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Could the minimum wage policy reduce food insecurity among households of formal workers in Indonesia?

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Abstract

Background Previous studies have concluded that minimum wages increase workers' wages. However, whether this effect will continue to improve households' food insecurity is an interesting question, especially in Indonesia, where food insecurity is still a public policy challenge. This study explores the ongoing impact of minimum wages on household food insecurity in Indonesia, leveraging data from the National Socioeconomic Survey (2017–2019) and provincial-level variations in minimum wages. The study employs unconditional quantile regression to provide nuanced insights by analyzing three food insecurity indicators: per capita calorie intake, per capita consumption of vegetables and fruits, and food diversity. We also investigate potential mechanisms driving the link between the minimum wage and food insecurity.

Results The study revealed that the real minimum wage reduced food insecurity, especially at specific distribution points. Significantly, the effect on per capita calorie intake was observed in lower deciles. The impact on dietary diversity was observed up to the seventh decile. However, the minimum wage increase did not significantly improve the consumption of nutritious foods like fruits and vegetables, except for the top deciles. The study confirmed that the minimum wage's impact on food insecurity operated through wage increases, particularly in the bottom-to-median wage distribution within the manufacturing sector.

Conclusions The study concluded that the minimum wage policy ameliorated household food insecurity indicators in specific distribution segments. Our results support the effectiveness of government policies in increasing the minimum wage as a viable approach to mitigating food insecurity among formal worker households, especially within the manufacturing sector. However, additional policies targeting the lower end of the per capita calorie intake distribution are necessary, as the minimum wage was recognized to have no impact on this group.

Keywords Food diversity, Minimum wage, Per capita calorie intake, Per capita consumption of fruits and vegetables, Unconditional quantile regression

JEL Clacifications C21, D12, J48, Q18

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Background

Numerous academic studies on minimum wage's impact, particularly on labor market outcomes ([1–3]). While consensus supports wage increases, evaluating its broader effects is essential. A review by Neumark [4] shows that beyond labor market outcomes, current studies explore the extended minimum wage's impact on well-being [5–8], poverty and inequality [9–12], health [13–15], consumption [11, 16], and food insecurity [17–19].

In developing countries, including Indonesia, food insecurity as a direct measure of economic well-being [20–22] is still the main challenge for public policy. Food security is achieved when all people always have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active, healthy life [23]. Conversely, food insecurity signifies insufficient access to safe and nutritious food. Food insecurity is also linked to adverse health indicators [24–27]. From 2017 to 2019, around 7%, or 18.7 million people in Indonesia faced moderate to severe food insecurity. The lowest expenditure group saw a rising trend in the proportion with a minimum calorie intake below 1400 kcal/capita/day [28].

The initial perspective attributing food insecurity to insufficient food availability has shifted, emphasizing the fundamental issue tied to the dimension of access [29]. The study asserts that constrained financial resources lead to low consumption and calorie intake [30]. Rodgers [31] notes that households with limited income will face tradeoffs. When allocating a limited budget, they prioritize essentials like health and education over food, because food consumption is the most flexible choice compared to other expenses.

Research on minimum wage's impact on food-related outcomes is expanding. Nevertheless, Gundersen and Ziliak's review [32] reveals a need for more credible studies on the minimum wage's influence on food insecurity. This study analyzes the link between minimum wages and food insecurity outcomes in Indonesia, providing comprehensive insights into policy effectiveness. By connecting it to basic worker needs, this approach enhances accuracy. Additionally, this research provides the potential mechanisms underlying the relationship between minimum wages and food insecurity through income or wage channels.

The literature covering various food insecurity indicators indicates that raising the minimum wage decreases aggregate food insecurity [17, 20, 31]. Additional studies [18, 19, 30, 33–36] affirm this relationship. Using the Household Food Security Survey Module (HFSSM) or the Food Insecurity Experience Scale (FIES), previous research [17, 20, 31] establishes that minimum wages correlate with reduced food insecurity. Del Carpio et al. [37] found that the minimum wage lowers per capita consumption inequality for the bottom 50% in Thailand, and in Canada, a higher minimum wage enhances consumption spending [38]. Alonso [16] demonstrated increased nominal and real food sales in the U.S. with a minimum wage hike.

A minimum wage increase in China boosts income, with about 0.26–0.32 percent allocated to food consumption [34]. Studies on vegetable and fruit consumption as one of the food insecurity indicators show conflicting outcomes: Clark et al. [35] report a positive effect, while Andreyeva and Ukert [33] find a reduction in the U.S., especially among older, married, and white populations. Horn [39] supports the latter, but Chapman et al. [36] find no significant impact. Meanwhile, Palazzolo and Pattabhiramaiah [19] find that a higher minimum wage helps households gain additional daily calories. For the affordability of nutritious food, Newell et al. [30] note that a 79% minimum wage increase reduces the deficit for purchasing nutritious food.

Despite numerous studies in Indonesia on food insecurity and minimum wage, they are often explored independently. Research tends to concentrate on the minimum wage's impact on wages or employment [40–47], while food insecurity literature often delves into the effects of social assistance [48–51]. Notably, a study by Kharisma and Abe [52] attempts to connect minimum wage to food insecurity in Indonesia, revealing that urban workers earning above the minimum wage experience better food security.

We contribute novel insights to minimum wage impact literature, addressing critical policy questions. While the minimum wage aims to cover living needs, including food, the impact of policies that do not explicitly focus on food security in alleviating food insecurity remains uncertain. Factors like incomplete policy implementation due to noncompliance contribute to this uncertainty. The second contribution entails the utilization of varied indicators for measuring food insecurity. Addressing the broad and multidimensional aspects of food insecurity, we acknowledge the challenge of determining the superiority of one indicator over another due to their respective advantages and disadvantages [53, 54].

Most food insecurity studies rely on HFSSM or FIES [17, 18, 20, 31], capturing perceptions and experiences but not measuring food consumption or diet quality. However, using these indicators may pose moral hazards if respondents expect their answers will affect the likelihood of receiving government assistance [55]. This study uses per capita calorie intake to represent food insecurity quantitatively, following Palazzolo and Pattabhiramaiah [19]. However, fulfilling calories does not ensure nutritional adequacy. Previous research identifies dietary diversity [56–59] and fruit and vegetable consumption [60] as proxies for nutritional adequacy.

Methodology

Study area

This study was conducted in Indonesia, the world's fourth most populous country, with around 278.69 million people in mid-2023. Indonesia ranks second in the world for people with insufficient food consumption [61]. In the Asia Pacific region, Indonesia has a high prevalence rate, affecting about 19 percent or almost 52 million people. The Global Food Security Index for 2022 indicates Indonesia's low value of about 17.9 percent for the share of non-starchy food consumption, compared to the world average of 48.4 percent [62]. Additionally, FAO et al. [63] report a high average percentage (70.9%) of the population unable to afford a healthy diet from 2017 to 2021.

