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The impact of food poverty on educational achievement: a New Zealand case study in global context

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Hunger negatively impacts a student's ability to engage and learn at school. Rising food poverty among school students across the globe is increasingly recognized as a critical factor impacting educational achievement. International assessments show a consistent and strong link between student hunger and lower academic performance, yet detailed analysis remains limited. The aim of this paper is to quantify the impact of student hunger on educational attainment. We use New Zealand as a case study, a high-income country with surprisingly high levels of food poverty. We carry out a cross sectional study of New Zealand data from three large-scale educational datasets comparing student achievement scores with self-reported food insufficiency at home. We observed a consistent, repeated and large effect size, with students experiencing hunger showing a learning gap of up to 4 years compared to their peers. This effect holds constant even after adjusting for student socio-economic status. Overall, these large dataset results demonstrate how being hungry at school and/or home is a major barrier to learning and that structural changes to reduce poverty, as well as programmatic responses such as free school lunches, must become national education priorities.

KEYWORDS

food security, educational attainment, large-scale assessment, PISA and TIMSS, PIRLS, hunger, school meals

Introduction

In 2021, more than 2 billion people globally faced moderate or severe food insecurity (FAO, IFAD, UNICEF, WFP & WHO, 2023), with up to one in five individuals in high-income countries affected (Pollard and Booth, 2019). Children are disproportionately impacted. In New Zealand, children's food insecurity has reached its highest level in over a decade, with 21.3% of children living in households where food runs out sometimes or often, a figure that is much higher (35.1%) among Māori children (the Indigenous people of New Zealand) (Ministry of Health, 2023).

Children affected by ongoing food insecurity (food poverty) have been found to be at heightened risk of negative health behaviors and poorer health outcomes, including, but not limited to: higher odds of drinking, smoking, and substance abuse (Fram et al., 2022); higher rates of depressive symptoms and suicidal attempts (Utter et al., 2018), increased risk of eating disorders (Hooper et al., 2022) and higher rates of obesity (Hooper et al., 2022; Widome et al., 2009). Additionally, inadequate food and poor nutrition also affect children's and adolescents' behavior, concentration and cognitive function, impairing their ability to engage in school (Shankar et al., 2017). Food poverty in children is associated with higher rates of missed

school, increased bullying, reduced cognitive abilities, poorer memory, and long-term impacts on brain development (Fram et al., 2022).

Recognizing the important relationship between food poverty and learning, several long-running and large-scale international assessments have begun to monitor student hunger and its impact on achievement. However, in-depth analysis and use of this data to inform policy decisions is scarce. In this research brief, we use New Zealand data from three large-scale international assessments as a case study to quantify the cross-sectional relationship between hunger and learning outcomes across different student age groups and different subjects of interest.

Methods

Description of international student assessment data included

We analyzed secondary data from three large-scale international assessments of student achievement using publicly available databases. The methods of these international studies are described in detail in official reports; this section aims to briefly describe the context of the assessment surveys, students included in the analysis, achievement and food poverty measures.

Programme for International Student Assessment (PISA)—PISA assesses 15-year-old students' capabilities in reading, mathematics and science across nearly 90 OECD and partner countries every 3 years. In 2022, PISA incorporated data on student hunger and its correlation with achievement for this first time. Students in 66 countries responded to the question "in the past 30 days, how often did you not eat because there was not enough money to buy food?"

Trends in International Mathematics and Science Study (TIMSS)—Established in 1995, TIMSS assesses mathematics and science knowledge of fourth and eighth grade students (Year 5 and Year 9 in New Zealand). TIMSS started collecting student hunger data in the 2019 assessment cycle, where students from 64 countries reported how often they felt hungry on arrival at school (never, sometimes, almost every day, and every day). This was repeated in TIMSS 2023 and the hunger data will be released in February 2025.

Progress in International Reading Literacy Study (PIRLS)—Established in 2001, PIRLS measures reading achievement in fourth grade (Year 5 in New Zealand). In 2016, PIRLS started collecting data on how often students arrived at school feeling hungry (never, sometimes, almost every day, every day). Hunger data was also collected in PIRLS 2021, offering an insight into trends over time.

