

UCLA

UCLA Previously Published Works

Title

Economic policy and the double burden of malnutrition: cross-national longitudinal analysis of minimum wage and women's underweight and obesity

Permalink

<https://escholarship.org/uc/item/9c33g8wj>

Journal

Public Health Nutrition, 21(5)

ISSN

1368-9800

Authors

Conklin, Annalijn I
Ponce, Ninez A
Crespi, Catherine M
et al.

Publication Date

2018-04-01

DOI

10.1017/s1368980017003433

Peer reviewed

Economic policy and the double burden of malnutrition: cross-national longitudinal analysis of minimum wage and women's underweight and obesity

Annaliijn I Conklin^{1,2,*}, Ninez A Ponce³, Catherine M Crespi⁴, John Frank⁵, Arijit Nandi⁶ and Jody Heymann¹

¹Centre for Health Evaluation and Outcomes Science and Faculty of Pharmaceutical Sciences, University of British Columbia, 2405 Wesbrook Mall, Room 4623, Vancouver, British Columbia, Canada, V6T 1K3: ²WORLD Policy Analysis Center, UCLA Fielding School of Public Health, Los Angeles, CA, USA: ³Department of Health Policy and Management and Center for Global and Immigrant Health, UCLA Fielding School of Public Health, Los Angeles, CA, USA: ⁴Department of Biostatistics, UCLA Fielding School of Public Health, Los Angeles, CA, USA: ⁵Scottish Collaboration for Public Health Research & Policy, Usher Institute of Population Health Sciences and Informatics, The University of Edinburgh, Edinburgh, UK: ⁶Institute for Health and Social Policy and Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, Montréal, Québec, Canada

Submitted 8 May 2017: Final revision received 2 October 2017: Accepted 20 October 2017: First published online 6 December 2017

Abstract

Objective: To examine changes in minimum wage associated with changes in women's weight status.

Design: Longitudinal study of legislated minimum wage levels (per month, purchasing power parity-adjusted, 2011 constant US dollar values) linked to anthropometric and sociodemographic data from multiple Demographic and Health Surveys (2000–2014). Separate multilevel models estimated associations of a \$10 increase in monthly minimum wage with the rate of change in underweight and obesity, conditioning on individual and country confounders. Post-estimation analysis computed predicted mean probabilities of being underweight or obese associated with higher levels of minimum wage at study start and end.

Setting: Twenty-four low-income countries.

Subjects: Adult non-pregnant women (n 150 796).

Results: Higher minimum wages were associated (OR; 95% CI) with reduced underweight in women (0.986; 0.977, 0.995); a decrease that accelerated over time (P -interaction = 0.025). Increasing minimum wage was associated with higher obesity (1.019; 1.008, 1.030), but did not alter the rate of increase in obesity prevalence (P -interaction = 0.8). A \$10 rise in monthly minimum wage was associated (prevalence difference; 95% CI) with an average decrease of about 0.14 percentage points (−0.14; −0.23, −0.05) for underweight and an increase of about 0.1 percentage points (0.12; 0.04, 0.20) for obesity.

Conclusions: The present longitudinal multi-country study showed that a \$10 rise in monthly minimum wage significantly accelerated the decline in women's underweight prevalence, but had no association with the pace of growth in obesity prevalence. Thus, modest rises in minimum wage may be beneficial for addressing the protracted underweight problem in poor countries, especially South Asia and parts of Africa.

Keywords
Economic policy
Minimum wage
Weight status
Multilevel analysis
Women

A major public health and policy challenge in low-income countries (LIC) is the unique epidemiological phenomenon of growing obesity concurrent with a substantial prevalence of underweight, commonly referred to as the double nutritional burden, which can occur within individuals, households and populations, and across the life course⁽¹⁾. Obesity rates are rising globally, with higher

prevalence among women, which raises serious concerns for prevention of the consequent health and economic burdens^(2,3). Although obesity is more prevalent than underweight in many regions^(1,2), underweight remains a serious public health problem in South Asia and Central and East Africa, since chronic energy deficiency is also a risk factor for adult morbidity, mortality and low

productivity⁽¹⁾. Moreover, obesity and underweight among women present transgenerational concerns for prevention, as both have adverse consequences among their offspring in terms of multiple chronic conditions⁽⁴⁾. Tackling the challenge of this double nutritional burden requires a better understanding of the broader determinants of underweight and obesity among adult women in LIC⁽⁴⁾.