During our research period (2017–2019), Indonesia, comprising 34 provinces and 514 districts/cities, implemented the minimum wage policy at both provincial and district/city levels. Limited district/city-level data led us to focus our empirical analysis on the policy heterogeneity across the 34 provinces. Given the diverse minimum wage variations and persistent food insecurity issues, Indonesia is a compelling and pertinent case for our research.

Data sources and collection method

We estimate our equations by combining household-level microdata with provincial-level minimum wage data. The microdata, sourced from the National Socioeconomic Survey (Susenas) conducted by the Indonesian Central Bureau of Statistics in 2017, 2018, and 2019, is a repeated cross-section dataset covering households in 514 districts/cities across 34 provinces. The nationally and annually representative sample comprises nearly 300000 households, providing detailed demographic characteristics and consumption/expenditure information. This data enables the calculation of per capita calorie intake, per capita consumption of fruit and vegetables, and dietary diversity.

In 2017, a three-stage stratified sampling method was employed. The first stage involved selecting a 30000-sample enumeration area based on the probability proportional to size from the 2010 Population Census. The second stage entailed selecting a census block in each chosen enumeration area, and in the third stage, ten households were systematically selected from each census block. Further information and detailed methodology can be found in [64].

In 2018, 25% of population census blocks were selected in the first stage based on probability proportional to size from the 2010 Population Census. In the second stage, ten households were chosen using systematic sampling with implicit stratification based on household head education. In 2019, 40% of census blocks were selected, and the second stage involved selecting ten households using systematic sampling with implicit stratification based on household head education, the presence of toddlers, and nine-month pregnant women.

We utilize secondary data from the 2017–2019 National Labor Force Survey (Sakernas) to explore potential mechanisms linking the minimum wage to food insecurity indicators. Conducted by the Central Bureau of Statistics (BPS), Sakernas gathers information on employment status, educational attainment, income, and industry sectors using multistage sampling with households as the sample unit. The survey covers household members aged five years and over, with 20000 census blocks sampled in 2017 and 2018, increasing to 30000 in 2019. Provincial minimum wage data and macro variables (e.g., inflation and economic growth) as control variables are sourced from the Indonesian Central Bureau of Statistics.

Unit analysis and sampling

This study employs a household-level unit of analysis covering all regions in Indonesia. The variable of interest, minimum wage, is regulated at the district/city or provincial level. Since households in the same location are subject to the same minimum wage policy, variation in this variable occurs across regions, not households. Due to incomplete data on the minimum wage in 514 districts/cities, the study uses the provincial minimum wage. Further details on the provincial minimum wage are provided in the next section.

From a total of 908103 households observed over three years, the final sample used comprised 15545. The study focused on formal workers in the manufacturing sector, specifically employees, as this sector houses a significant proportion of formal employees in Indonesia (22.2%). This selection aligns with previous research [44, 45]. The research sample includes households where the head is a full-time employee in the manufacturing sector with a single source of income. Households relying primarily on remittances, investments, and pensions are excluded.

Meanwhile, to explore the potential mechanism, the sample assessing the positive impact of the minimum wage on wages includes individuals aged 15–65 with a full-time formal job as their primary employment. Additionally, the sample is limited to individuals reporting no additional work to ensure that income is solely derived from a single job.

Modeling approach and estimation

Conceptual framework: minimum wage impact on food insecurity using unconditional quantile regression

Given the dependence of the minimum wage and food insecurity relationship on initial conditions, addressing this using unconditional quantile regression (UQR) is a likely approach, as introduced by Firpo et al. [65]. Focusing solely on conditional means, such as per capita calorie intake in this study, limits the perspective of policymakers, who may be more concerned about the lower tail of the distribution.

As our dependent variable was not ordinal, models like ordered probit were irrelevant. Traditional regression has limitations in capturing distributional aspects of food insecurity or identifying subgroups with varying vulnerability. While the minimum wage can raise conditional means of per capita calorie intake, it may reduce conditional dispersion. In our study, the minimum wage tends to boost calorie intake in the lower quantile but has minimal impact in the upper quantile, where households already have high intake levels. Consequently, even if the minimum wage affects the upper tail, its impact will likely decrease.

UQR estimates the impact of marginal changes in the minimum wage across the entire distribution of food insecurity indicators without altering other distribution features. This approach, aligning with argument of Del Carpio et al. [37], is more pertinent as formal workers with diverse characteristics are situated at different points in the food insecurity distribution, resulting in heterogeneous effects of the minimum wage. From a policy implication perspective, UQR offers nuanced insights for effective policy formulation to address the most vulnerable segment.

Econometric model

Variables Dependent variable

Measuring food security accurately is challenging [66]. The Food Security Cluster indicator handbook [67] outlines first-level outcome indicators (food consumption and livelihood) and second-level indicators (nutrition and mortality). Constructing an index at the regional or national level helps capture multidimensional aspects comprehensively. However, at the household level, this strategy is not applicable.

The INDDEX Project [68] categorizes food security indicators based on quantity and quality dimensions, along with grouping by food security pillars. Traditional household food security measures, such as dietary energy intake, assess the access pillar of the quantity dimension [66, 68, 69]. On the quality dimension, dietary diversity and fruit/vegetable consumption are proxies representing the utilization dimension [67–72], providing a measure for nutritional adequacy [73].

The dependent variable in this study comprises three food insecurity indicators: per capita calorie intake per day, per capita consumption of fruits and vegetables, and food diversity. Per capita calorie intake represents the quantity of food consumed and is linked to the affordability pillar. To address quantity and nutritional adequacy, we also included per capita consumption of vegetables and fruits. These foods, rich in fiber and essential nutrients [74], are associated with nutritional sufficiency [75], healthier consumption patterns [76–78], and food security in terms of utilization [79–81].

Food diversity is measured using the Simpson Index of Dietary Diversity (SIDD), chosen over the Household Dietary Diversity Score (HDDS), as it considers the relative contribution of consumption of food groups, capturing differences in consumption distribution [72]. The following formula calculates SIDD:

$$\text{Simpson index of dietary diversity (SIDD)} = 1 - \sum_{j=1}^{n} w_j^2 \tag{1}$$

where w_j is the proportion of the j-th food type of total food consumption. SIDD values range from zero to one, indicating the balance of household food diversity, with higher values reflecting greater diversity. The calculation still employs the grouping from HDDS, which consists of 12 food groups. Ready-to-eat food is excluded, potentially resulting in very low or zero SIDD when consumption primarily involves ready-to-eat purchases.

Independent variables

The primary variable of interest is the provincial minimum wage, applicable to workers within a province. Several considerations arise when using the provincial minimum wage. Firstly, it tends to be lower than the district/city minimum wage, potentially resulting in workers earning more than the provincial minimum wage but less than the district/city minimum wage. Secondly, in Indonesia, the minimum wage is mandated for workers with 0–1 year of tenure, implying that those with over one year of tenure should receive higher pay, but this is not consistently observed. Therefore, some workers over one year of tenure may still earn less than the provincial minimum wage.

As a control variable, demographic characteristics include household income [35, 82] and education [34, 82]. Rose et al. [82] emphasize that education, specifically the spouse/wife's education in a male-headed household, reflects the human capital influencing food-related factors such as purchasing efficiency, food knowledge, and skills.

