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From Commitments to Compliance: The Right to Food Today

Addressing the Right to Food Through Food Expenditure Burdens: Distributional Evidence Among Low-Income Farming Families in Brazil (2012–2023)

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ABSTRACT

Household food expenditure continues to be a key factor in ensuring the realization of the Human Right to Adequate Food. Particularly in Brazil, access to food can be limited by economic constraints in vulnerable families, especially among farming families, who have been more vulnerable to food insecurity in recent years in the country. This study examines the association between the proportion of income allocated to food expenditures, per capita household income and sociodemographic characteristics among low-income farming families in Brazil. The study utilizes repeated cross-sectional microdata for the period from 2012 to 2023, extracted from Brazil's main registry of individuals and families in situations of social vulnerability (CadÚnico). Quantile regression models were used to verify the effects of covariates at different quantiles of the conditional distribution of the outcome. The results suggested that food expenses absorbed a large part of the budget of farming families during the period analyzed. Over time, elasticity patterns remained relatively stable. The modeling step suggested unequal effects of Engel's Law among low-income Brazilian farming families, confirming that the weight of food expenses is structurally heavier among poorer families. The realization of the human right to food in Brazil depends fundamentally on a sustained political commitment to redistributive, distribution-sensitive, and food system-oriented policies that protect vulnerable populations, such as farming families, from both structural deprivation and systemic shocks.

摘要

家庭食品支出仍然是确保实现“适足食物权”的关键因素。特别是在巴西，经济制约限制了弱势家庭（尤其是务农家庭）获取食物的能力；近年来，该国的务农家庭更容易遭受粮食不安全问题的困扰。本研究探讨了巴西低收入务农家庭的食品支出占收入比例、人均家庭收入以及社会人口学特征之间的关联。研究利用了2012年至2023期间的重复横截面微观数据，这些数据提取自巴西针对社会弱势群体（个人及家庭）的主要登记系统（CadÚnico）。研究采用分位数回归模型，考察了协变量在结果变量条件分布的不同分位数上的效应。结果显示，在分析期间，食品支出占据了务农家庭预算的很大一部分。从时间维度看，弹性特征保持相对稳定。模型分析表明，恩格尔定律在巴西低收入务农家庭中的效应存在差异，证实了食品支出在较贫困家庭的预算中结构性占比更高。在巴西，实现食物权从根本上取决于持续的政治承诺，即实施具有再分配性质、关注分配公平并以粮食系统为导向的政策，从而保护务农家庭等弱势群体免受结构性匮乏和系统性冲击的影响。.

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RESUMEN

El gasto familiar en alimentos sigue siendo un factor clave para garantizar la realización del Derecho Humano a una Alimentación Adecuada. Particularmente en Brasil, el acceso a los alimentos puede verse limitado por restricciones económicas en familias vulnerables, especialmente entre las familias campesinas, que han sido más vulnerables a la inseguridad alimentaria en los últimos años en el país. Este estudio examina la asociación entre la proporción del ingreso destinada al gasto en alimentos, el ingreso familiar per cápita y las características sociodemográficas entre familias campesinas de bajos ingresos en Brasil. El estudio utiliza microdatos transversales repetidos para el período de 2012 a 2023, extraídos del principal registro de individuos y familias en situaciones de vulnerabilidad social de Brasil (CadÚnico). Se utilizaron modelos de regresión de cuantiles para verificar los efectos de las covariables en diferentes cuantiles de la distribución condicional del resultado. Los resultados sugieren que el gasto en alimentos absorbió una gran parte del presupuesto de las familias campesinas durante el período analizado. A lo largo del tiempo, los patrones de elasticidad se mantuvieron relativamente estables. El análisis de modelos sugirió efectos desiguales de la Ley de Engel entre las familias campesinas brasileñas de bajos ingresos, confirmando que el peso de los gastos en alimentación es estructuralmente mayor en las familias más pobres. La realización del derecho humano a la alimentación en Brasil depende fundamentalmente de un compromiso político sostenido con políticas redistributivas, sensibles a la distribución y orientadas al sistema alimentario, que protejan a las poblaciones vulnerables, como las familias campesinas, tanto de la privación estructural como de las crisis sistémicas.

1 | Introduction

Understanding the role of economic resources in shaping access to food remains a fundamental challenge for the realization of the Human Right to Adequate Food. Globally, food insecurity and unaffordability of healthy diets still affects billions of people, particularly in low- and middle-income countries marked by persistent social and economic inequalities (Mumah et al. 2025; Galanakis et al. 2025). The FAO's 20-year review of the Right to Food Guidelines emphasizes that realizing the right to food requires ensuring both physical and economic access to adequate food through coherent legal, institutional, and policy frameworks (FAO 2024). In this context, household food expenditure comprises an important indicator of economic access to food and living standards, as higher expenditure shares devoted to food often reflect tighter budget constraints and reduced capacity to meet other essential needs such as health, education, and housing (Manikas et al. 2023; Fiedler et al. 2012; Pérez-Escamilla 2024).

A central empirical regularity linking income and food access is reflected in Engel's Law, which postulates that the proportion of income devoted to food declines as household income rises, even when absolute food expenditure increases (Clements and Si 2018). This relationship has been observed across diverse countries and historical periods, and implies that poorer households allocate a substantially larger share of their resources to food acquisition than wealthier households, thus compromising the allocation of resources to other needs (Ritchie 2023; Cirera and Masset 2010). Consequently, food expenditure shares provide a useful lens through which to examine economic vulnerability and inequality in access to food. Small income fluctuations or food price increases may compromise dietary adequacy and food security among low-income households, since food generally represents the largest expenditure category. Understanding the distribution of food expenditure burdens within vulnerable populations is therefore critical for designing social protection policies and monitoring progress toward the realization of the right to food (Clements and Si 2018; Mulamba 2022; D'Odorico et al. 2019).

Despite the longstanding relevance of Engel's Law, important questions remain regarding the heterogeneity of food expenditure behaviors among vulnerable households. Traditional empirical approaches typically focus on conditional mean effects and may therefore conceal substantial variation across the distribution of food expenditure shares. Such limitations are particularly relevant in contexts characterized by income instability, food price volatility, and unequal access to market and public services (Cirera and Masset 2010). Recent evidence has highlighted the value of distribution-sensitive approaches for studying food expenditure behaviors. Using longitudinal quantile regression, Gupta et al. (2021) showed that the determinants of food expenditure vary considerably across different points of the expenditure distribution among United States households, revealing patterns that would not be captured by mean-based models. This distributional dimension is especially important from a right-to-food perspective because average outcomes may obscure the circumstances of households facing the most severe economic constraints. Quantile regression therefore offers a suitable framework for examining how income and sociodemographic characteristics shape food expenditure burdens across different segments of vulnerable populations (Koenker and Bassett 1978; Silbersdorff et al. 2018; Silbersdorff and Schneider 2019).

