of food-secure students in the US multiplying the above coefficient and the difference in the highest versus lowest categories in food insecurity scale.

Figure 2 about here

One obvious reason for the variation in the country-specific estimates reported in Figure 2 is that the frequency of food insecurity and student absence greatly varies across countries. To illustrate this relationship, we plotted the frequency of student absence, food insecurity, and the magnitude of the relationship between food insecurity and student absence across countries in Figure 3. We found that the magnitude of the relationship (e.g., empirical Bayes estimates) is

higher in countries with lower average absence. The correlation between average student absences and the magnitude of the country-specific estimates is -0.81 (t = -11.01, CI = [-0.88, -0.71]). Though small in magnitude, the country-specific estimates are negatively correlated with the frequency of food insecurity by -0.37 (t = -3.11, CI = [-0.56, -0.13]).

Figure 3 about here

Countries exhibiting lower average levels of absence and food insecurity typically show higher coefficients, and conversely. For instance, some East Asian countries noted earlier such as Korea, Chinese Taipei, and Hong Kong (China) have the lowest average absence and the highest coefficients. Similarly, countries with higher average absence such as Baku (Azerbaijan), Dominican Republic, Kosovo, Qatar, and Saudi Arabia have the smallest coefficients. Countries where the relationship between food insecurity and absence is not statistically different from zero (gray circles in Figure 4) cluster in the highest average absence group. It is important to highlight that such statistical differences do not necessarily mean that the relationship in those countries is statistically different from the global estimate. Another apparent reason for the weak relationship in those countries is that average food insecurity is relatively higher. These results imply that food insecurity does not distinguish student absence in those countries since student absenteeism is quite prevalent independent of food insecurity, which is also slightly more common in those countries. Overall, the results suggest that except for those high-absenteeism countries, there is a consistent relationship between food insecurity and student absenteeism.

Discussion

Our research reveals a significant and consistent correlation between food insecurity and student absenteeism, both in the United States and globally. Notably, in the U.S., a one-unit increase in the food insecurity scale correlates with an 8% increase in student absence, underscoring 40% greater absenteeism among students facing the highest level of food insecurity compared to their food-secure counterparts. This differential starkly illustrates the substantial barrier that food insecurity poses to regular school attendance. Globally, the relationship is even more pronounced, with the highest level of food insecurity leading to a 75% increase in student absence compared to food secure peers. These findings persist even when controlling for a variety of factors, including, especially, student and school socioeconomic status, highlighting the robust nature of the relationship between food insecurity and absenteeism across diverse educational contexts. The consistent relationship indicates that food insecurity correlates with student absenteeism independently of the connection between socioeconomic status and absenteeism.

Further analysis through country-specific estimates shows variability in the strength of this relationship, with some regions, particularly in East Asia, exhibiting a stronger association between food insecurity and student absence. Countries with lower absence and food insecurity tend to have stronger relationship between food insecurity and absence. Further, this variability suggests that the extent to which food insecurity is associated with absenteeism may be mediated by national or regional policies, socioeconomic conditions, and the availability of support systems. However, the overarching trend underscores a universal truth: food insecurity significantly impedes students' ability to attend school regularly, thus hindering their educational progress. These results call for a nuanced understanding of the multifaceted impacts of food

insecurity on educational access and equity, necessitating targeted interventions that address the root causes of both food insecurity and absenteeism.

Bronfenbrenner's ecological systems theory provides a useful framework for understanding the nuanced ways in which food insecurity may contribute to student absenteeism. This theory delineates the complex interrelations between the multiple layers of an individual's environment, from the immediate settings of family and school (the microsystem) to broader societal and cultural influences (the macrosystem) (Lenhoff et al. 2022). Our findings align with this framework, showing that food insecurity, rooted in the microsystem, impairs students' capacity to engage consistently in their education. The observed correlation between food insecurity and increased student absenteeism can be attributed to the immediate effects of hunger on a child's physical well-being and academic engagement (Ashiabi, 2005; Gundersen & Ziliak, 2015), as well as the stress and anxiety stemming from food scarcity within the household (Alaimo et al., 2001).