Theoretically, capital influences nutritious food consumption. Following Rose et al. [82], home ownership status is a proxy for household wealth. Additionally, household size and other control variables include the sex of the head of the household, marital status, and government assistance receiver [33, 34, 82, 83]. The operationalization of these variables is detailed in Table 6, and provincial-level control variables are incorporated in the estimation to mitigate bias, as explained in the next section.

Empirical strategy Estimating the effects of minimum wage on food insecurity indicator

Under the basic framework explaining the channel of influence of the minimum wage on food insecurity in the introduction, in general, the econometric model specifications to be used are represented as follows following Del Carpio et al. [37]:

$$y_{ipt} = \beta_0 + \beta_1 MW_{pt} + \boldsymbol{X_{it}\theta} + \varepsilon_{ipt} \tag{2}$$

where y_{ipt} is an indicator of household food insecurity for the i-th formal worker household in province p in year t. Food insecurity indicators include per capita calorie intake per day, per capita consumption of vegetables and fruits, and food diversity (SIDD). While MW_{pt} is the real minimum wage for province p in year t, every worker working in a particular province is exposed to the same minimum wage. Meanwhile, $\boldsymbol{X_{it}}$ is a vector of a set of covariates as a control variable consisting of household demographic characteristics.

For β_1 to be interpreted as a causal estimator, the error variation (ε_{ipt}) must be uncorrelated with the minimum wage. This assumption holds when the idiosyncratic and unobserved outcomes are unrelated to the local government-set minimum wage, preventing endogeneity issues. The study minimizes endogeneity concerns by employing household-level analysis for the unit of analysis, while the treatment (minimum wage policy) operates at the provincial level. Del Carpio et al. [37] and Hohberg and Lay [41] highlight that endogeneity bias intensifies when using provincial/district/city-level analysis.

The impact of the minimum wage on household food insecurity may face omitted variable bias. Unobserved variables at the regional level can influence variations in minimum wage and household food insecurity. Del Carpio et al. [37] address this by incorporating regional-level inflation and economic growth in their estimates to mitigate confounding factors. Economic conditions and regional policies can influence household food insecurity and minimum wage levels. For inflation, the study employs provincial-level food inflation, considering its relevance to explaining food insecurity indicators.

Despite efforts to isolate the minimum wage policy, it may be entwined with other public welfare policies in a province. Numerous factors influence minimum wage calculation, and concurrent policies or provincial-level changes might coexist. To mitigate bias, the estimation incorporates province and year-fixed effects. Province fixed effect (γ_p) controls for systematic differences across provinces, while year effect (δ_t) controls common changes across provinces over time. Therefore, the general equation that is estimated is:

$$\begin{aligned} y_{ipt} = {} & \beta_0 + \beta_1 lnMW_{pt} + \boldsymbol{X_{it}\theta} + \beta_2 food\_Inf_{pt} \\ & + \beta_3 RGDP_{pt} + \delta_t + \gamma_p + \varepsilon_{ipt} \end{aligned} \tag{3}$$

In the base model, we accounted for potential spatial spillover from neighboring minimum wage areas to the food security indicator. Spatial spillover, with implications for bias in minimum wage effect estimation [84, 85], can lead to omitted variable bias if overlooked. This study addresses the indirect effect of the employment path, considering the positive and negative effects on labor mobility [42]. Spatial spillover effects are captured by including the primary explanatory variable from neighboring areas, using the minimum wage value for the neighboring province or the average of minimum wages for several bordering provinces following [86].

Unobserved factors at the household level may still be linked to food insecurity indicators through individual or household preferences. These unobserved variables may reflect attributes of the local food environment and household culture related to food consumption. For instance, low consumption of vegetables and fruits might be influenced by taste rather than a lack of income-based access. While recognizing this as a study limitation, these unobserved household-level factors are not expected to influence the determination of the minimum wage policy.

Estimating the potential mechanism: effects of minimum wage on wages

We employ kernel density plots and wage regression to analyze the underlying relationship between minimum wages and food insecurity. Kernel density estimation is used to visualize wage distribution, particularly the difference between workers' wages and the applicable minimum wage in their province.

We also estimate the minimum wage's effect on wages using the UQR approach and the standard OLS estimation method. The UQR approach is particularly relevant for elucidating the mechanisms behind the relationship between minimum wages and food insecurity. The main argument centers on the potential heterogeneity in the impact of the minimum wage across different points in the wage distribution. The effect is expected to be more significant for workers at the bottom of the distribution than those in the median to upper parts.

In the basic Mincerian model, the variable of interest is the provincial minimum wage ($lnMW_{pt}$), with control variables ($\boldsymbol{X_{it}}$) including individual characteristics like gender [41, 44, 45, 87, 88], age [41, 45, 87, 89], education level [41, 44, 45, 87, 89, 90], location [41, 44], and tenure [88, 90]. Given the provincial-level application of minimum wages, additional provincial-level covariates (inflation and economic growth) are included, influencing both minimum and individual wages. To account for potential spatial spillover, we use the average minimum wage of neighboring provinces ($MWNEIGHB_{pt}$) as a control variable following [86]. The estimated equation is as follows.

$$Wage_{ipt} = \beta_0 + \beta_1 lnMW_{pt} + \boldsymbol{X_{it}\theta} + \beta_2 Inf_{pt} + \beta_3 RGDP_{pt} + \beta_3 MWNEIGHB_{pt} + \varepsilon_{ipt} \quad (4)$$

Results and discussions

Descriptive statistics

As explained in the methodology section, the study utilized repeated cross-section data from 2017 to 2019 from the National Socioeconomic Survey and National Labor Force Survey conducted by BPS. The unit of analysis was at the household level, but policy interventions occurred at the provincial level. Table 1 presents the proportion of the sample based on demographic characteristics, and Table 2 displays descriptive statistics for the study variables. Around 66 percent of households resided in urban areas, 93.8 percent were married, and 95 percent were male-headed. Roughly 70 percent of households owned their homes. However, only 19.7 percent had received food assistance in the last four months, and 7.3 percent were recipients of Conditional Cash Transfer (CCT) programs. Additionally, the education level of the spouse or head of household was mostly at the higher secondary level.

Households reported an average per capita calorie intake of 2180 kcal, indicating that, on average, they met the energy adequacy rate. Almost 50 percent had a per capita calorie intake below 2100 kcal, with 66 percent of such households in urban areas. Among the 3059 food assistance recipients, 52 percent still had a per capita calorie intake below the energy adequacy. Although households with over four members constituted only 21 percent of the total sample, the proportion of those with a per capita calorie intake below 2100 kcal increased with family size. Those with a calorie intake below 2100 kcal were in the bottom 25 percent of per capita expenditure. Detailed data descriptions based on specific characteristics can be found in Table 7.