In Brazil, food insecurity among low-income households remains a major public policy concern. Rural households, particularly those dependent on agricultural labour and small-scale farming, experience disproportionately high levels of socioeconomic vulnerability. In 2023, food insecurity affected 34.4% of rural households, with 5.5% experiencing severe food insecurity (IBGE 2025). Moreover, reductions in public investment in family farming policies since the mid-2010s have constrained access to productive resources, public services, and market opportunities, further increasing vulnerability among rural families (Leite and Leite 2022). These challenges make Brazil a particularly relevant setting for examining how income constraints translate into unequal food expenditure burdens.

In this context, as part of the Brazilian social protection architecture, the Unified Registry for Social Programmes (CadÚnico)—a national registry of socially vulnerable families—functions as the primary source of administrative information for identifying

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households eligible for social programmes, including those related to nutrition and food security (Government of Brazil 2026). CadÚnico collects standardized household-level information on income, demographic characteristics, housing conditions, and access to public services, being widely used in empirical research on health, poverty, inequality, and risk of severe food insecurity in Brazil (Barreto et al. 2022; Ortelan et al. 2024; Pescarini et al. 2022; Government of Brazil 2025). Importantly, CadÚnico also plays a key operational role in the implementation and monitoring of policies that contribute to the progressive realization of the right to food, making it a particularly relevant data source for rights-based empirical analyses (Government of Brazil 2026).

The study contributes to broader debates on food security, social protection, inequality, and the realization of the Human Right to Adequate Food by presenting the empirical lens on the Brazilian case to examine structural food-related inequalities in middle-income countries. Accordingly, this study examines the association between the proportion of income allocated to food expenditures, per capita household income, and sociodemographic characteristics among low-income farming families in Brazil, using nationally representative administrative microdata spanning more than a decade.

2 | Methodology

2.1 | Data Source

This study uses repeated cross-sectional microdata from Brazil's Unified Registry for Social Programmes (CadÚnico) covering the period from 2012 to 2023. The analytical sample was restricted to households whose reference person reported employment in agriculture, encompassing family farmers and other agricultural workers registered in CadÚnico during the study period. On average, the CadÚnico database included information on approximately 30.4 families per year, ranging from 25.1 in 2012 to 43.9 in 2023. It is important to highlight that the registrations and updates of the administrative datasets occur independently over time without individual- or household-level identifiers to track cases throughout time; therefore, the study represents an analysis of repeated cross-sectional data spanning 12 years.

2.2 | Outcome and Explanatory Variables

The outcome variable is the proportion of household income allocated to food expenditures, calculated as the ratio between monthly household food expenditure and total monthly household income and expressed as a percentage ranging from 0 to 100. Higher values indicate greater food expenditure burden and tighter household budget constraints.

The main explanatory variable is per capita household income, computed as total monthly household income divided by the number of household members. Additional covariates included characteristics commonly associated with food access and socioeconomic inequality: sex of the household reference person, household location (urban/rural), race/ethnicity of the reference person, and the presence of children in the household. Continuous variables were winsorized at the 99th percentile to reduce the influence of extreme values. All monetary variables were deflated using the Brazilian official consumer price index (IPCA) (IBGE 2026) and expressed in constant prices to ensure comparability across years. Table 1 below summarizes the variables included in the analysis, their definitions, and measurement characteristics.

2.3 | Data Analysis

Descriptive statistics were used to characterize the study population and examine temporal patterns in food expenditure and income. Given the skewed distributions, food expenditure shares and per capita household income are reported using medians and interquartile range (Q1–Q3). Age is summarized using means and standard deviations, while categorical variables are presented as absolute frequencies (n) and percentages (%). We also report the proportion of agricultural households

TABLE 1 | Definition and nature of variables used in the study.

Variable	Definition	Nature
Proportion of food expenditure	Ratio between total household food expenditure and total household income (both deflated by IPCA)	Continuous (%: 0–100)
Per capita household income	Total household income divided by the number of household members (deflated by IPCA)	Continuous (BRL)
Sex of reference person	Sex of the individual identified as the household reference person	Categorical (male/female)
Age of reference person	Age of the household reference person at the time of registration	Continuous (years)
Household location	Classification of household as urban or rural, according to CadÚnico criteria	Categorical (urban/rural)
Race/ethnicity of reference person	Self-declared race/color/ethnicity of the household reference person (White, Black, Asian, Brown, Indigenous)	Categorical
Presence of children	Indicator of whether at least one child resides in the household	Categorical (yes/no)

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relative to the total number of households registered in CadÚnico in each year to contextualize the analytical sample within the broader registry. Graphical analyses were used to illustrate trends in median food expenditure shares and per capita income between 2012 and 2023, as well as changes in income elasticity across the distribution of food expenditure burdens over time.

Quantile regression models were estimated to examine the association between income, sociodemographic characteristics, and the proportion of income allocated to food expenditures. Unlike ordinary least squares regression, which estimates average effects, quantile regression allows the relationship between explanatory variables and the outcome to be examined at different points of the conditional distribution (Koenker and Bassett 1978; Koenker and Hallock 2001). This approach is particularly useful when the association between income and food expenditure burden is not uniform across households. By estimating effects at different quantiles, the model captures distributional heterogeneity and identifies whether specific characteristics exert stronger influences among households facing lower or higher food expenditure burdens (Hao and Naiman 2007; Geraci and Bottai 2014). All analyses were conducted using R software, version 4.4.2.

3 | Results

3.1 | Descriptive Statistics

Table 2 summarizes the sociodemographic and economic characteristics of low-income agricultural households registered in CadÚnico between 2012 and 2023. Throughout the study period, agricultural households represented a relatively stable share of all registered households, accounting for approximately 8%–9% of the registry for most years before declining slightly in 2023.

The descriptive results reveal a population characterized by persistent socioeconomic vulnerability and considerable heterogeneity. Most households were located in rural areas, although a substantial minority resided in urban settings, highlighting the growing relevance of agricultural livelihoods beyond strictly rural territories. Female-headed households predominated throughout the period, while households headed by individuals identifying as brown skin color consistently represented the majority of the sample. The gradual increase in the proportion of Indigenous reference persons and the expansion of households with children suggest important demographic changes among vulnerable agricultural families over time.