It is well known that economic resources are a critical determinant of women's weight status, but most of the evidence is concentrated at the individual level in terms of income, education, class and material deprivation^(5,6). Despite reviews advocating for more research on policy-level determinants, very few international studies have examined how increases in national wage levels might influence weight outcomes. Individual-level research indicates that people reporting greater economic insecurity show higher levels of obesity and weight gain^(7,8). Whereas higher gross domestic product improves a country's level of wealth, minimum wage is a policy lever that affects an individual's experience of economic (in)security by providing an economic environment with a secure income floor that may be especially important for women, who are disproportionately affected by low-wage employment globally. Longitudinal evidence from the USA reveals a relationship between minimum wage levels and women's body weight^(9,10). By providing more material resources, higher minimum wage could improve a person's weight status through multiple pathways including lowering physiological stress responses and improving dietary intakes⁽¹¹⁾.

There have been few longitudinal or quasi-experimental studies of the relationship between minimum wage and health in low- and middle-income countries. One longitudinal multi-country study reported mixed associations of minimum wage with early-life health outcomes measured by height-for-age Z-scores⁽¹²⁾, while another showed protective effects against child stunting and a composite measure of anthropometric failure⁽¹³⁾. In a cross-sectional multi-country study of adult non-pregnant women, the relationship between minimum wage and excess weight varied by country income level⁽¹⁴⁾. The unknown question that we therefore aimed to address is whether there is a relationship between minimum wage and weight status among adult women over time. We therefore used longitudinal data on national minimum wages and individual anthropometric measures in women, to examine longitudinally whether a country's legally mandated minimum wage level is associated with the rate of change in underweight or obesity in LIC. We hypothesized that a modest rise in minimum wage (\$10 per month) would alter the trend in women's weight status outcomes.

Methods

Data sources and study sample

We used data on legally mandated minimum wage linked to individual anthropometry and sociodemographic

characteristics over the period 2000–2014. National minimum wages (per month, adjusted for purchasing power parity (PPP)) for twenty-five LIC were year-specific, applied to private-sector workers and were constructed mainly from the International Labour Organization (ILO) Global Wage database, as detailed elsewhere⁽¹⁴⁾. Additional country-level statistics came from the World Bank (World Development Indicators), Heritage Foundation (Economic Freedom Index) and ILO (Global Employment Trends) databases.

Individual-level anthropometric and control variables came from the population-based Demographic and Health Survey (DHS), which collects nationally representative health and well-being data from young and adult women (13–49 years) approximately every 5 years in countries receiving US development funds. As only seven middle-income countries with policy data had multiple DHS surveys collecting anthropometry, we examined LIC only (defined based on World Bank income thresholds). There were twenty-four LIC with at least two cross-sectional DHS surveys conducted between 2000 and 2014, with varying intervals between measurements (mean 9 (SD 3) years) and providing sociodemographic information on 723 817 young and adult women. Of these, 521 155 were measured objectively for BMI over the study period. We excluded 187 216 young females (15–23 years) and 29 327 adult women who reported being pregnant, to examine non-pregnant adult women of working age with completed education and physiological development. The final sample included women with complete information for multivariable analysis (see online supplementary material, Supplemental Fig. 1). All participants provided informed consent and the DHS survey procedures were approved by the ICF International Institutional Review Board. Details of the sample are given in Supplemental Tables 1, 2 and 3 available online.