Table 1 Proportion of sample based on demographic characteristics

Demographic Characteristics	Categories	Proportion (%)
Location	- Urban	65.98
	- Rural	34.02
Marital Status	- Married	93.79
	- Not married	6.21
Sex of HH head	- Male	95.01
	- Female	4.99
Home ownership	- Self-owned	70.07
	- Others	29.93
Food assistance recipient	- Yes	19.68
	- No	80.32
CCT recipient	- Yes	7.34
	- No	92.66
No.of HH members	- ≤ 4	79.0
	- > 4	21.0
Education	- Less than primary	6.95
	- Primary	22.78
	- Lower secondary-Higher secondary	25.4436.96
	- Undergraduate	7.73
	- Postgraduate	0.14

The total observation is 15545 households

Table 2 Summary statistics

Variables	Mean	Std. dev	Min	Max
Per capita calorie intake (kcal)	2180.40	588.89	1000.35	4497.58
Per capita consumption of fruits and vegetables (kg)	0.22	0.14	0.001	1.77
SIDD	0.69	0.10	0.06	0.88
Provincial Minimum Wage	2138209	537331	1337645	3940973
Age of HH head (years)	39.53	8.57	16	65
Total expenditure/month (Rp)	4136104	3091968	501183	61900000
Per capita expenditure (Rp)	1160273	919531	176363	20600000
Number of household members	3.77	1.08	2	12

The total observation is 15545 households

Vegetable and fruit consumption remained low, averaging 5.27 kg per week, fifty percent below the WHO-recommended 0.4 kg per day per capita. The majority (90.8 percent) consumed less than 0.4 kg of fruits and vegetables daily, averaging around 0.19 kg. However, 9.17 percent of households exceeded this, averaging 0.53 kg per capita. Like per capita calorie intake patterns, households with per capita fruit and vegetable consumption below 0.4 kg were mostly in the bottom 25 percent of expenditure, with average consumption increasing with higher per capita expenditure.

For food diversity, the average was relatively high at 0.69 (the highest SIDD was equal to one). Rural households had lower SIDD than urban ones, and those receiving food assistance had low SIDD. In the lowest 25 percent per capita expenditure group, the average SIDD was 0.63, increasing with higher expenditure groups. Additionally, households with an education level above high school had the highest average SIDD.

The provincial minimum wage in this study ranged from approximately Rp 1.3 million to Rp 3.9 million per month, with Yogyakarta consistently having the lowest and Jakarta the highest during 2017–2019. Figure 1, depicting the scatter plot between the provincial minimum wage and the prevalence of moderate or severe food insecurity, suggests a preliminary association: higher minimum wages correlate with lower prevalence of food insecurity.

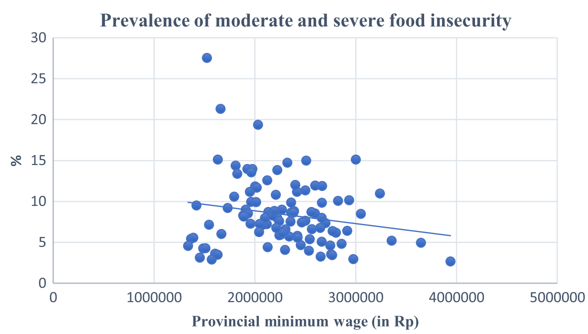

Fig. 1 Scatter plot between provincial minimum wage and the prevalence of moderate and severe food insecurity

Estimation results: effects of minimum wage on household food insecurity

Table 3 presents the minimum wage effect on various food security indicators, focusing on working households in the manufacturing sector. The distribution of these effects is visualized in Fig. 2. For the first indicator of food security, per capita calorie intake, the minimum wage had little impact on the bottom of the distribution, especially the second and third deciles. The increase in the real minimum wage by 100000 rupiahs increased per capita calorie intake in the second and third deciles by 103 and 88.35 kcal, respectively. Our results resonated with findings from a study [19] focusing on minimum wage earners. Notably, the evidence from both studies emphasized the positive impact of a minimum wage hike on calories. However, [19] employed a different method, making direct comparisons for each distribution segment challenging.

The visual representation in Fig. 2 further illuminates the intricacies of this relationship. The heterogeneous effect observed along the per capita calorie intake distribution underscores the complexity of how minimum wage adjustments reverberate through different population segments. Positive effects were conspicuous up to the eighth decile, showcasing a tangible improvement in calorie intake. However, this impact displayed a non-monotonic decline beyond the eighth decile.

Table 3 The effect of the minimum wage across the distribution of food security indicators

Decile	Per capita calorie intake (kcal)		Per capita consumption of fruits and vegetables (kg)		SIDD	
	Coefficients	Value at p^{th} decile	Coefficients	Value at p^{th} decile	Coefficients	Value at p^{th} decile
	(1)	(2)	(3)	(4)	(5)	(6)
1	57.69	1463.19	0.01	0.09	0.02**	0.54
2	103.00**	1658.10	0.01	0.12	0.02*	0.61
3	88.35***	1810.89	0.02	0.14	0.01*	0.64
4	55.36	1951.11	0.02	0.17	0.01**	0.67
5	51.15	2092.10	0.01	0.19	0.02***	0.70
6	33.18	2237.25	0.02	0.22	0.01**	0.73
7	16.96	2409.75	0.02	0.26	0.01*	0.75
8	17.36	2631.75	0.03**	0.31	0.01	0.77
9	− 8.618	2993.71	0.03*	0.40	− 0.004	0.80

Variable of interest: real provincial minimum wage (in 100000 Rp)

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The total observation is 15545 households. Control variables at the provincial level: food inflation, economic growth, and neighboring real minimum wage. Control variables at the household level: location, sex of HH head, marital status, age of HH head, home ownership, social assistance program recipient, number of HH member, spouse education, per capita real expenditure, and share of food expenditure. Fixed effect: province and year.