Economic indicators point to a deterioration in living conditions during the second half of the study period, followed by a partial recovery in the final years. Median per capita household income declined markedly between 2016 and 2021 before increasing again after 2022. In contrast, food expenditure burdens remained persistently high throughout the entire period and increased substantially after 2017. Notably, median food expenditure shares exceeded household income in most years, indicating that many households relied on alternative coping strategies to meet their food needs.

The wide interquartile ranges observed for food expenditure shares indicate substantial dispersion around the median, suggesting that economic pressures associated with food acquisition were not uniformly distributed across households. Finally, the average age of the household reference person declined steadily over the study period, suggesting a gradual shift in the demographic profile of low-income agricultural households registered in CadÚnico.

3.2 | Food Expenses Among Families With no Income

A noteworthy feature of the CadÚnico data is the existence of households reporting food expenditures despite declaring no monetary income. These expenditures may reflect access to non-monetary resources, including food donations, social transfers, informal support networks, exchanges, vouchers, borrowing, or food produced for self-consumption. Such households represent an important group for understanding extreme forms of economic vulnerability, as their food acquisition depends on mechanisms that are not directly captured by conventional income measures.

Figure 1 illustrates the evolution of food expenditure among agricultural households with no declared income between 2012 and 2023. Across all expenditure quantiles, food expenditures increased over time, although the magnitude and timing of these increases differed substantially across the distribution.

The most pronounced increases occurred among households located in the upper expenditure quantile, where food expenditures remained consistently higher and exhibited greater volatility over time. In contrast, households in the lower expenditure quantile experienced more modest expenditure growth and a prolonged period of stagnation until the early 2020s. Households located around the median followed an intermediate trajectory, characterized by successive periods of expansion and contraction.

Taken together, these patterns suggest that even among households reporting no income, food acquisition requirements remained substantial and intensified over the study period. Moreover, the divergence in expenditure trajectories across quantiles indicates that the burden of securing food is itself heterogeneous among households facing extreme income deprivation, further supporting the use of distribution-sensitive analytical approaches.

3.3 | Spatial and Temporal Evolution of Income and Food Expenditure Shares

Figure 2 illustrates the evolution of median per capita household income and median food expenditure shares among low-income farming households between 2012 and 2023. The results reveal a clear divergence between income dynamics and food expenditure burdens over time.

These dynamics are also clearly illustrated by the spatial patterns shown in Figure 3, which presents the spatial distribution of the median proportion of food expenditures among farming households by Brazilian state from 2012 to 2023. These patterns

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TABLE 2 | Descriptive statistics of monetary and sociodemographic variables of low-income farming families in Brazil, 2012–2023.

Variable	Statistic	2012	2013	2014	2015	2016	2017
Part 1: 2012–2017							
Agricultural workers	*n* (%)	1,591,793 (6.3)	2,138,513 (7.9)	2,423,985 (8.3)	2,512,276 (9.2)	2,527,390 (9.6)	2,501,636 (9.3)
Age of reference person	Mean ± SD	51 ± 11.1	51 ± 11.2	50 ± 11.3	49 ± 11.2	48 ± 11.2	47 ± 11.1
Sex of reference person							
Male	*n* (%)	323,871 (20.3)	473,757 (22.2)	570,298 (23.5)	604,054 (24.0)	607,193 (24.0)	619,477 (24.8)
Female	*n* (%)	1,267,922 (79.7)	1,664,756 (77.8)	1,853,686 (76.5)	1,908,221 (76.0)	1,920,196 (76.0)	1,882,159 (75.2)
Race/ethnicity of reference person							
White	*n* (%)	349,233 (22.0)	457,389 (21.7)	520,934 (21.8)	545,092 (21.9)	528,362 (21.1)	506,908 (20.3)
Black	*n* (%)	128,354 (8.1)	164,126 (7.8)	183,220 (7.7)	188,856 (7.6)	189,908 (7.6)	186,845 (7.5)
Asian	*n* (%)	7924 (0.5)	10,460 (0.5)	12,744 (0.5)	13,638 (0.5)	13,473 (0.5)	13,006 (0.5)
Brown	*n* (%)	1,090,290 (68.6)	1,450,137 (68.9)	1,647,014 (68.8)	1,709,130 (68.7)	1,742,303 (69.4)	1,750,726 (70.2)
Indigenous	*n* (%)	12,387 (0.8)	22,041 (1.0)	28,731 (1.2)	31,353 (1.3)	35,137 (1.4)	37,277 (1.5)
Presence of children							
No	*n* (%)	1,149,317 (72.2)	1,506,703 (70.5)	1,651,895 (68.1)	1,644,830 (65.5)	1,565,259 (61.9)	1,469,086 (58.7)
Yes	*n* (%)	442,476 (27.8)	631,810 (29.5)	772,090 (31.9)	867,446 (34.5)	962,131 (38.1)	1,032,550 (41.3)
Household location							
Urban	*n* (%)	699,058 (43.9)	929,107 (43.5)	1,063,608 (43.9)	1,124,632 (44.8)	1,133,363 (44.8)	1,120,855 (44.8)
Rural	*n* (%)	892,633 (56.1)	1,209,222 (56.5)	1,360,119 (56.1)	1,387,357 (55.2)	1,393,706 (55.2)	1,380,437 (55.2)
Per capita household income	Median (Q1–Q3)	73.8 (30.7–137.3)	71.6 (27.1–145.1)	72.8 (25.5–158.2)	72.3 (26.3–180.8)	68.0 (24.7–176.3)	61.6 (22.5–150.2)
Proportion of food expenditure	Median (Q1–Q3)	100.0 (58.3–240.0)	100.0 (55.6–245.1)	100.0 (51.7–250.0)	100.0 (50.0–250.0)	100.0 (49.1–255.6)	108.1 (50.0–289.5)
Part 2: 2018–2023							
Variable	Statistic	2018	2019	2020	2021	2022	2023
Agricultural workers	*n* (%)	2,424,089 (9.0)	2,439,196 (8.4)	2,416,608 (8.4)	2,664,185 (8.2)	3,376,957 (8.2)	3,052,264 (7.0)
Age of reference person	Mean ± SD	46 ± 11.1	45.5 ± 11.2	45 ± 11.1	44.6 ± 11.4	43 ± 11.7	43 ± 11.9

(Continues)

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TABLE 2 | (Continued)