Measures

Exposure variable

National data on PPP-adjusted monthly minimum wage between 1999 and 2013 were used to examine minimum wages 12 months before the interview year when DHS surveys were conducted (2000–2014). The one-year time lag between minimum wage and weight status was used to allow for the non-instantaneous biological response to a policy-level factor on an individual's weight status, and to ensure that the policy exposure occurred before the outcome. National minimum wage values were expressed in 2011 constant US dollars (constant\$) to adjust for inflation, and were rescaled (dividing by 10) to interpret a 1-unit change in the predictor as an increase of \$10 per month (country means in Supplemental Table 2).

Anthropometric outcomes

BMI (kg/m²) was calculated from objective measures of women's body weight and height. BMI was examined as a

dichotomous rather than a continuous outcome because the implications of a change in BMI depend on where a given value is located in the distribution; that is, differences in BMI at the threshold of a desirable outcome (between 18 kg/m² and 19 kg/m²) cannot be compared with differences in BMI at the threshold of an undesirable outcome (between 29 kg/m² and 31 kg/m²). Thus, underweight and obesity were examined as separate dichotomous outcome variables. Underweight was coded as 1 = less than 18.5 kg/m² and 0 = 18.5–29.9 kg/m² (thus excluding obese women); and obese was coded as 1 = 30.0 kg/m² or more and 0 = 18.5–29.9 kg/m² (thus excluding underweight women). Sample sizes were n 150 796 and n 145 622, respectively.

Sociodemographic and country control variables

The underweight and obese outcomes were analysed with different concurrent sociodemographic variables to control for distinct risk factors because underweight and obesity are each generated by distinct sociobiological processes. Individual-level covariates for the underweight outcome included: age (years); marital status (single, currently/previously married (reference)); parity (having no children, 1–2 children, 3–5 children, 6 or more children (reference)); anaemia level (severe (reference), moderate, mild, not anaemic, unknown/missing); agriculture labour (yes (reference), no); education (no education (reference), primary, secondary, higher); geographic location (rural (reference), urban); employer type (someone else, family member, self-employed (reference)); and employment tenure (all year, occasional, seasonal (reference)). The underweight model included agriculture since women working as farmers are three times more likely to be underweight and are disproportionately more exposed to multiple risk factors for underweight, including physical stress, infections and toxic chemicals^(15–17). Anaemia serves as a limited proxy for poor availability of nutrients which is not measured directly in the DHS but is another major risk factor of underweight in women in LIC; and, since Fe deficiency is aggravated by infections, the anaemia variable might also capture potential infections that could cause underweight. Models for the obesity outcome included the same covariates except for anaemia and agriculture, and had different reference groups (i.e. single, no children, higher education, urban location, work for someone else, work all year).

All models included the same macroeconomic control variables and were informed by the literature as previously reported⁽¹⁴⁾: market size (per capita gross domestic product, PPP-adjusted, 2011 constant\$); public-sector health spending (as a percentage of total health expenditure); market-liberal regulatory structure (Economic Freedom Index); and waged/salaried workers (as percentage of adult female labour force). Country statistics were for one year (or closest available) prior to the year when DHS surveys were fielded in a given country.

Statistical methods

We first characterized the sample of countries and sample of women using summary statistics. We then fit multilevel mixed-effects logistic regression models using the statistical software package Stata version 14.2, with QR decomposition of the variance-components matrix (command 'meqrlogit'). Specifically, we used a two-level model, with women nested within countries, that assumed a linear trend in the log odds of the outcome, underweight or obese status, over the study period. The data would not support a quadratic or other higher-order time trend because anthropometry was measured at only two (70% of countries) or three (30% of countries) time points per country. Country-specific random intercept and slope models were tested and indicated that a random slope for time was not needed as its variance was close to zero. Thus, we used a longitudinal multilevel model for change with random intercepts for country and common slope, which had several advantages, namely: estimating the initial level and conditional rate of change in the outcome; incorporating time-varying predictors and variably spaced measurement time points; treating time more flexibly; and enabling each estimate to borrow strength from the others in the small sample of countries⁽¹⁸⁾.