Data analysis

The prevalence of food poverty for students across the studies, OECD and in New Zealand are reported as percentages. The impact on achievement is referred to as the food poverty gap and is reported as raw scores. For the PISA2022 mathematics results, a regression analysis was undertaken to adjust for measures of socio-economic status. The linear regression model was used to estimate the effect that food insecurity had on the student's mean PISA maths score, holding the student's level of socio-economic deprivation constant (PISA economic, social and cultural status (ESCS) variable). The model was created using the PISA SAS macro.

Results

Student hunger and achievement

In PISA 2022, the prevalence of food poverty revealed disparities among low- to high-income countries, with an average across OECD countries of 8.2% of students not eating at least once a week in the past 30 days due to lack of money to buy food (range 2.6–67.8% across all countries) (Schleicher, 2023). As reported in the international report, New Zealand had the third highest rate in the OECD with 13.8% of students missing meals at least once a week and 6.5% missing meals four or more times a week (Schleicher, 2023). Subgroup analyses showed that for Indigenous Māori students, the rates were substantially higher with 23.5% missing meals at least once a week and 9.5% missing meals four or more times a week (McKelvie Sebileau and Railton, 2024).

All countries showed a similar pattern whereby food poverty was negatively related to student achievement. Globally, there was a negative correlation between food insecurity and mathematics performance in PISA 2022[1] (Pearson's $r = -0.61$) (Schleicher, 2023). The present analysis further clarifies this impact by demonstrating that the size of the achievement gap between hungry and "never hungry" students was substantial, even when the effect of students' socio-economic status was accounted for.

To disentangle the impact of food poverty and hunger from the impact of more generalized poverty and low socio-economic status, we carried out regression analyses holding socio-economic status constant. The results are displayed in Table 1 showing that students who miss meals every or almost every day due to lack of money are 76 points behind the reference group of students who never miss meals due to lack of money (Schleicher, 2023). To put this in perspective, 20 points on the PISA scale is equivalent to approximately an average year of learning for 15-year-olds (Avvisati and Givord, 2021). As such, after accounting for the impact of socio-economic differences, Table 1 shows that the substantial and graded achievement gap for mathematics for students who miss meals due to lack of money was equivalent to 2–4 years of lost learning compared to their peers who never miss meals. This pattern was the same for reading and science scores.

TIMSS 2019 found that on average, 28% of fourth graders self-reported feeling hungry every day or almost every day when they

1 Note from International report, p148: The relationship between food insecurity and mean score in mathematics is not driven by countries/economies where food insecurity is extremely high. After taking out of the analysis the four countries/economies where the percentage of "students that did not eat at least once a week in the past 30 days because there was not enough money to buy food" was higher than 35% (Baku [Azerbaijan], Cambodia, Jamaica* and the Philippines), the strength of the relationship between food insecurity and mean score in mathematics across the remaining 63 countries and economies does not change much (correlation coefficient = −0.63) compared to when all 67 countries with available data are included in the analysis (correlation coefficient = −0.61).

TABLE 1 Regression analysis of PISA 2022 mathematics achievement scores for New Zealand students and food insecurity after adjusting for socio-economic deprivation.

Variable	PISA score estimate	Standard Error (SE)	*t*-value
Intercept	482.35	1.72	279.44
Socio-economic deprivation - ESCS	37.66	1.95	19.25
Miss meals due to lack of money once a week	−37.72	6.14	−6.13
Miss meals due to lack of money 2–3 times a week	−56.35	10.65	−5.28
Miss meals due to lack of money 4–5 times a week*	−91.90	15.62	−5.88
Miss meals due to lack of money every or almost every day	−76.27	6.27	−12.14

*Note limited number of students in this category in NZ.

arrived at school (Mullis et al., 2020). This was higher for eight graders with 33% feeling hungry every day or almost every day when they arrived at school (Mullis et al., 2020). Student hunger was observed even in high-income countries with low levels of poverty, such as Republic of Korea and France (Canbolat et al., 2023). Younger New Zealand students showed levels of hunger similar to the International average: 29% of New Zealand Year 5 (Grade 4) arriving at school hungry every day or almost every day, but the number of Year 9 (Grade 8) students arriving at school hungry was lower at 25% (Mullis et al., 2020).