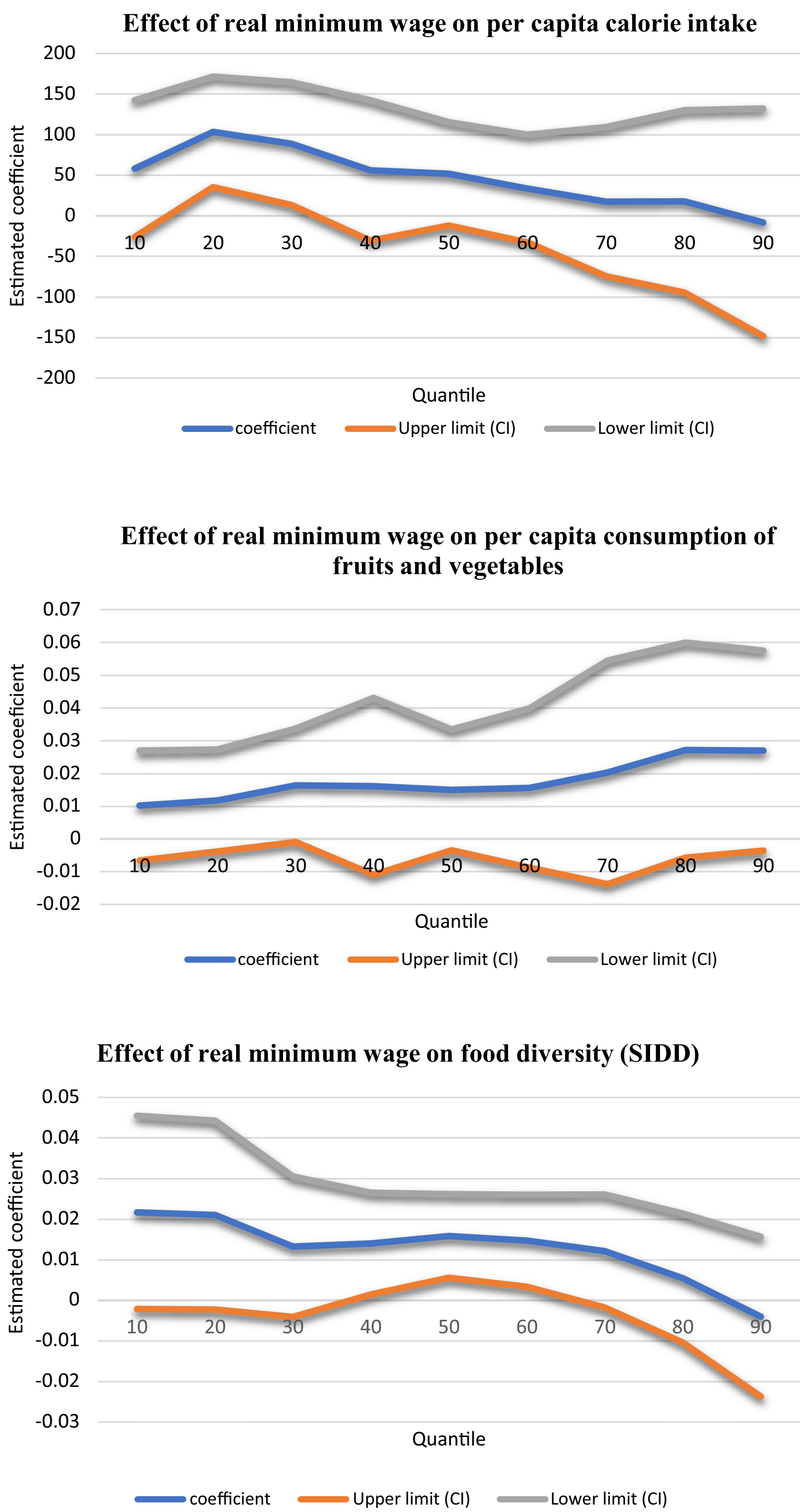

Fig. 2 The plot of the coefficient values of the real minimum wage variable across the distribution

In contrast, in the upper distribution, where the cutoff level for this segment was at 2993 kcal, the influence of the minimum wage turned negative. This aligned with nutritional principles, suggesting that excessive calorie intake beyond adequacy levels may not contribute positively to overall health. Thus, the negative effect at the highest part of the distribution lent credence to the argument that the minimum wage's impact was nuanced and context-dependent, with nutritional considerations playing a pivotal role.

Furthermore, it becomes evident that the minimum wage wielded a negligible effect in the lowest decile. In this segment, where per capita calorie intake hovered near the minimum adequacy threshold of 1463.19 kcal, the effects were notably marginal. Notably, the World Food Programme, as outlined in [91], designates households with calories per capita below 1470 kcal as the "poor" food-insecure group. The study's findings, in alignment with this classification, suggest that the minimum wage policy may not optimally reach and benefit households with calorie intake levels below the minimum adequacy threshold.

Despite the statistically insignificant impact on most of the distribution, the UQR results revealed a more uniform effect of the minimum wage on per capita consumption of fruits and vegetables. Interestingly, the minimum wage notably impacted the upper distribution of per capita fruit and vegetable consumption. Specifically, in the eighth and ninth deciles, a rise in the minimum wage of 100000 rupiahs led to a 0.03 kg increase in per capita consumption of fruit and vegetables. The World Health Organization [92] recommends a daily per capita consumption of 400 g (0.4 kg) of fruits and vegetables. Examination of column (4) in Table 3 revealed that the recommended consumption level of 400 g aligns with the top of the distribution. As we mentioned in the descriptive statistic section, about 90.8 percent of the sample had a daily consumption of fruits and vegetables below 0.4 kg (see Table 7), with an average of around 0.19 kg. This implies that per capita consumption of fruits and vegetables in Indonesia remained relatively low, underscoring potential nutritional gaps.

On a national scale, the expenditure on these food items in Indonesia experienced a decline from 2017 to 2019, with reductions of 6.29%, 6.06%, and 5.61%, respectively. This decline in spending suggests potential challenges in accessing or affording these nutritious food items, emphasizing the need for a nuanced understanding of how economic policies, including the minimum wage, intersect with dietary habits and nutritional outcomes.

Examining the minimum wage's effect on vegetable and fruit consumption in our study yielded inconclusive results. While our findings generally aligned with the observations made by Chapman et al. [36], who identified insignificant effects, they differed from the conclusions drawn by Horn et al. [39], who reported adverse effects. Nevertheless, considering only upper distribution findings, we concluded that the minimum wage positively impacted per capita consumption of fruits and vegetables, aligning with the prior research of Clark et al. [35]. However, the reliance on prior studies that did not employ UQR methodology limited our ability to conduct a detailed comparison for each distribution segment.

However, the overarching trend of an insignificant impact across most segments, except for the eighth decile, suggests that a more substantial stimulus from minimum wage increases might be required to bring about noticeable improvements in fruit and vegetable consumption. This highlights the complex interplay of economic factors and dietary choices, urging a closer examination of the magnitude and mechanisms through which minimum wage policies influence nutritional habits.

The impact of the minimum wage on food diversity, as gauged by the SIDD, demonstrated significance in multiple deciles, particularly from the first to the seventh, albeit at a 10% significance level. An increase in the real minimum wage of 100000 rupiahs increases SIDD by an average of 0.01 points in the first to seventh decile groups. Notably, this influence exhibited a relatively uniform pattern across the distribution.

It is crucial to emphasize that there needs to be more precedent in the existing literature regarding linking minimum wage policies directly to dietary diversity. This need for comparable studies makes drawing direct parallels or contrasts with the current findings challenging. Unlike prior studies that explored diverse impacts of government assistance programs on food diversity, such as Hoddinot et al. [56] in Niger and Zhou and Hendriks [93] in Mozambique, the nuances of the relationship between minimum wage policies and dietary diversity remain unexplored. The intricacies of the relationship between minimum wage policies and dietary diversity warrant further investigation to deepen our understanding of how minimum wage might influence the composition of household' diets.

Robustness check

In the robustness check, we excluded the variable accounting for spatial spillover from neighboring provinces, and the coefficient and standard error remained stable, indicating no significant impact on the results. In another check, we explored whether the coefficients changed when not accounting for social assistance (food aid and CCT). Despite the potential correlation between minimum wage changes and social assistance policy, our results with similar estimated coefficients remained consistent.