Variable	Statistic	2012	2013	2014	2015	2016	2017
Sex of reference person							
Male	*n* (%)	620,269 (25.6)	654,137 (26.8)	669,226 (27.7)	787,284 (29.6)	1,238,442 (36.7)	1,153,852 (37.8)
Female	*n* (%)	1,803,820 (74.4)	1,785,059 (73.2)	1,747,382 (72.3)	1,876,901 (70.4)	2,138,515 (63.3)	1,898,412 (62.2)
Race/ethnicity of reference person							
White	*n* (%)	466,348 (19.2)	461,966 (18.9)	452,493 (18.7)	505,129 (19.0)	638,969 (18.9)	562,194 (18.4)
Black	*n* (%)	180,172 (7.4)	178,845 (7.3)	176,235 (7.3)	193,605 (7.3)	250,258 (7.4)	223,131 (7.3)
Asian	*n* (%)	12,296 (0.5)	12,105 (0.5)	11,910 (0.5)	13,020 (0.5)	17,886 (0.5)	15,527 (0.5)
Brown	*n* (%)	1,726,573 (71.2)	1,747,528 (71.7)	1,736,831 (71.9)	1,908,592 (71.7)	2,411,863 (71.4)	2,190,608 (71.8)
Indigenous	*n* (%)	37,945 (1.6)	38,231 (1.6)	38,403 (1.6)	43,173 (1.6)	57,208 (1.7)	60,350 (2.0)
Presence of children							
No	*n* (%)	1,352,584 (55.8)	1,330,099 (54.5)	1,293,289 (53.5)	1,432,048 (53.8)	1,973,840 (58.5)	1,739,272 (57.0)
Yes	*n* (%)	1,071,505 (44.2)	1,109,097 (45.5)	1,123,319 (46.5)	1,232,137 (46.2)	1,403,117 (41.5)	1,312,992 (43.0)
Household location							
Urban	*n* (%)	1,084,502 (44.7)	1,088,499 (44.6)	1,071,379 (44.3)	1,186,959 (44.6)	1,524,097 (45.1)	1,305,131 (42.8)
Rural	*n* (%)	1,339,105 (55.3)	1,349,969 (55.4)	1,344,557 (55.7)	1,476,542 (55.4)	1,852,002 (54.9)	1,746,062 (57.2)
Per capita household income	Median (Q1–Q3)	59.51 (18.9–145.2)	57.0 (18.1–139.2)	54.6 (16.0–133.1)	49.6 (15.7–125.8)	57.2 (19.4–152.1)	67.8 (25.1–190.2)
Proportion of food expenditure	Median (Q1–Q3)	120.5 (51.4–312.5)	122.0 (50.1–333.3)	128.6 (53.6–357.1)	136.4 (55.6–384.6)	150.0 (57.5–400.0)	150.0 (50.0–400.0)

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FIGURE 1 | Evolution of food expenditures among households that declared zero income in CadÚnico, by quantiles, Brazil, 2012-2023. Legend: R$: Brazilian Real (BRL).

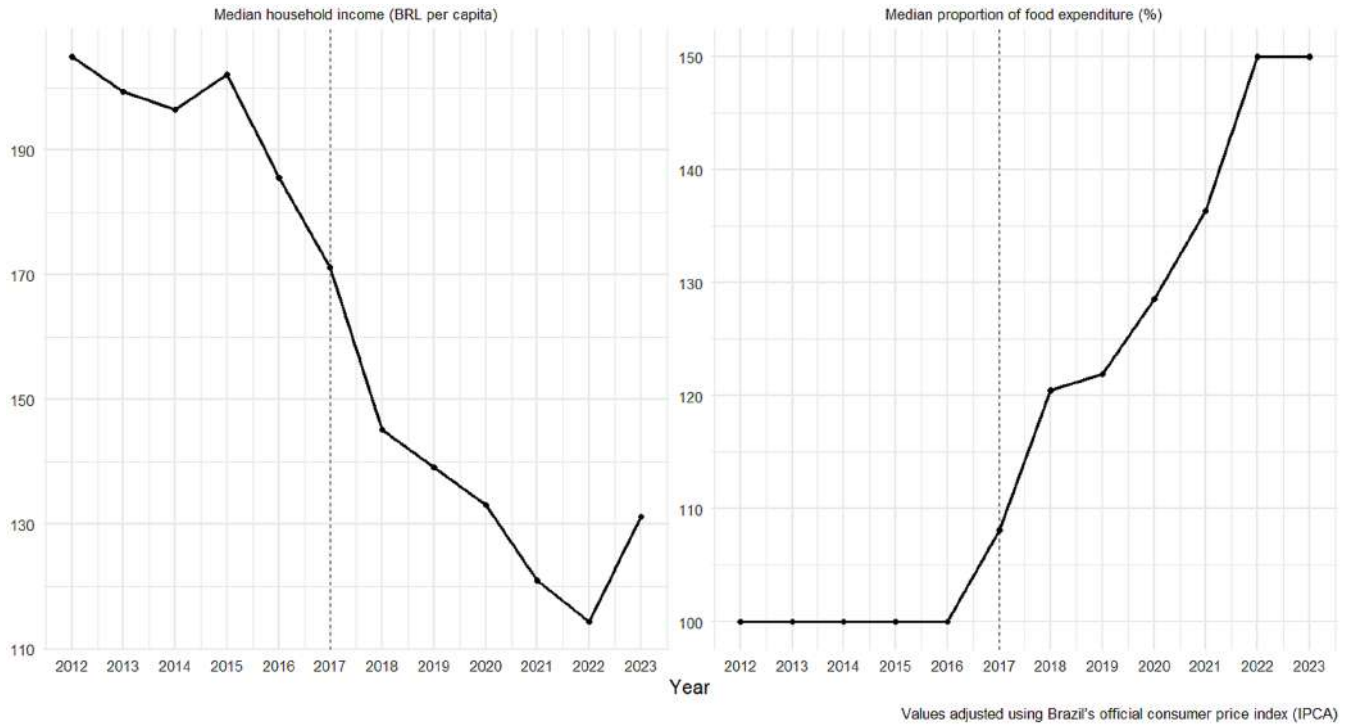


FIGURE 2 | Evolution of the median proportion of household food expenditure and per capita income of low-income farming families in Brazil, from 2012 to 2023. *Note:* The dashed line under the year 2017 marks the midpoint of the period analyzed.

highlight the vulnerability of states located in the North and Northeast of the country, which have historically been affected by food insecurity.