We fit a series of models beginning with the unconditional means model to estimate the variance components. The unconditional growth model served as the base model with random intercepts for country and a fixed effect for time. Next, to determine whether the time trend in the outcome depended on the value of the minimum wage, we added minimum wage and the interaction between minimum wage and time. Minimum wage was lagged by one year as previously described. Finally, we added the control variables for each outcome to determine whether results held up after conditioning on potential confounders. Models were fit centring time at 2013 so that the OR for minimum wage could be interpreted as the association of a \$10 increase in the minimum wage with the outcome at the endpoint of the study period. To aid interpretation of our models, we graphed the predicted mean probability of being underweight, or obese, across the sample's range of minimum wage values. The interaction between minimum wage and time was illustrated by graphing the associations for the start (2000) and endpoint of the study (2013). Predictions of average marginal effects were obtained by post-estimation calculation from the multilevel logistic regression coefficients at observed values of covariates (coefficients in the online supplementary material, Supplemental Tables 4 and 5). We also used post-estimation to calculate and graph the population-averaged adjusted prevalence difference (PD) for a \$10 increase in minimum wage across the whole study period, with covariate values as observed.

As sensitivity analyses, we further adjusted the main models by adding an indicator for childbirth in the past year to check whether results were robust to recent

gestational weight change. We also checked whether findings remained after including tobacco consumption (non-user (reference), user, unknown/missing (i.e. Armenia, Bangladesh, Ethiopia, Mali)); and separately after excluding countries identified as outliers based on Cook's D influence statistic (Ethiopia and Madagascar for underweight; Lesotho for obesity). Finally, we recoded BMI to study overweight/obesity *v.* normal weight as an alternative outcome ($1 = 25 \text{ kg/m}^2$ and above, $0 = 18.5\text{--}24.9 \text{ kg/m}^2$).

Results

On average, we found lower mean obesity prevalence with less variation (7.5 (SD 5.2)%) than overall levels of underweight in women in LIC (12.3 (SD 7.1)%). Obesity prevalence increased over time in most of these LIC ($n = 19$, 79%), while underweight prevalence typically decreased ($n = 14$, 58%; Supplemental Table 1). The proportions of underweight or obese women were unevenly distributed across categories of different socio-economic status variables (Fig. 1). Generally, the proportions of underweight women were largest among women who were uneducated, employed seasonally and by family, and from rural areas. By contrast, the proportions of obese women were largest among those who were urban, higher educated, employed all year and by someone else.

Women in the sample were 35 years old on average and were predominantly married, had multiple children and limited or no education, lived in rural areas, were not anaemic or unknown status, were employed all year and for themselves, and came from countries with an overall

mean minimum wage of \$154.3 (SD 76; interquartile range 91.3; per month, PPP-adjusted, 2011 constant\$). Countries varied widely in the amount of increase seen in the monthly minimum wage across 14 years (median \$34.61), with 80% of countries showing increases above \$10 over the study period (range \$6–117). In addition, the share of the female workforce that was subject to wages varied widely across countries from less than 5% (Mozambique) to over 50% (Armenia); and nearly 60% of countries (14/24) had more than 10% of the female working population receiving a wage/salary.

Rising minimum wage and change in underweight prevalence

The unconditional growth model showed that the annual rate of change in underweight was negative (OR = 0.976; 95% CI 0.972, 0.980), indicating a decrease in prevalence over time (Table 1). In multivariable mixed models, we found a weak interaction between minimum wage and time, indicating that with each additional year, a minimum wage increase was associated with an increasingly more negative impact on the prevalence of underweight (OR = 0.999; 95% CI 0.998, 0.999; P -interaction = 0.02). We also found that the main association between minimum wage and underweight was significant at the end of the study (OR = 0.984; 95% CI 0.975, 0.993; Table 1).