In parallel to the earlier PISA results described, students across the globe who arrived at school hungry had significantly lower TIMSS science and mathematics scores than students who never felt hungry (Mullis et al., 2020). In New Zealand, Year 5 (Grade 4) students who indicated they were hungry every day or almost every day scored on average 48 points lower in mathematics and science and Year 9 (Grade 8) students scored 43 points lower in mathematics and 49 points lower in science, compared to students never arriving at school hungry. To put this in context, TIMSS uses scale anchoring to provide international benchmarks of achievement: Advanced (625), High (550), Intermediate (475) and Low (400). For both student years (grades) the average scores in science and mathematics for students experiencing hunger every day or almost every day were on, or below, the intermediate benchmark, whereas the average scores for students never arriving at school hungry were all above the intermediate benchmark.

PIRLS 2016 data showed that on average, 26% of Grade 4 students across the globe self-report feeling hungry on arrival at school every day or almost every day. This figure rose to 35% in PIRLS 2021 (Mullis et al., 2017; Reynolds et al., 2024). Again, New Zealand data reflected higher than average levels of hunger; 33 and 43% in 2016 and 2021, respectively.

As with the previous two studies, students arriving at school hungry every day or almost every day had significantly lower PIRLS reading scores than students never arriving at school hungry. On average, a 32-point difference was observed across participating countries in 2016 and a 26-point difference in 2021. Despite higher levels of achievement overall for New Zealand students, the impact of hunger on reading achievement was pronounced, with a consistent and steep gradient of difference across the years. Students who were hungry occasionally scored slightly (10–26 points) below students who were never hungry and those who were hungry every or almost every day scored far (42–55 points) below their peers (Table 2).

PIRLS also uses scale anchoring to provide international benchmarks of achievement: Advanced (625), High (550), Intermediate (475) and Low (400). In 2021, the average reading score for New Zealand students not experiencing hunger was 554 (High), whereas the average reading score for students arriving at school hungry every day or almost every day was 505 (Intermediate) (Reynolds et al., 2024).

TABLE 2 Average point difference across reading scores in Programme for International Reading Literacy Study (PIRLS) and levels of food poverty in Year 5 (Grade 4) New Zealand students.

Frequency of arriving at school hungry (PIRLS score)	PIRLS 2016	Frequency of arriving at school hungry (PIRLS score)	PIRLS 2021
Never (545)	Reference	Never (545)	Reference
Once or twice a month (535)	−10 (4.3)*	Sometimes (535)	−10 (4.9)
Once or twice a week (519)	−26 (4.9)		
Almost every day/ every day (490)	−55 (6.3)	Almost every day/ every day (503)	−42 (5.1)

*All tests significant at $p < 0.05$, standard error in brackets. PIRLS 2016 analyses carried out with NCES PIRLS online database; in PIRLS 2021 two categories were merged in the student questionnaire and analyses were carried out by the authors as PIRLS 2021 data not yet available in database.

Discussion

The data from these three large-scale international assessments consistently show reduced educational achievement for students experiencing food poverty. New Zealand as a case study shows surprisingly high levels of student food poverty for a high-income country, and a persistent effect of hunger on achievement, even after socio-economic status is accounted for.

Although these robust data have been freely available for several years, very limited analysis at a country level is available regarding the association between student hunger and achievement, despite high political interest and potential policy impact. Recent analyses of TIMSS 2019 data found that student hunger was also associated with disorderly behavior in the mathematics classroom (Canbolat and Rutkowski, 2024). Canbolat and Rotkowski's analyses demonstrate that hunger in school-aged children has substantial effects on learning, not just for the

individual but also for others in a classroom where one or more students are experiencing hunger. The results remained significant after adjusting for student socio-economic status, socio-economic composition of classes, teacher experience, educational attainment, and class size.

Although these analyses are only cross-sectional, we applied the Bradford Hill criteria (Hill, 1965) for causality between hunger and low student achievement and find that all nine criteria are fulfilled. The associations described above have strength, shown by the effect size between student hunger and achievement; they are consistent in that they were reproduced across the global dataset, across three independent studies, and across the PIRLS cycles; they are specific as shown through the regression analyses accounting for the effect of socio-economic status; they are temporal from the natural experiments noted; the gradient is strong; the results are plausible and coherent with both epidemiological studies showing an impact of student hunger on short-term and long-term achievement (Canbolat et al., 2023; Canbolat and Rutkowski, 2024; Lundborg et al., 2022); experimentally valid as an analysis of the long-term impact of universal primary school lunch provision in Sweden demonstrated that the programme had substantial positive effects on educational attainment (years of education completed) (Lundborg et al., 2022); and finally, the findings are analogous in that many factors from household, school and student environments are identified as affecting learning outcomes across these studies, with hunger being one of them.