Periods of declining income, particularly between the mid-2010s and early 2020s, were accompanied by increases in the share of income allocated to food expenditures. Conversely, periods of

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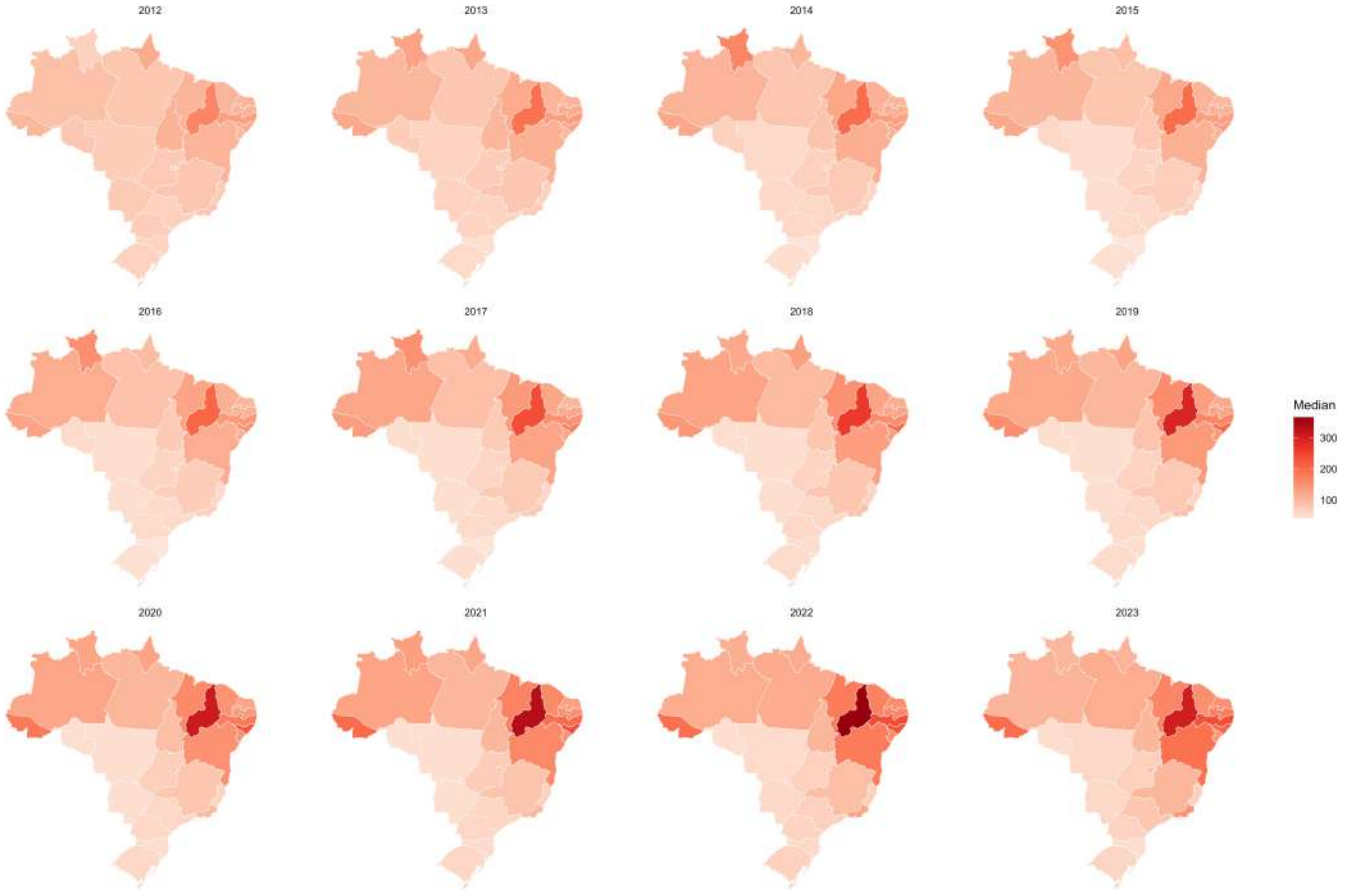


FIGURE 3 | Spatial evolution of the median proportion of household food expenditure of low-income farming families, by Brazilian states, from 2012 to 2023.

income recovery in the final years of the series were not associated with proportional reductions in food expenditure burdens, which remained persistently high.

Overall, these results suggest a weak synchronization between income variation and food expenditure shares over time. This pattern indicates that improvements in income do not translate proportionally into reduced budget pressure from food, highlighting the rigidity of food expenditure commitments among low-income agricultural households. These findings are consistent with the descriptive evidence presented in Table 2 and reinforce the presence of structural constraints in economic access to food.

3.4 | Quantile Regression Results

Table 3 presents the results of the quantile regression models estimating the association between per capita household income and the share of income allocated to food expenditures, along with sociodemographic characteristics of low-income farming households in Brazil between 2012 and 2023.

Across all quantiles, income is consistently negatively associated with the proportion of income spent on food, confirming the presence of Engel-type behavior among vulnerable agricultural households. Importantly, this association is not uniform across the distribution of food expenditure burdens. Overall, the results highlight substantial heterogeneity in food expenditure behavior across both income levels and sociodemographic groups. Rather than uniform effects, the findings point to differentiated responses across the distribution of food expenditure burdens, reinforcing the relevance of quantile regression for identifying inequalities that would remain hidden under mean-based approaches (Koenker and Hallock 2001).

3.4.1 | Income Heterogeneity Across the Distribution

The magnitude of the negative association between income and food expenditure increases at higher quantiles of the distribution in most years, suggesting that income constraints are particularly binding among households facing the highest food expenditure burdens. While lower quantiles display relatively more stable coefficients over time, upper quantiles exhibit greater sensitivity to income fluctuations, especially during periods of economic stress between 2015 and 2021. This pattern indicates that income changes have stronger effects among the most economically burdened households.

3.4.2 | Household Composition and Sociodemographic Inequalities

Sociodemographic characteristics also exhibit clear distributional heterogeneity. Female-headed households tend to display

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TABLE 3 | Quantile regression association coefficients between household food expenditure, income, and sociodemographic characteristics of low-income farming families in Brazil, 2012–2023.