Figure 2 shows the simple main association between higher wages and predicted mean probability of being underweight. It illustrates that there is more decrease in women's underweight at higher wages and that the time trend in underweight depended on the value of the minimum wage. In other words, there was a more pronounced

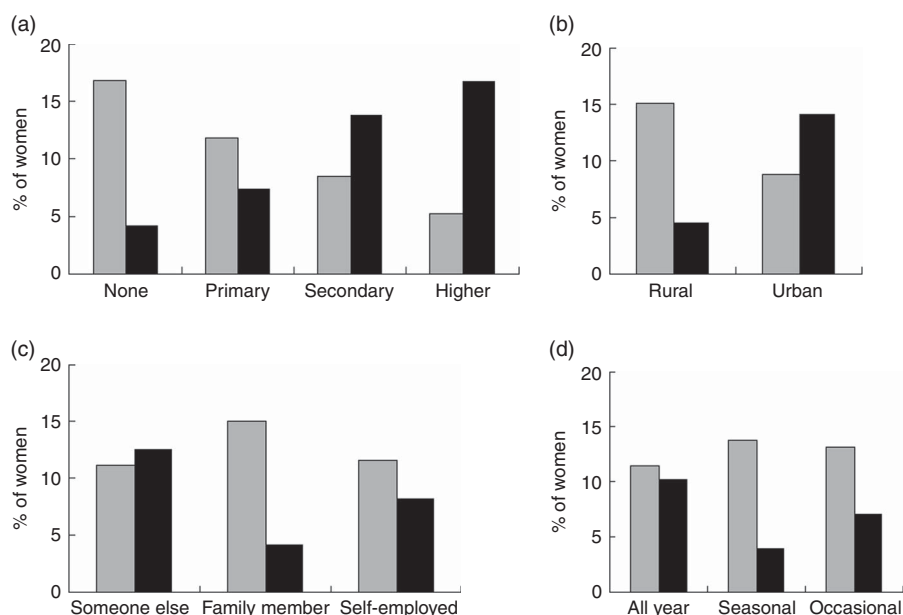


Fig. 1 Distribution of weight status outcomes (□, underweight; ■, obesity) across categories of women's socio-economic status: (a) education, (b) geographic location, (c) employer type and (d) employment tenure, among 150 796 adult non-pregnant women in twenty-four low-income countries

Table 1 OR (95% CI) of underweight associated with change in minimum wage at study endpoint among 150 796 adult non-pregnant women in twenty-four low-income countries

	Unconditional growth model			Growth model conditioned on minimum wage			Growth model conditioned on minimum wage & covariables		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Time	0.976	0.972, 0.980	0.000	0.992	0.981, 1.003	0.156	1.007	0.993, 1.02	0.314
Minimum wage				0.988	0.980, 0.996	0.004	0.984	0.975, 0.993	0.001
Minimum wage × Time				0.999	0.998, 0.999	0.002	0.999	0.998, 0.999	0.020

Minimum wage was converted to 2011 constant US dollar values and adjusted for purchasing power parity. Time was centred at 2013; thus, the OR associated with minimum wage is interpreted as the effect of a \$10 increase in minimum wage at the study endpoint. Significant results are shown in bold font.

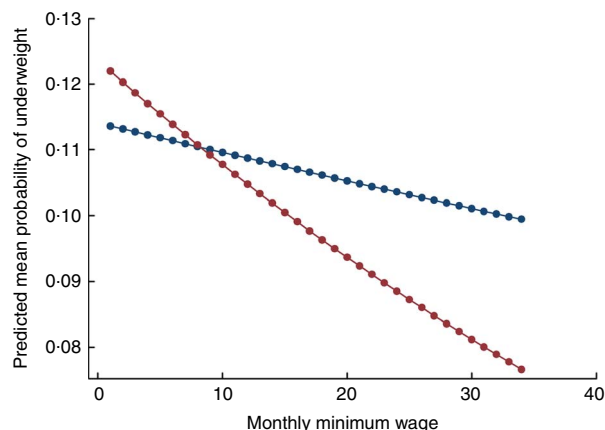


Fig. 2 (colour online) Main association of monthly minimum wage and predicted probability of underweight among 150 796 adult non-pregnant women in twenty-four low-income countries in 2000 (—●—) and 2013 (—●—). Minimum wage was converted to 2011 constant US dollar values and adjusted for purchasing power parity

difference in underweight prevalence between low and high levels of minimum wage at study end (2013) than at the start (2000).