In technical robustness checks, the UQR estimation employed the Gaussian kernel in the probability density function (PDF) and cumulative distribution function (CDF) calculations. As part of the check, we used the kernel Epanechnikov. Alternative testing confirmed the robustness of the estimated coefficients in Table 3. Detailed results are provided in Tables 6, 7, 8, 9 and 10. Overall, the estimated coefficients remained consistent across all robustness checks.

Potential mechanism: effects of minimum wage on wages

This section explores the link between the minimum wage and food insecurity indicators, focusing on the positive impact on workers' wages. Figures 3 and depict the kernel density plot of the wage gap compared to the provincial minimum wage. A zero on the X-axis signifies wages equal to the minimum wage. Figure 3 illustrates the wage distribution disparity based on tenure, revealing that, on average, workers with over one year of tenure had higher wages. However, a significant portion of workers still earned below the minimum wage, particularly among those with 0–1 year of tenure. Figure 4 further shows that, within the 0–1 year tenure group, employees in the manufacturing sector had a higher average wage than those in nonmanufacturing sectors.

Rather than using the worker's economic sector as a control variable, as in previous studies [88, 94], we conduct separate regressions for each economic sector to avoid potential issues related to bad controls. Angrist and Pischke [95] caution against using control variables that may result from other independent variables. This approach helps address sorting and self-selection issues. Table 4 presents the results of estimating the minimum wage's effect on individual workers' wages as a potential channel explaining the relationship with household food security. Using UQR and OLS with different standard errors, the minimum wage significantly and positively affects wages in the manufacturing sector. An increase in the real minimum wage of 1 percent will increase the average wage of manufacturing sector workers by 2.6 percent.

Positive effects were also observed in the median through UQR, albeit at a 10 percent significance level. The mechanism explaining the impact of the minimum wage on food insecurity was explicitly validated for workers in the manufacturing sector. These results reinforce the use of a household sample in the main research question, focusing exclusively on samples from the manufacturing sector.

Differing coefficient values in UQR regressions on the mean and median implied potential variations in the impact of the minimum wage across the wage distribution. Therefore, in more detail, Table 5 provides detailed insights, indicating a heterogeneous positive impact of the minimum wage from the bottom to the median section of the wage distribution for all manufacturing worker samples. For example, the wages of manufacturing workers in the lowest 10 percent, those earning less than 1 million rupiah, will increase by 5.6 percent if there is an increase in the minimum wage of 1 percent. However, this effect tends to diminish in the higher deciles of the wage distribution. The significant effect at the lower deciles to the median and insignificance for higher

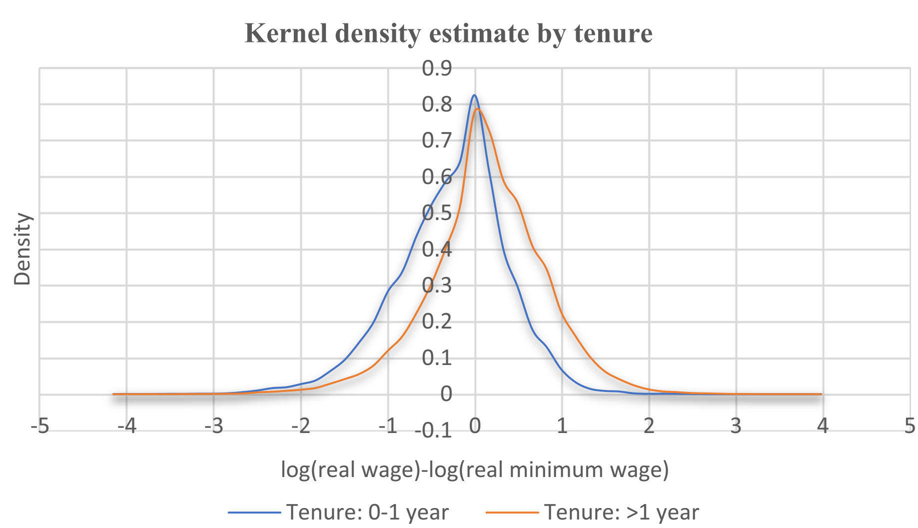

Fig. 3 Kernel densities based on tenure

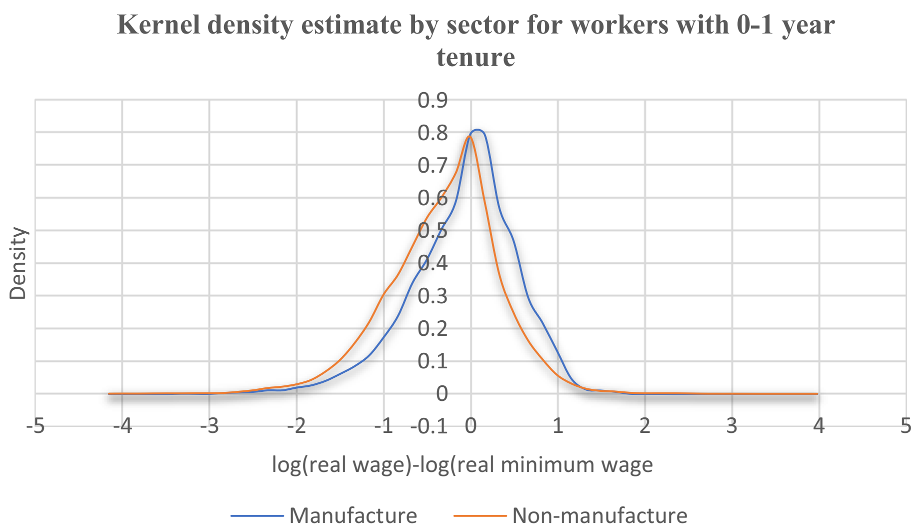

Fig. 4 Kernel densities for tenure 0–1 year based on economic sector

Table 4 The effect of log real minimum wage on log real wages

Sector	OLS[a]	UQR in mean[b]	UQR in median[b]
Agriculture (*n* = 20115)	− 0.164	− 0.164	− 1.282
Mining and quarrying (*n* = 7728)	− 0.924	− 0.924	− 2.076
Manufacture industries (*n* = 45492)	2.587***	2.587**	3.108*
Electricity, Gas and Water Supply (*n* = 2673)	0.679	0.679	1.963
Construction (*n* = 22138)	0.538	0.538	1.312
Trade, Hotel and Restaurant (*n* = 46120)	0.489	0.489	1.427
Transport and Communication (*n* = 13409)	0.610	0.610	0.833
Finance Dwelling and Business (*n* = 14234)	1.322*	1.322	0.702
Services (*n* = 66593)	− 0.015	− 0.015	− 0.295

a Robust standard errors b Bootstrapped standard errors (100 replications)

t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Control variables at the provincial level: inflation, economic growth, and neighboring real minimum wage. Control variables at the individual level: location, gender, age, age squared, education, and job tenure. Fixed effect: province and year

deciles suggests a compression of the wage distribution due to the minimum wage [96]. These findings are consistent with prior studies, including [86, 87, 97–99], and align with similar results in Indonesia [11, 41, 42, 45, 100].