Panel B—Quantile 0.50	2012	2013	2014	2015	2016	2017
Part 1: 2012–2017						
Variable	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)
Intercept	168.4 (< 0.001)	168.7 (< 0.001)	175.1 (< 0.001)	179.1 (< 0.001)	193.4 (< 0.001)	209.0 (< 0.001)
Per capita household income	−0.24 (< 0.001)	−0.21 (< 0.001)	−0.19 (< 0.001)	−0.20 (< 0.001)	−0.21 (< 0.001)	−0.22 (< 0.001)
Household location						
Urban*	—	—	—	—	—	—
Rural	0.91 (< 0.001)	3.1 (< 0.001)	3.5 (< 0.001)	3.3 (< 0.001)	3.6 (< 0.001)	4.3 (< 0.001)
Age of reference person	−0.12 (< 0.001)	−0.17 (< 0.001)	−0.29 (< 0.001)	−0.38 (< 0.001)	−0.49 (< 0.001)	−0.56 (< 0.001)
Sex of reference person						
Male*	—	—	—	—	—	—
Female	−17.3 (< 0.001)	−19.2 (< 0.001)	−20.4 (< 0.001)	−20.4 (< 0.001)	−20.5 (< 0.001)	−22.9 (< 0.001)
Race/ethnicity of reference person						
White*	—	—	—	—	—	—
Black	−5.4 (< 0.001)	−2.5 (< 0.001)	−0.71 (0.004)	0.31 (0.139)**	0.71 (0.015)	2.0 (< 0.001)
Asian	2.8 (0.002)	4.3 (< 0.001)	2.7 (0.005)	1.4 (0.051)**	−1.1 (0.295)**	0.86 (0.198)**
Brown	−6.7 (< 0.001)	−3.0 (< 0.001)	−0.16 (0.157)**	0.83 (< 0.001)	1.2 (< 0.001)	2.5 (< 0.001)
Indigenous	−15.0 (< 0.001)	−12.1 (< 0.001)	−12.7 (< 0.001)	−12.7 (< 0.001)	−6.6 (0.005)	−10.3 (< 0.001)
Presence of children						
No*	—	—	—	—	—	—
Yes	−7.2 (< 0.001)	−6.5 (< 0.001)	−7.1 (< 0.001)	−7.7 (< 0.001)	−9.7 (< 0.001)	−12.5 (< 0.001)
Part 2: 2018–2023						
Panel B—Quantile 0.50	2018	2019	2020	2021	2022	2023
Variable	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)	Coefficient (*p*-value)
Intercept	222.9 (< 0.001)	228.2 (< 0.001)	238.6 (< 0.001)	251.3 (< 0.001)	271.6 (< 0.001)	251.2 (< 0.001)
Per capita household income	−0.22 (< 0.001)	−0.23 (< 0.001)	−0.25 (< 0.001)	−0.27 (< 0.001)	−0.15 (< 0.001)	−0.22 (< 0.001)

(Continues)

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TABLE 3 | (Continued)

Panel B—Quantile 0.50	2012	2013	2014	2015	2016	2017
Household location						
Urban*	—	—	—	—	—	—
Rural	5.1 (< 0.001)	5.7 (< 0.001)	5.6 (< 0.001)	9.3 (< 0.001)	8.4 (< 0.001)	9.5 (< 0.001)
Age of reference person	−0.59 (< 0.001)	−0.56 (< 0.001)	−0.54 (< 0.001)	−0.62 (< 0.001)	−0.64 (< 0.001)	−0.25 (< 0.001)
Sex of reference person						
Male*	—	—	—	—	—	—
Female	−27.4 (< 0.001)	−27.4 (< 0.001)	−25.8 (< 0.001)	−24.3 (< 0.001)	−29.8 (< 0.001)	−29.1 (< 0.001)
Race/ethnicity of reference person						
White*	—	—	—	—	—	—
Black	3.0 (< 0.001)	4.3 (< 0.001)	3.2 (< 0.001)	7.1 (< 0.001)	7.7 (< 0.001)	14.7 (< 0.001)
Asian	1.3 (0.299)**	3.5 (< 0.001)	4.4 (0.002)	8.2 (< 0.001)	4.4 (< 0.001)	7.5 (< 0.001)
Brown	3.3 (< 0.001)	3.9 (< 0.001)	3.1 (< 0.001)	5.8 (< 0.001)	3.8 (< 0.001)	6.2 (< 0.001)
Indigenous	−15.4 (< 0.001)	−21.5 (< 0.001)	−26.6 (< 0.001)	−40.3 (< 0.001)	−54.4 (< 0.001)	−53.8 (< 0.001)
Presence of children						
No*	—	—	—	—	—	—
Yes	−16.2 (< 0.001)	−18.0 (< 0.001)	−20.7 (< 0.001)	−23.9 (< 0.001)	−36.2 (< 0.001)	−38.9 (< 0.001)

*Reference category.
**Not statistically significant at 5% level.

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systematically lower food expenditure shares across most quantiles, with differences becoming more pronounced in the upper tail of the distribution. Similarly, households with children show consistently lower expenditure shares, particularly among higher quantiles, suggesting tighter budget constraints and greater pressure to allocate resources across competing essential needs.

3.4.3 | Racial and Ethnic Disparities

Racial and ethnic differentials are more heterogeneous and vary across quantiles and over time. At lower quantiles, coefficients for black and brown households are predominantly negative, while at median and upper quantiles the associations become increasingly positive in later years, indicating widening disparities in food expenditure burdens within the distribution. Indigenous households, in contrast, show a tendency toward increasingly negative associations over time across all quantiles, suggesting a distinct expenditure profile relative to other groups.

3.5 | Income Elasticity of Food Expenditure Shares

Figure 4 presents the estimated income elasticities of the share of food expenditure across quantiles between 2012 and 2023. The results consistently indicate negative elasticities, confirming that income increases are associated with reductions in the proportion of income allocated to food among low-income agricultural households. This pattern is consistent with Engel-type behavior and reinforces the interpretation of food as a necessity good in this population.

Beyond this general relationship, the results reveal important distributional heterogeneity and temporal dynamics. Elasticities are systematically more negative in higher quantiles, suggesting greater sensitivity of food expenditure burdens among households facing higher budgetary pressure. This indicates that income changes have a stronger proportional effect on reducing food expenditure shares among more economically constrained households.

Over time, the trajectory of elasticities points to three broad phases. The first phase (2012–2015) is characterized by relative stability and modest variation around zero, indicating limited responsiveness of food expenditure shares to income changes. The second phase (2016–2021) shows a progressive increase in the absolute magnitude of elasticities, particularly in the upper quantiles, suggesting heightened sensitivity of food expenditure burdens to income fluctuations during a period of increasing economic stress. The final phase (2022–2023) is marked by partial reversion toward lower absolute values, indicating a moderation in the responsiveness of food expenditure shares to income changes. Overall, these results suggest that while Engel-type behavior remains stable over time, its intensity varies across both the distribution and macroeconomic conditions.