Moreover, our research underscores the significance of the mesosystem in mediating the relationship between food insecurity and absenteeism. This layer of Bronfenbrenner's theory emphasizes the connections and interactions between the different microsystems in a child's life, such as the relationship between family and school (Gottfried & Gee, 2017). The disparities in absenteeism among students from food-secure and food-insecure backgrounds signal the need for schools and communities to work collaboratively in addressing the barriers to attendance (Childs and Grooms 2018). The consistency of the food insecurity-absenteeism relationship across countries, despite varying magnitudes, suggests that interventions need to be both localized and informed by an understanding of the broader systemic and structural influences on student well-being. Integrating our findings with Bronfenbrenner's theory, it becomes evident

that tackling food insecurity and its impact on education requires a multifaceted approach that considers the interconnectedness of individual, familial, institutional, and societal factors (Singer, 2021). This approach not only aligns with our empirical evidence but also provides a framework for developing targeted interventions aimed at reducing absenteeism and promoting educational equity. Studies can further analyze PISA data to expand our comparative knowledge of student absenteeism. For instance, future research can examine how absenteeism has changed in recent years across countries, by student demographics and school characteristics.

Our study has several limitations. Despite the advantage of directly surveying students rather than households, a potential limitation of the study lies in the use of a single-item measure to assess food insecurity. Research indicates that single-item measures can underestimate the true prevalence of food insecurity (McKechnie et al. 2018). Second, it is important to note that our study's findings do not establish causal relationships which are often difficult to draw from cross-section ILSAs (D. Rutkowski et al. 2024). Third, food insecurity represents just one aspect of several material hardships that could potentially impact absenteeism. Therefore, in modeling the relationship between food insecurity and absenteeism, there exists a multitude of unobserved variables. Additionally, self-reported measures of attendance may contain some bias as students could have a hard time recalling their attendance.

Despite the above limitations, the implications of our findings for policymakers highlight the urgent need for catholic strategies to combat food insecurity and its direct impact on student absenteeism. Given the substantial link between food insecurity and increased student absence, policymakers are provided with a data-driven rationale for implementing or continuing comprehensive food assistance and nutritional support programs within schools. Moreover, the findings underscore the importance of extending support beyond the school environment to

address the broader socioeconomic factors contributing to food insecurity (Kearney et al. 2022). Furthermore, the variability in the strength of the relationship between food insecurity and absenteeism across different countries suggests that policy responses should be tailored to the specific needs and contexts of each region. Policymakers should consider the implementation of targeted interventions that are sensitive to the unique cultural, economic, and educational landscapes of their constituencies. Additionally, our findings point to the necessity for continuous monitoring and evaluation of policies to ensure they effectively reduce barriers to education for food-insecure students. By leveraging the insights provided by this research, policymakers have the opportunity to make informed decisions that not only enhance educational access and equity but also contribute to the holistic well-being of students.

In conclusion, this study sheds light on the ways in which food insecurity contributes to student absenteeism, presenting evidence of a consistent relationship across different socioeconomic and international contexts. By integrating empirical findings with Bronfenbrenner's ecological systems theory, we argue for the interconnectedness of individual, familial, and systemic factors in promoting educational attendance and access. The relationship between food insecurity and absenteeism, underscored by our analysis, calls for a concerted effort among policymakers, educators, and communities to address this multifaceted issue. Implementing comprehensive interventions that go beyond the classroom to address the root causes of food insecurity can significantly improve student attendance and, by extension, their academic achievement and future prospects. As we move forward, it is imperative that stakeholders across all levels of society collaborate to develop and support policies that ensure every child has access to the necessary nutritional and educational resources, thereby fostering a more equitable and inclusive educational landscape.

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Tables

Table 1: Correlation Between Variables and Descriptive Statistics at the International Level

		Student absence	Food insecurity	ESCS	Immigrant	Male	Number of siblings
Correlation between variables	Student absence						
	Food insecurity	0.07					
	ESCS	-0.02	-0.14				
	Immigrant	0.02	-0.01	0.10			
	Male	0.02	0.04	0.02	0.00		
	Number of siblings	0.07	0.07	-0.16	-0.01	-0.03	
	Localee	0.01	-0.06	0.22	0.15	0.00	-0.09
Descriptive Statistics	Mean	0.29	1.32	-0.36	1.17	1.19	3.24
	Median	0	1	1.14	0.5	0.5	1.26
	SD	0.63	0.94	-0.24	1	1	3

Table 2: Food insecurity predicting student absence, global estimates (N= 442,622)