The positive impact of the minimum wage, particularly for workers with more than one year of tenure, dominated the overall effect (see Table 12 for details). However, when focusing on workers with less than one year of tenure in a subsample, the minimum wage did not significantly impact wages in any part of the distribution. Despite attempting to address spatial spillover by incorporating the average minimum wage of neighboring provinces as a covariate, the coefficient estimates across the wage distribution were insignificant (see detailed results for all covariates in Table 11).

Conclusion

The study elucidated the real minimum wage's positive and noteworthy impact on food security, although this effect was discernible in specific distributions for each indicator. The favorable influence on per capita calorie intake was particularly evident in the second and third deciles, indicating an inclination towards enhanced energy sufficiency within these deciles. However, it is crucial to note the absence of a significant impact on the lowest decile, which is classified as a "poor" and food-insecure group. This raises concerns about the effectiveness of the minimum wage in addressing food insecurity within this specific demographic. The incremental increase in the real minimum wage may fall short of providing adequate support to them, potentially rendering it insufficient to alleviate food insecurity issues.

Table 5 The minimum wage impacts along the wage distribution of formal manufacturing workers

Decile	Coefficients of log of real minimum wage	Wage value at p^{th} decile
1	5.655**	1000000
2	5.097**	1400000
3	3.572**	1600000
4	3.772**	1870000
5	3.044**	2134000
6	0.602	2500000
7	1.477	3000000
8	− 2.520	3500000
9	− 0.149− 0.149	4100000
Obs	45492	45492

Dependent variable: log of real wage

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Control variables at the provincial level: inflation, economic growth, and neighboring real minimum wage. Control variables at the individual level: location, gender, age, age squared, education, and job tenure

This underscores the need for specific and targeted measures tailored to households in this low-calorie intake bracket. Social assistance programs require nuanced policy tools to address the unique challenges faced by this particular group effectively. However, a caveat is warranted. While low-calorie intake indicates a potential food security concern, it does not necessarily correlate directly with low income. Acknowledging that individuals might consciously opt for lower-calorie diets due to intentional dietary choices made for health reasons is crucial. Therefore, any policy interventions targeted at this group should be designed with a nuanced understanding of the factors contributing to low-calorie intake.

Furthermore, the study hints at the insufficiency of the real minimum wage increase to stimulate greater consumption of fruits and vegetables, except for groups that already consume these items adequately. This may be influenced by factors such as the low level of education among workers. From the perspective of food security policy, improving food security entails increasing productivity in the production of essential crops, with a specific focus on staples such as rice. To enhance the production and accessibility of nutritious foods like fruits and vegetables, there is a need for focused programs under the Ministry of Agriculture. Additionally, implementing educational initiatives should bridge household knowledge gaps regarding the importance of consuming fruits and vegetables for health.

The SIDD is influenced by the minimum wage across a broad spectrum of segments, although the observed impact tends to be relatively modest. This finding indicates a positive association between the minimum wage and dietary diversity. The recognition that the minimum wage contributes modestly to enhancing dietary diversity prompts a call for further investigation to deepen our understanding of this dynamic. Future research endeavors should corroborate and expand upon these results, exploring how minimum wage adjustments influence household dietary choices.

Additional empirical evidence supports the pathways explaining the link between minimum wages and food security. The positive and significant effect of the minimum wage is observed in the bottom-to-median distribution, primarily among formal workers in manufacturing sector.

This study, relying on self-reported data from the National Socioeconomic Survey and the National Labor Force Survey, is susceptible to measurement errors, potentially reducing the statistical power of estimates. Another limitation is the exclusion of examining the minimum wage's impact on employment, a factor integral to understanding the broader effects of minimum wage on food insecurity. Further research is needed to comprehensively assess the net impact on employment and identify the beneficiaries and drawbacks of this policy. Additionally, the study's focus on the manufacturing sector raises concerns about generalizability to other sectors due to varying sector characteristics.

Appendix

See Table 6, 7, 8, 9, 10, 11 and 12

Table 6 Operational definitions of variables

Variables	Operationalization	Scale
Dependent		
Per capita calorie intake	The number of calories consumed in the past week divided by the number of household members multiplied by seven (in kilo calories)	Metric
Food diversity: SIDD	Food diversity considers the relative contribution of food group consumption	Metric (0–1)
Per capita consumption of vegetables and fruits	Total fruits and vegetables consumed by HH in the past week divided by the number of household members multiplied by seven (in kg)	Metric
Explanatory		
Real provincial minimum wage	Provincial minimum wage (deflated by provincial CPI, base year = 2012)	Metric
Neighboring real provincial minimum wage	The average minimum wage of neighboring provinces (deflated by the provincial CPI, base year = 2012)	Metric
Food inflation	Food inflation at the provincial level (%)	Metric
Provincial economic growth	Economic growth at the provincial level (%)	Metric
Household characteristics		
Location	1 = urban; 0 = rural	Dummy
Marital status	1 = married; 0 = others	Dummy
Age of HH head	Age of household head (in years)	Metric
Gender of HH head	1 = male; 0 = female	Dummy
Homeownership status	1 = own house; 0 = others	Dummy
Food assistance recipient	1 = yes; 0 = no	Dummy
Conditional Cash Transfer (CCT) recipient	1 = yes; 0 = no	Dummy
HH size	Number of household members	Metric
Spouse education	If the HH head is married, then the education used is the highest educational level of the spouse (wife). If the HH is female-headed or the HH were unmarried male-headed, the education level of the HH head is used. This variable consists of 5 dummies (elementary school/equivalent, junior high school/equivalent, high school/equivalent, diploma/bachelor, masters/Ph.D)	Dummy
Real expenditure per capita	Total household expenditure in a month divided by the number of household members (deflated by the provincial CPI, base year = 2012)	Metric

Table 7 The proportion of the samples and mean value of each outcome (dependent variable) based on several demographic characteristics

Dependent variables	Proportion (%)	Mean
Per capita calorie intake		
< 2100 kcal	49.5	1722.4 kcal
≥ 2100 kcal	50.4	2628.8 kcal
Per capita calorie intake < 2100 kcal		
Urban	66.2	1722.5 kcal
Rural	33.8	1722.3 kcal
HH members ≤ 4	71.5	1743.8 kcal
HH members > 4	28.5	1668.8 kcal
≤ Higher secondary	92.9	1722.0 kcal
> Higher secondary	7.1	1727.9 kcal
Per capita consumption of fruits and vegetables		
< 0.4 kg	90.8	0.19 kg
≥ 0.4 kg	9.2	0.53 kg
Per capita consumption of fruits and vegetables < 0.4 kg	65.8	0.19 kg
	34.2	0.19 kg
Urban	65.8	0.19 kg
Rural	34.2	0.19 kg
HH members ≤ 4	77.5	0.20 kg
HH members > 4	22.5	0.16 kg
≤ Higher secondary	92.7	0.19 kg
> Higher secondary	7.3	0.22 kg
SIDD		
Urban	66.0	0.70
Rural	34.0	0.67
HH members ≤ 4	79	0.70
HH members > 4	21	0.67
≤ Higher secondary	92.1	0.69
> Higher secondary	7.9	0.74