4 | Discussion

Our study analyzed the associations between the proportion of income spent on food by Brazilian farming families, household income per capita, and sociodemographic characteristics. By employing quantile regression models, we explicitly accounted for distributional heterogeneity in food expenditure shares, revealing how income-related constraints vary across different levels of food expenditure burden. The findings demonstrate that food expenditure burdens are structurally concentrated

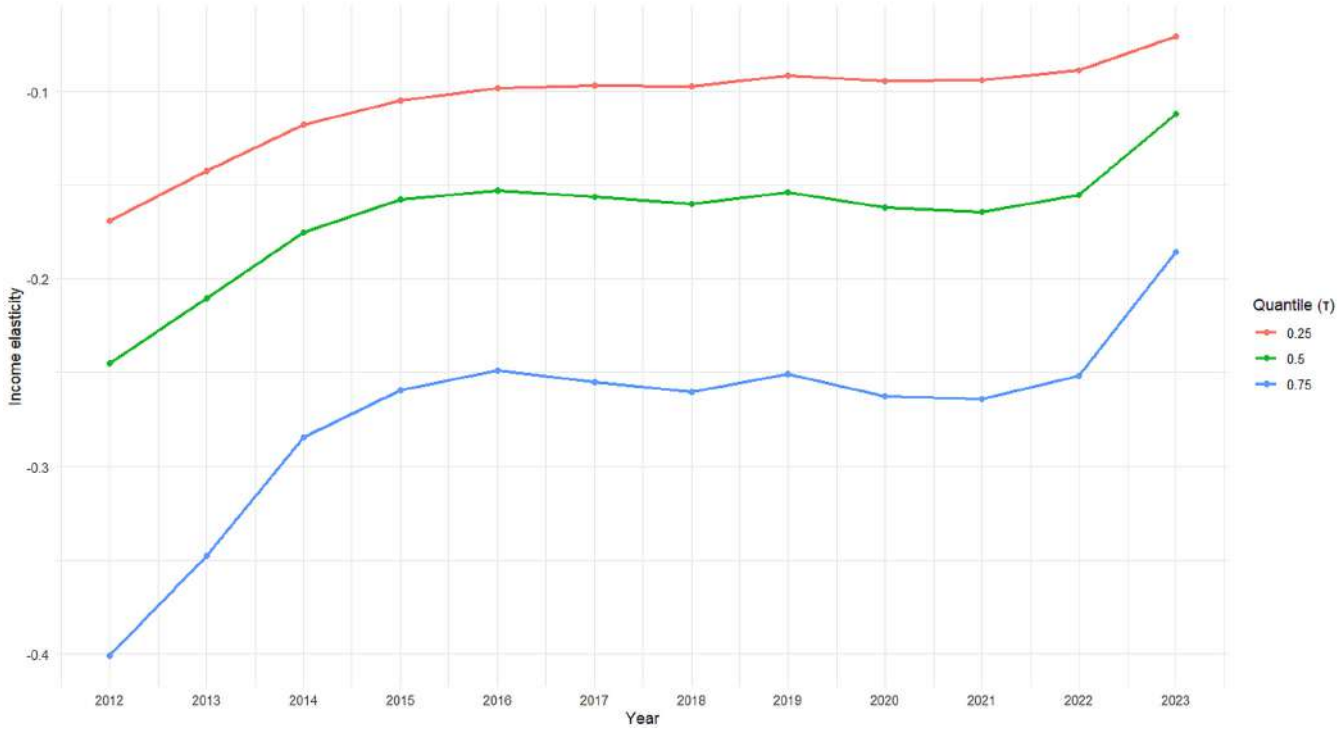


FIGURE 4 | Income elasticity in relation to food expenditure among low-income farming families in Brazil, by quantiles, from 2012 to 2023.

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among the poorest farming households, compromising the realization of the right to food.

The observed trends indicate that, despite increases in income over the study period, food expenditures continued to absorb a substantial share of household budgets. The stability of elasticity patterns across time suggests that the structural relationship between income and food expenditure remained largely unchanged despite broader economic transformations. Consistent with Engel's Law, the negative and increasingly pronounced coefficients of per capita income across quantiles show that lower-income households bear disproportionately higher food expenditure burdens, leaving fewer resources available for other essential needs such as education, health, and housing (Chai et al. 2015). These findings are aligned with evidence from Brazil showing that the share of food expenditure declines as total household expenditure increases, reinforcing the characterization of food as a necessary good and highlighting persistent inequalities in economic access to food (Almeida et al. 2019).

Food expenditure patterns among low-income households reflect broader structural inequalities, including labour market informality, income instability, and unequal social protection. Income remains one of the most important determinants of food insecurity in low- and middle-income countries, particularly among socially vulnerable populations (FAO et al. 2025b; Golgher 2024; Liang et al. 2024; Nzayiramya et al. 2025). In this context, CadÚnico provides a unique empirical lens through which structural inequalities in the realization of the right to adequate food can be examined. According to General Comment No. 12 of the United Nations Committee on Economic, Social and Cultural Rights, States have obligations to respect, protect, and fulfill the right to food, including ensuring the material conditions necessary for adequate food access and protecting vulnerable groups from structural barriers to food security (United Nations 2009; United Nations 2009). This implies not only avoiding measures that restrict people's access to food but also protecting individuals and groups against actions by third parties that may compromise such access and adopting policies that ensure the material conditions for adequate food.

The persistence of high food expenditure burdens must also be interpreted within the broader economic context. Although the Brazilian minimum wage increased substantially during the study period (IPEA 2025), food and beverage inflation remained elevated in key years, increasing the cost of basic food consumption (IBGE 2026; Lameiras and de Carvalho 2016; NEBIN 2025). These pressures were intensified by the COVID-19 pandemic, disruptions in global food systems, and the food price shocks associated with the war in Ukraine (Barman et al. 2021; FAO et al. 2025a; Sánchez-Ortiz et al. 2025; Rudolfsen et al. 2024; Leal Filho et al. 2023). At the national level, the weakening of food and nutrition security governance and reductions in support programmes further constrained the State's capacity to guarantee the right to food (Recine et al. 2020; Carvalho et al. 2021). These dynamics are consistent with evidence showing increasing food insecurity among Brazilian households, particularly in rural areas (Ribeiro et al. 2025; World Food Programme 2025; Sousa et al. 2019; FAO et al. 2024; High Level Panel of Experts on Food Security and Nutrition 2020).