Educational success benefits a country's long term economic stability, health and social outcomes and structural changes are required to address the underlying causes of household food insecurity, such as poverty. In addition, policies and programs are needed to alleviate the impact of poverty on educational outcomes and to address barriers to educational achievement. One form of governmental policy which has been shown to reduce hunger and improve student outcomes is the provision of free and/or subsidized school meals. Studies in China, India, Ghana, and Egypt have found that access to free/subsidized school lunch programs led to improvements in reading and mathematics achievement (Fang and Zhu, 2022; Metwally et al., 2020; Chakraborty and Jayaraman, 2019; Aurino et al., 2023). Evidence from South Korea also demonstrated that providing a universal lunch program reduced the frequency of behavioral incidents, particularly physical fights, by ~35% (Altindag et al., 2020). In New Zealand, the school lunch program introduced in 2020 has been shown to improve emotional and social functioning in secondary learners as well as attendance for high-risk students (Vermillion Peirce et al., 2022).

The New Zealand Government initiated *Ka Ora, Ka Ako* | the Healthy School Lunch Programme in 2020 with funds from their COVID19 response budget. In a targeted universal approach, *Ka Ora, Ka Ako* provides a free healthy lunch every school day to all students in the most disadvantaged schools in New Zealand (>230,000 learners, 25% of all students). This is particularly important for Indigenous Māori learners, who make up approximately half of the students receiving the lunches and experience some of the highest rates of food insecurity in New Zealand and lowest levels of education attainment in mainstream schooling. However, since its inception, no formal evaluations have been conducted to investigate the impact of the lunches on objective measures of educational achievement. Given the positive improvements in educational outcomes reported in other countries receiving free/subsidized school lunches, this is an area of evaluation that should be prioritized, especially since the program is now funded from an Education budget. The *Ka Ora, Ka Ako* program has already shown significant impacts on hunger at school, wellbeing, dietary patterns, local employment, and school attendance (Vermillion Peirce et al., 2022), and contributes to broader food security and resilience for Māori students and their families (Aikman and Yates-Pahulu, 2023). Despite this evidence, the coalition government formed following the 2023 elections, severely cut the programs budget by over one-third, making ongoing evaluations of critical importance.

Strengths and weaknesses

Major strengths of this study are that consistent results were observed in the data from three major international student assessments, over several cycles of data collection, with students of different ages, across different subjects and different ways of measuring food poverty. The future cycles of these surveys, (for example, TIMSS2023 student hunger data to be released in 2025), will allow for trends analysis and more in-depth investigation of the impact of hunger, as well as the impact of policies to alleviate hunger in certain countries. The direct representation of child and youth voice on issues of hunger and food poverty is a further strength of this study. However, a potential limitation is the use of self-reported student data on the socioeconomic variable representing household socioeconomic status and the different ways of measuring food poverty. The measure of arriving at school hungry employed in TIMSS and PIRLS is not necessarily synonymous with "missing meals because there was not enough money to buy food" (PISA). A further limitation is the potential residual confounding of low socio-economic status which is associated with lower resources for learning, less parental availability for support and lower student levels of achievement (Schleicher, 2023). The effects of these feedback loops are difficult to separate in classical statistical adjustments used in regression analyses to identify the independent effect of food insecurity.

Conclusion

Using a high-resource country like New Zealand as a case study, where childhood food poverty is higher than international averages, these international survey data revealed strong evidence that childhood food poverty is impacting educational achievement across the globe. Food poverty rates are an international concern and must become a policy priority, particularly for countries where food security is impacted by climatic conditions and cost of living crises.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://www.oecd.org/en/data/datasets/pisa-2022-database.html; https://pirls2021.org/results/; https://www.iea.nl/studies/iea/timss/2019.

Author contributions

PM: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. BS: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing. JD: Formal Analysis, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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