			Model 1						Model 2					
		Variable	Coef.	se	p	Odds. Ratio.	Confidence Intervals		Coef.	se	p	Odds. Ratio.	Confidence Intervals	
							Lower	Upper					Lower	Upper
Zero-inflation Model		(Intercept)	-1.32	0.02	<.01	0.27	0.26	0.27	-1.37	0.02	<.01	0.25	0.25	0.26
Conditional Model	Fixed Effects	(Intercept)	-1.54	0.12	<.01	0.21	0.19	0.24	-2.04	0.13	<.01	0.13	0.11	0.15
		Food insecurity	**0.17**	**0.02**	**<.01**	**1.18**	**1.16**	**1.20**	**0.14**	**0.01**	**<.01**	**1.15**	**1.13**	**1.16**
		SES							0.05	0.01	<.01	1.05	1.04	1.05
		Male							0.15	0.01	<.01	1.17	1.16	1.17
		Siblings							0.06	0.01	<.01	1.06	1.06	1.06
		Immigrant							0.01	0.01	0.308	1.01	1.00	1.02
		Locale							0.01	0.01	0.190	1.01	1.00	1.01
		School SES							-0.20	0.01	<.01	0.82	0.81	0.83
	Random Effects (Variance)	School (Intercept)	0.24						0.24					
		Country (Intercept)	0.99						0.95					
		Food Insecurity	0.01						0.01					
Model Characteristics	ICC (Between Country)		0.81						0.80					
	−2LL		615768.7						561729.4					
	Number of Parameters		5						11					