A study conducted by Santana and Sarti 2020 analyzed the evolution of the purchasing power of the minimum wage in relation to the purchase of items in the basic food basket in Brazil and show that, from 1959 to 2018, there was a deterioration in the relevance of the minimum wage in ensuring basic food needs—especially through effective and enforceable public policies—with losses in the relevance of income and the basic food basket in the food context due to political and economic events, as well as changes in the population's eating habits that have occurred throughout the country's recent history.

Our findings also underscore the strategic role of social protection policies in reducing food insecurity and mitigating budget constraints among vulnerable households. Cash transfers and other social protection mechanisms—especially those focused on food assistance—can increase food purchasing capacity and contribute to the progressive realization of the right to food (Magalhães et al. 2024; Robles and Mirosevic 2013; Veras Soares and Jaramillo Mejia 2024; United Nations 2025). CadÚnico plays a central role in this process by facilitating the identification and inclusion of socioeconomically vulnerable populations.

The analysis further highlights the relevance of sociodemographic inequalities. Consistent with international and national evidence, food insecurity is shaped not only by income but also by gender, race/ethnicity, and household composition (FAO, NRI, et al. 2025; FAO 2025; Santos et al. 2022). Female-headed households face additional vulnerabilities associated with lower earnings, labour market disadvantages, and caregiving responsibilities (Quisumbing et al. 2001; Gebrihet and Gebresilassie 2025; Rodrigues et al. 2025). Likewise, racial inequalities and historical disadvantages affecting Black, Indigenous, Quilombola, and other traditional populations continue to limit access to income, productive resources, social protection, and food security (IBGE 2020; Luiz et al. 2025; Miguel et al. 2025; FIAN BRASIL 2023; Almeida 2018; Sato et al. 2026). The stronger food expenditure burdens observed among female-headed households, Indigenous-headed households, and families with children suggest that these inequalities operate as structural mechanisms reproducing food insecurity (Sott et al. 2026; de Filleti et al. 2022; High Level Panel of Experts on Food Security and Nutrition 2020; FAO et al. 2021; Dysard et al. 2025).

Beyond income deprivation, poverty is frequently associated with broader forms of social exclusion that restrict access to education, information, participation in decision-making processes, and justice. These constraints can undermine individuals' and communities' agency to influence the conditions that shape their food systems and livelihoods, thereby exacerbating food insecurity. In this sense, inadequate access to food should be understood not only as a consequence of economic hardship but also as the result of structural barriers that limit opportunities, rights, and social participation (High Level Panel of Experts on Food Security and Nutrition 2020; Bernaschi et al. 2023).

Although this study focuses on economic access to food, the findings also raise concerns regarding dietary quality. Evidence suggests that low-income households often rely on ultra-processed foods because of their lower relative cost and greater accessibility, indicating that increases in income alone

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may not be sufficient to ensure healthy diets (Darmon and Drewnowski 2015; Gupta et al. 2019). Additional evidence from Brazil shows important regional inequalities in food access and food acquisition patterns, with poorer households prioritizing staple foods over nutritionally adequate dietary components (IBGE, 2025; De Oliveira et al. 2024; Silveira et al. 2024; De Carli et al. 2025). Given the country's vast territory, these differences are clearly evident across regions, with the North and Northeast having historically worse food security indicators than the South and Southeast (IBGE 2025). Therefore, income-support policies should be complemented by actions that promote healthy food environments, strengthen local food systems, and improve access to nutritious foods.

This study has several key strengths, including the unprecedented use of the CadÚnico repeated cross-sectional dataset to assess food expenditures over more than a decade, and the application of quantile regression methods capable of identifying heterogeneous effects across the distribution of food expenditure burdens. At the same time, some limitations should be acknowledged. The observational nature of the data does not allow causal inference; food expenditure is only a proxy for economic access to food and does not capture dietary quality, intra-household allocation, or self-consumption, and CadÚnico is not representative of the entire Brazilian population.

5 | Conclusion and Policy Implications

Taken together, the findings of this study provide robust empirical evidence that food expenditure burdens among low-income agricultural households are shaped by deeply entrenched structural inequalities in income, gender, race and territory, rather than by food availability alone. By revealing persistent heterogeneity in the association between income and food expenditure shares, the analysis reinforces Engel's Law as a mechanism through which inequalities translate into unequal access to food and unequal enjoyment of the Right to Adequate Food.

The results indicate that food expenditure burdens among low-income farming households are not solely a consequence of individual income constraints, but also reflect broader processes of social exclusion and unequal access to social protection. The Brazilian case, examined through more than a decade of large-scale microdata, illustrates how the strengthening or weakening of social protection, market regulation, and family farming policies directly conditions households' economic access to food.

From a policy perspective, the findings highlight the importance of maintaining and expanding social protection mechanisms and other redistributive policies capable of reducing structural inequalities and protecting vulnerable populations from economic shocks. In this sense, the study contributes to international food policy debates by demonstrating that the realization of the right to food in middle-income countries depends fundamentally on sustained political commitment to equity-oriented and food-system-sensitive policies.

Future research should explore regional heterogeneity in food expenditure burdens among low-income farming households, given the marked territorial inequalities that characterize food access, income distribution, and social protection coverage in Brazil. In addition, further studies should investigate whether increases in household income are associated with improvements in diet quality, particularly through the substitution of highly processed foods by fresh or minimally processed foods. Such analyses would contribute to a better understanding of whether gains in economic access to food are accompanied by advances in the nutritional adequacy of diets.

Author Contributions

All authors contributed to the study's conception. L.A.M. and D.M.L.M. obtained the data, and L.A.M. conducted data analysis. L.A.M. prepared the first version of the manuscript, and F.M.S., C.R.S., and D.M.L.M. commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data used in this research is protected by the Brazilian General Data Protection Law (LGPD—Law No. 13,709/2018) (Government of Brazil 2018) and can be accessed through a formal request to the Department of Evaluation, Information Management, and Single Registry of the Ministry of Development, Social Assistance, Family, and Hunger Combating of the Brazilian Federal Government.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** (Part 1: 2012–2017) - Quantile regression association coefficients between household food expenditure, income, and sociodemographic characteristics of low-income farming families in Brazil,. Brazil, 2012–2023. **Table S1:** (Part 2: 2018–2023).

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