Table 8 The estimated coefficient of real minimum wage of alternative model specifications: per capita calorie intake

Decile	Baseline (Table 3)	Exclude: neighboring minimum wage	Exclude: food assistance and CCT recipient	Kernel function: epanechnikov
1	57.69	58.86*	57.96	57.5
2	103.00**	91.53***	102.0**	102.9***
3	88.35***	81.80***	84.87**	88.67**
4	55.36	51.88*	52.72	55.3
5	51.15	46.83*	49.14	51
6	33.18	28.56	31.92	33.37
7	16.96	9.66	14.21	16.9
8	17.36	8.32	13.77	17.37
9	− 8.62	− 19.48	− 6.79	− 8.62

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 The estimated coefficient of real minimum wage of alternative model specifications: per capita consumption of fruits and vegetables

Decile	Baseline (Table 3)	Exclude: neighboring minimum wage	Exclude: food assistance and CCT recipient	Kernel function: epanechnikov
1	0.01	0.01	0.01	0.01
2	0.01	0.01	0.01	0.01
3	0.02	0.01**	0.01	0.01
4	0.02	0.01	0.01	0.01
5	0.01	0.01	0.01	0.01
6	0.02	0.01	0.01	0.02
7	0.02	0.01	0.02	0.02
8	0.03**	0.02**	0.03**	0.03*
9	0.03*	0.03*	0.03*	0.03

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 10 The estimated coefficient of real minimum wage of alternative model specifications: SIDD

Decile	Baseline (Table 3)	Exclude: neighboring minimum wage	Exclude: Food assistance and CCT recipient	Kernel function: Epanechnikov
1	0.02**	0.02*	0.02	0.02*
2	0.02*	0.02	0.02	0.02*
3	0.01*	0.01	0.01	0.01
4	0.01**	0.01**	0.01**	0.01**
5	0.02***	0.01**	0.01***	0.01***
6	0.01**	0.01**	0.01**	0.01**
7	0.01*	0.01**	0.01	0.01*
8	0.01	0.01	0.003	0.01
9	− 0.004	− 0.002	− 0.005	− 0.004

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11 Complete results of UQR estimation (dependent variable: log real wage)

	Decile				
	1	**2**	**5**	**8**	**9**
Ln real minimum wage	5.655** (2.02)	5.097** (2.54)	3.044** (2.22)	− 2.520 (− 0.74)	− 0.149 (− 0.05)
Ln neighboring real minimum wage	− 2.634 (− 0.87)	− 1.239 (− 0.51)	− 0.0260 (− 0.02)	− 0.653 (− 0.28)	− 0.177 (− 0.11)
Urban	− 0.014 (− 0.52)	− 0.027 (− 0.86)	0.004 (0.21)	0.027*** (2.71)	0.028* (1.84)
Male	0.387*** (5.52)	0.223*** (3.51)	0.119*** (2.58)	0.0991*** (4.24)	0.147*** (5.46)
Age	0.062*** (10.00)	0.054*** (12.74)	0.042*** (6.66)	0.019*** (4.43)	0.015*** (3.41)
Agesq	− 0.001*** (− 10.99)	− 0.001*** (− 13.39)	− 0.0005*** (− 6.59)	− 0.0001*** (− 3.13)	− 0.00003 (− 0.65)
Tenure < = 1 year	− 0.329*** (− 11.85)	− 0.253*** (− 9.88)	− 0.193*** (− 6.98)	− 0.0943*** (− 5.82)	− 0.0963*** (− 5.57)
educ = 1	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)
educ = 2	0.283*** (5.49)	0.177*** (6.52)	0.082*** (4.60)	0.033* (1.81)	0.043* (1.87)
educ = 3	0.601*** (8.27)	0.464*** (9.76)	0.294*** (6.04)	0.131*** (4.24)	0.146*** (5.60)
educ = 4	0.831*** (8.86)	0.733*** (11.28)	0.559*** (5.82)	0.354*** (5.49)	0.389*** (8.56)
educ = 5	0.943*** (10.46)	0.874*** (12.13)	0.865*** (6.82)	0.807*** (6.20)	1.233*** (7.00)
educ = 6	0.908*** (7.08)	0.872*** (10.56)	0.956*** (5.45)	1.266*** (5.98)	2.210*** (5.79)
Growth	0.007 (0.39)	0.006 (0.55)	− 0.0001 (− 0.01)	0.005 (0.43)	0.008 (0.59)
Inflation	0.021 (0.82)	0.024* (1.68)	0.016 (0.94)	− 0.032 (− 0.99)	0.034 (0.82)
Constant	− 30.99 (− 1.06)	− 42.27* (− 1.66)	− 29.69 (− 1.35)	58.93 (1.25)	18.54 (0.41)
Observations	45492	45492	45492	45492	45492
R^2	0.117	0.168	0.306	0.259	0.207
Adjusted R^2	0.116	0.167	0.306	0.258	0.206

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Fixed effect: province and year, the coefficient of the fixed effect is omitted (not written in the table) for brevity.

Table 12 The estimated coefficient of subsample estimation based on tenure

Decile	Tenure > 1 year	Value at pth decile	Tenure ≤ 1 year	Value at pth decile
1	7.255***	1,040,000	1.037	800,000
2	3.620**	1,475,000	1.438	1,000,000
3	4.836**	1,690,000	5.472	1,300,000
4	3.652**	2,000,000	1.850	1,500,000
5	3.059*	2,300,000	3.069	1,800,000
6	− 0.176	2,600,000	3.325	2,000,000
7	− 0.053	3,000,000	3.032	2,400,000
8	− 1.900	3,500,000	2.969	2,800,000
9	− 1.054	4,300,000	2.599	3,500,000
Obs	37600		7892	

Dependent variable: Log real wage, variable of interest: log real minimum wage.

Bootstrapped standard errors (100 replications). t-statistics: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Control variables at the provincial level: inflation, economic growth, and neighboring real minimum wage. Control variables at the individual level: location, gender, age, age squared, education, and job tenure.

Abbreviations

CCT Conditional cash transfer
CDF Cumulative distribution function
CPI Consumer price index
CQR Conditional quantile regression
FIES Food insecurity experience scale
HDDS Household dietary diversity score
HFSSM Household food security survey module
HH Household
kcal Kilo calori
kg Kilogram
OLS Ordinary least square
PDF Probability density function
RIF Recentered influence function
Rp Rupiah
SIDD Simpson index of dietary diversity
UQR Unconditional quantile regression
WFP World Food Programme
WHO World Health Organization

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Author contributions
HH generated the idea, designed the study, analyzed the data, and drafted the manuscript. NDN, IDGKW, and HS provided critical feedback and constructive guidance. All the authors have read and approved the final manuscript.

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Availability of data and materials
The datasets used for the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The authors have no ethical or conflicts of interest to declare that are relevant to the content of this article.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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