Figures

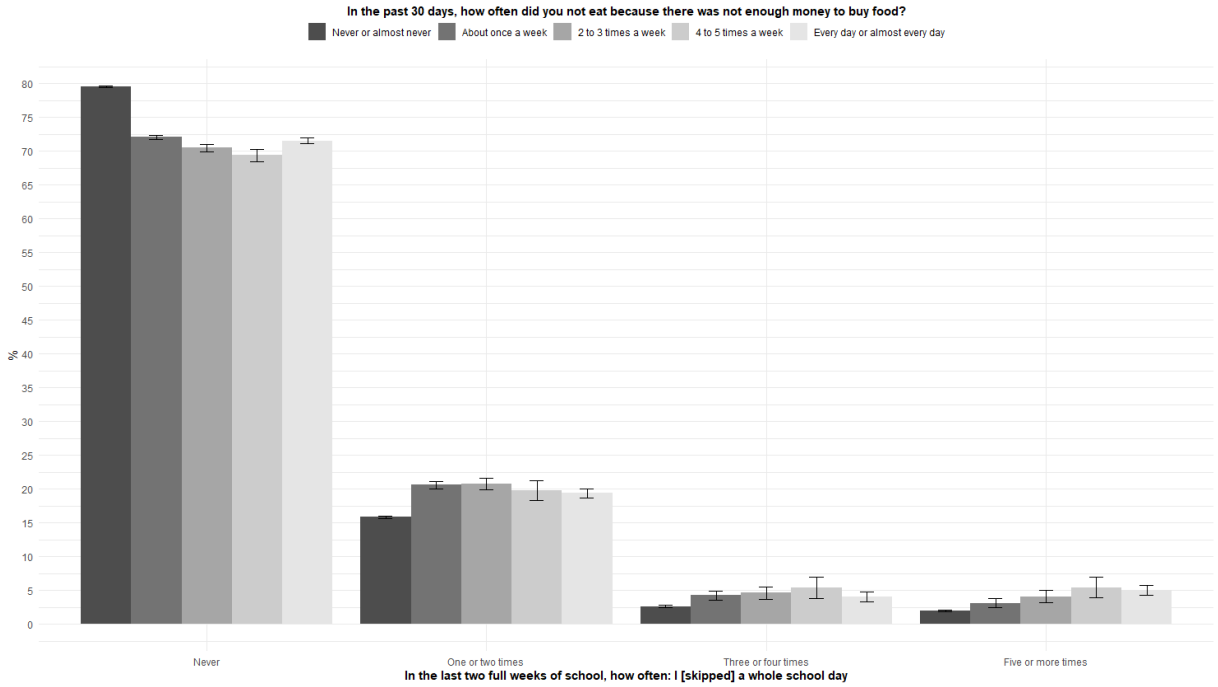

Figure 1: Distribution of student absence by food insecurity

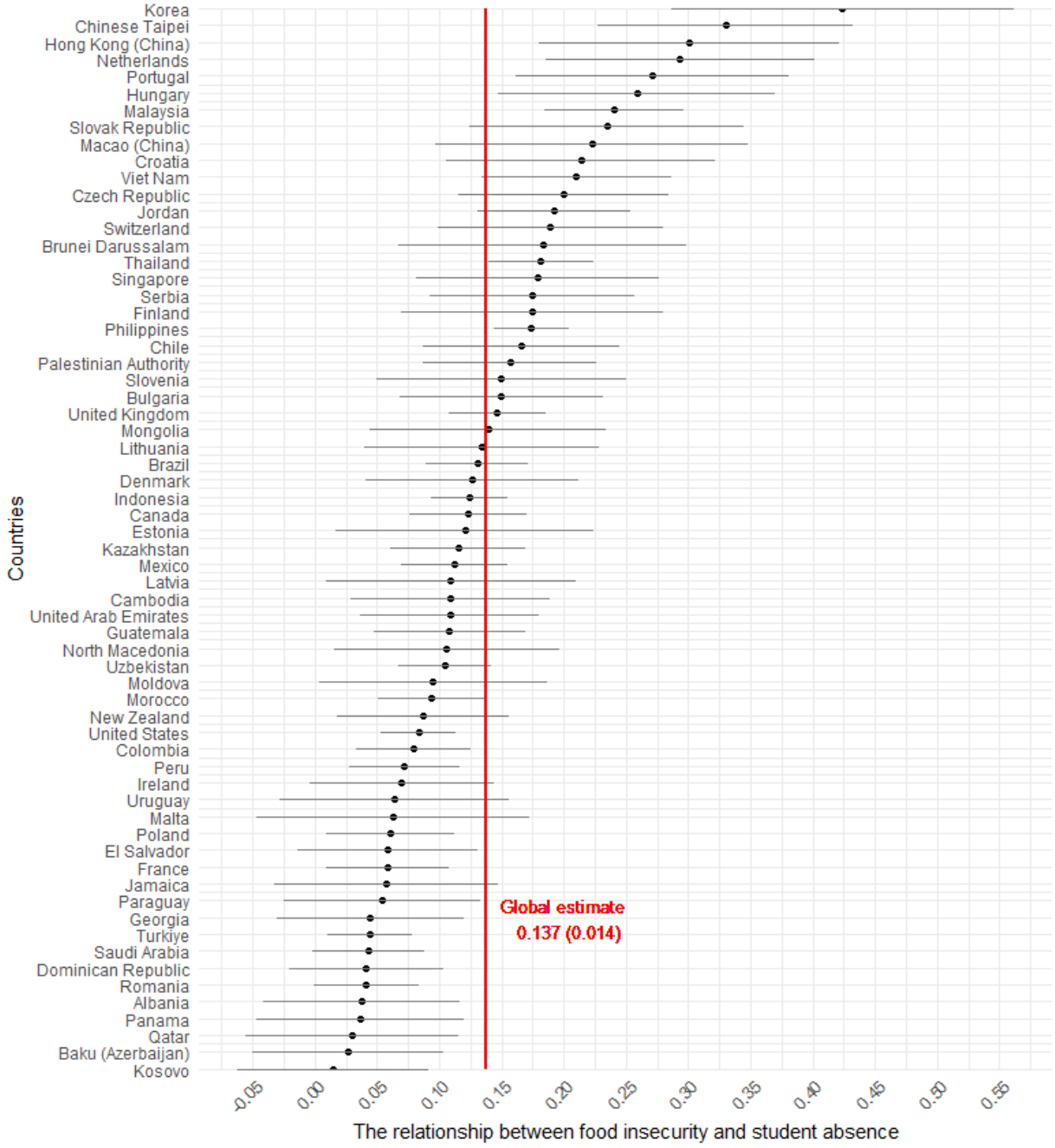

Figure 2: Food insecurity predicting student absence, country-specific estimates

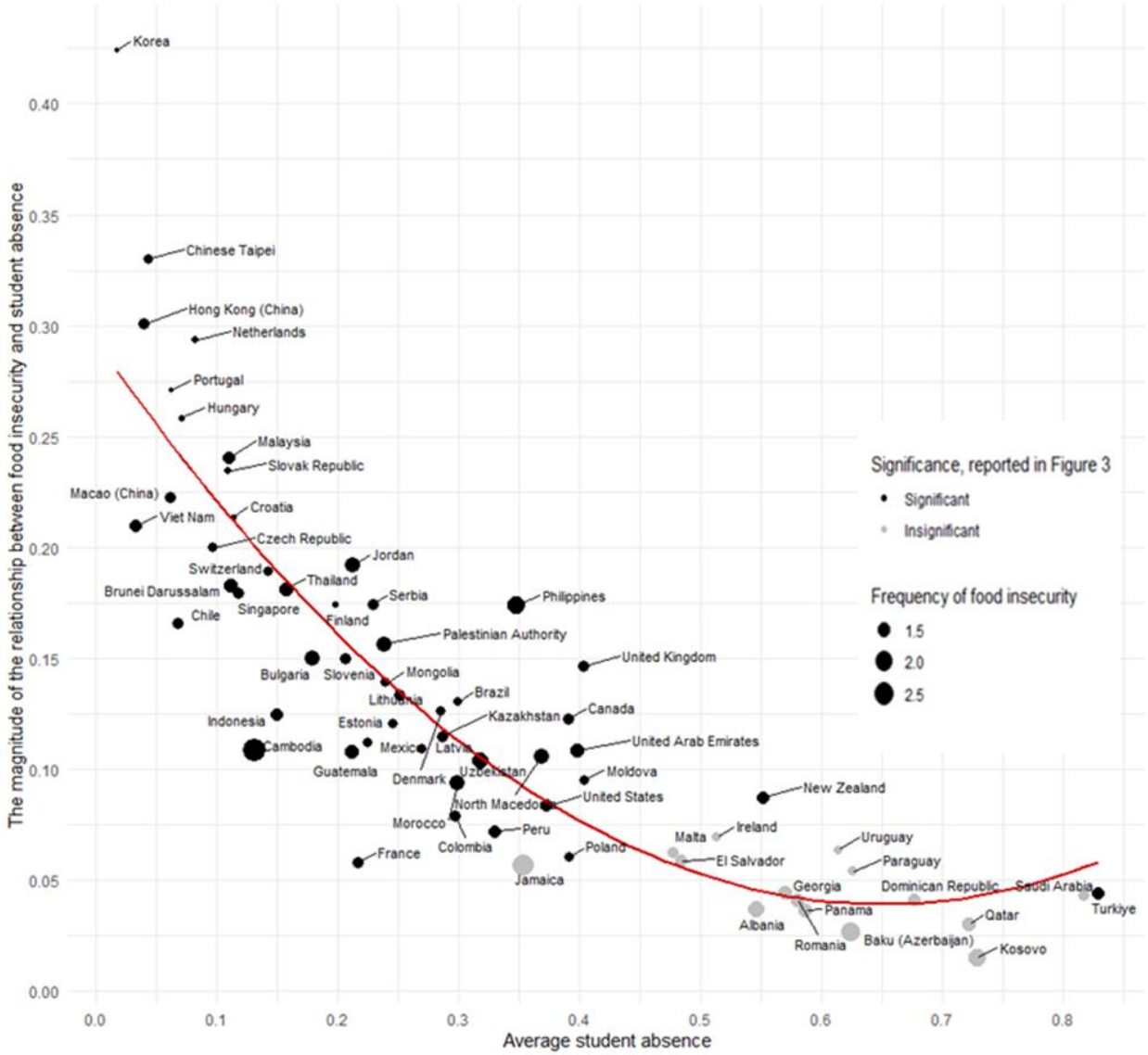

Figure 3: Average student absence, average food insecurity, and the magnitude of the relationship between food insecurity and student absence across countries

Note: Average student absence is the mean of the student absence scale score. The size of the circles expresses the mean of the food insecurity scale score. Statistical significance tests whether the country estimates differ from zero--not whether they differ from global estimates.

Appendices

Appendix 1: Percentages of students by food insecurity across countries

	In the past 30 days, how often did you not eat because there was not enough money to buy food?				
Country	Never or almost never (%)	About once a week (%)	2 to 3 times a week (%)	4 to 5 times a week (%)	Every day or almost every day (%)
Cambodia	31.02	22.32	16.47	6.96	23.23
Jamaica	53.29	9.27	6.78	3.53	27.13
Philippines	61.30	14.67	8.78	3.27	11.98
Baku (Azerbaijan)	62.16	10.76	6.99	3.13	16.96
Kosovo	70.62	7.03	3.75	1.97	16.63
Morocco	72.43	12.54	6.15	2.95	5.92
Uzbekistan	72.71	8.48	4.81	2.01	11.99
Jordan	73.95	10.02	6.19	3.47	6.38
Thailand	74.22	12.75	6.51	1.36	5.16
Albania	74.99	5.57	3.95	2.18	13.31
Palestinian Authority	75.20	9.45	5.44	3.02	6.89
Brunei Darussalam	76.31	9.88	6.39	1.76	5.67
Malaysia	77.63	11.42	6.37	1.45	3.13
Panama	77.82	9.33	4.41	1.48	6.96
Bulgaria	77.91	4.97	3.26	1.68	12.18
North Macedonia	78.23	6.98	3.87	1.39	9.54
Türkiye	79.95	11.07	5.18	1.87	1.93
Guatemala	80.10	7.22	3.27	1.06	8.35
Qatar	80.25	5.89	3.97	2.28	7.61
Georgia	81.06	5.58	3.10	1.96	8.30
Viet Nam	81.13	9.87	5.89	1.65	1.46
Peru	81.65	9.09	4.01	1.20	4.06
United Arab Emirates	82.19	4.98	3.79	2.02	7.01
El Salvador	82.74	7.91	3.44	1.21	4.70
Indonesia	82.87	7.10	3.51	1.17	5.35
Dominican Republic	83.38	6.60	3.33	1.09	5.61
Romania	84.18	3.09	1.63	0.78	10.32
International Average	**84.61**	**5.90**	**3.05**	**1.17**	**5.24**
Macao (China)	85.12	9.22	3.47	0.73	1.46
Saudi Arabia	85.16	7.14	4.07	1.55	2.09
Hong Kong (China)	86.15	8.11	2.97	0.75	2.03
New Zealand	86.18	5.34	2.02	0.65	5.81
United States	**87.00**	**4.16**	**1.70**	**0.85**	**6.28**
Mongolia	87.03	7.02	3.47	1.16	1.33
Singapore	87.26	6.17	2.97	0.72	2.88
Colombia	88.08	5.74	2.41	0.62	3.14
Paraguay	88.17	6.86	2.47	0.72	1.78
Lithuania	88.36	3.77	1.93	0.60	5.33
Kazakhstan	88.56	5.38	2.21	0.74	3.10
Chile	88.85	4.21	1.03	0.53	5.39
Chinese Taipei	89.62	5.52	2.40	0.59	1.88
Serbia	89.76	3.90	1.30	0.42	4.62
France	89.89	3.32	1.31	0.65	4.83
Mexico	89.91	5.86	1.94	0.48	1.81
Moldova	90.05	4.76	1.65	0.79	2.75
United Kingdom	90.08	2.95	1.15	0.35	5.47

Appendix 1: Percentages of students by food insecurity across countries

	In the past 30 days, how often did you not eat because there was not enough money to buy food?				
Country	Never or almost never (%)	About once a week (%)	2 to 3 times a week (%)	4 to 5 times a week (%)	Every day or almost every day (%)
Canada	90.77	3.00	1.45	0.55	4.23
Malta	90.97	2.20	1.05	0.54	5.24
Slovenia	91.05	2.10	0.99	0.55	5.32
Estonia	91.28	4.15	1.84	0.56	2.16
Czech Republic	91.42	3.31	1.30	0.37	3.59
Brazil	91.60	4.70	1.79	0.67	1.23
Latvia	92.69	2.02	1.02	0.39	3.88
Uruguay	92.72	3.79	1.66	0.42	1.40
Switzerland	92.97	2.10	0.90	0.30	3.73
Ireland	93.20	2.25	0.72	0.13	3.70
Poland	93.56	1.87	1.05	0.34	3.18
Denmark	93.88	1.17	0.66	0.31	3.97
Slovak Republic	95.14	2.69	0.85	0.25	1.07
Hungary	95.63	2.74	0.91	0.28	0.43
Croatia	95.76	2.41	0.86	0.21	0.76
Iceland	96.10	2.01	0.50	0.25	1.13
Korea	96.21	2.55	0.89	0.20	0.14
Finland	96.66	1.75	0.85	0.18	0.55
Netherlands	97.12	0.89	0.32	0.15	1.52
Portugal	97.65	0.93	0.36	0.10	0.96

Note: Countries are ranked by the percentage of students who report never or almost never food insecurity in ascending order.

Appendix 2: Percentages of students by absence across countries

	In the last two full weeks of school, how often did you skip a whole school day?			
Country	Never (%)	One or two times (%)	Three or four times (%)	Five or more times (%)
Saudi Arabia	38.56	46.71	9.23	5.50
Dominican Republic	47.22	43.89	5.93	2.96
Türkiye	47.56	32.49	10.94	9.01
Kosovo	49.48	37.00	7.58	5.95
Paraguay	51.30	40.13	5.57	3.00
Qatar	52.27	32.34	7.57	7.83
Uruguay	55.93	34.19	5.47	4.42
Panama	55.99	35.57	5.09	3.35
Baku (Azerbaijan)	57.95	29.03	7.32	5.71
Ireland	59.63	32.63	5.25	2.48
Romania	60.60	29.27	5.11	5.02
Albania	61.53	29.24	4.91	4.31
Georgia	61.58	27.29	6.14	4.99
New Zealand	62.61	26.87	5.95	4.58
El Salvador	64.36	29.84	3.17	2.63
Malta	66.51	24.55	5.13	3.81
Moldova	70.25	23.34	3.97	2.44
United Kingdom	70.46	22.82	3.99	2.73
Poland	71.45	22.12	3.27	3.16
United States	**71.65**	**22.50**	**3.70**	**2.15**
Peru	72.17	24.13	2.60	1.09
Canada	72.85	20.13	4.18	2.83
North Macedonia	73.97	20.25	3.73	2.05
United Arab Emirates	74.83	17.85	3.76	3.56
Colombia	75.34	21.82	1.82	1.02
Philippines	76.30	18.22	2.55	2.93
Uzbekistan	76.33	19.13	2.56	1.98
Jamaica	76.40	17.31	3.38	2.92
Kazakhstan	77.83	17.71	2.86	1.60
Morocco	77.88	17.79	2.81	1.51
Brazil	78.92	16.08	2.92	2.08
International Average	**78.40**	**16.44**	**2.86**	**2.92**
Denmark	79.32	15.88	2.43	2.37
Latvia	80.64	14.58	2.38	2.40
Estonia	82.01	14.20	2.24	1.54
Mexico	82.01	15.42	1.56	1.01
Lithuania	82.07	13.84	2.17	1.92
Mongolia	82.54	14.18	1.73	1.55
Palestinian Authority	84.63	11.23	1.93	2.21
Guatemala	84.91	13.34	0.86	0.89
Serbia	85.29	10.27	2.34	2.10
Finland	85.49	11.34	1.65	1.51
Jordan	87.67	8.67	1.65	2.01
Slovenia	87.74	8.68	1.60	1.99
France	87.83	7.88	1.70	2.60
Indonesia	88.53	9.49	1.08	0.89

Appendix 2: Percentages of students by absence across countries

	In the last two full weeks of school, how often did you skip a whole school day?			
Country	Never (%)	One or two times (%)	Three or four times (%)	Five or more times (%)
Thailand	89.27	7.96	1.26	1.52
Bulgaria	90.46	6.83	1.19	1.52
Switzerland	90.51	6.79	1.30	1.39
Singapore	91.52	6.49	1.08	0.91
Croatia	91.82	6.58	0.76	0.84
Malaysia	91.99	6.36	0.94	0.70
Brunei Darussalam	92.03	6.13	0.98	0.86
Cambodia	92.09	6.47	0.77	0.67
Slovak Republic	93.84	4.51	0.72	0.93
Czech Republic	94.22	4.02	0.57	1.19
Hungary	95.11	3.93	0.37	0.60
Netherlands	95.24	3.70	0.43	0.64
Macao (China)	95.33	3.71	0.57	0.38
Chile	95.49	3.48	0.55	0.48
Portugal	95.54	3.55	0.48	0.43
Chinese Taipei	97.56	1.49	0.42	0.53
Hong Kong (China)	97.65	1.63	0.33	0.38
Viet Nam	97.86	1.62	0.32	0.20
Korea	98.83	0.82	0.22	0.13

Note: Countries are ranked by the percentage of students who never skipped a whole school day in ascending order.