In further post-estimation of the final model, we also found that a \$10 increase in monthly minimum wage was associated with an average decrease of about 0.04 and 0.14 percentage points in the predicted probability of underweight in 2000 (PD = -0.04; 95% CI -0.15, 0.06; $P=0.41$) and in 2013 (PD = -0.14; 95% CI -0.23, -0.05; $P=0.002$), respectively.

Rising minimum wage and change in obesity prevalence

From the unconditional growth model, we found that the annual rate of change in obesity was positive (OR = 1.03; 95% CI 1.02, 1.03), indicating a time trend of increasing prevalence of obesity. There was no significant interaction between time and minimum wage, but there was a weak positive main association between minimum wage and likelihood of obesity (OR = 1.02; 95% CI 1.01, 1.03 in adjusted model; Table 2). Figure 3 illustrates how higher values of minimum wage are associated with higher obesity prevalence and that minimum wage does not alter the trend over time. Additional post-estimation revealed

that a \$10 increase in minimum wage was associated with an average increase of about 0.1 percentage points in the predicted probability of being obese in both 2000 and 2013 (PD = 0.11; 95% CI 0.03, 0.19 and PD = 0.12; 95% CI 0.04, 0.20, respectively).

Sensitivity analyses showed that results for both underweight and obesity persisted after including additional potential confounders and removing outlier countries with high Cook's D. Two covariates (age and percentage waged) became non-significant in the underweight model after removing outlier countries, while the interaction of minimum wage with time showed stronger significance levels. Results for overweight and obesity showed similar associations to main findings for obesity (data not shown).

Discussion

The present longitudinal study contributes novel evidence on the association between minimum wage and both obesity and underweight among adult women in LIC. A \$10 rise in monthly minimum wage was associated with a greater rate of change in the decline in underweight levels in women, but was not associated with the rising trend in obesity. In other words, results supported only part of our hypothesis that minimum wage would alter the slope of declining underweight in low-income settings.

To put these findings in context, we considered Cambodia as an example LIC with a mean gross domestic product closest to the sample's mean and a common LIC pattern of high underweight (>15%) and low obesity (<5%). Based on the population size of adult women aged 25–49 years (2 550 043), a \$10 rise in monthly minimum wage would result in fifty more obese women ($41\,311 \times 0.0012$), counterbalanced by 610 fewer underweight women ($436\,057 \times (-0.0014)$). While the associated lessening in undernutrition rates was small, it was significant even when the changes in minimum wage over time were quite modest. Greater improvements in minimum wage could have a more substantial effect so long as they are not so large as to cause changes in availability of employment. These findings with respect to minimum wage suggest how this policy lever might contribute to addressing underweight in key regions where there

Table 2 OR (95% CI) of obesity associated with change in minimum wage at study endpoint among 145 622 adult non-pregnant women in twenty-four low-income countries

	Unconditional growth model			Growth model conditioned on minimum wage			Growth model conditioned on minimum wage & covariables		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Time	1.03	1.02, 1.03	0.000	1.03	1.01, 1.04	0.000	1.002	0.987, 1.02	0.819
Minimum wage				1.01	1.004, 1.02	0.004	1.02	1.01, 1.03	0.002
Minimum wage × Time				0.999	0.999, 1.001	0.809	1.00	0.999, 1.001	0.884

Minimum wage was converted to 2011 constant US dollar values and adjusted for purchasing power parity. Time was centred at 2013; thus, the OR associated with minimum wage is interpreted as the effect of a \$10 increase in minimum wage at the study endpoint. Significant results are shown in bold font.

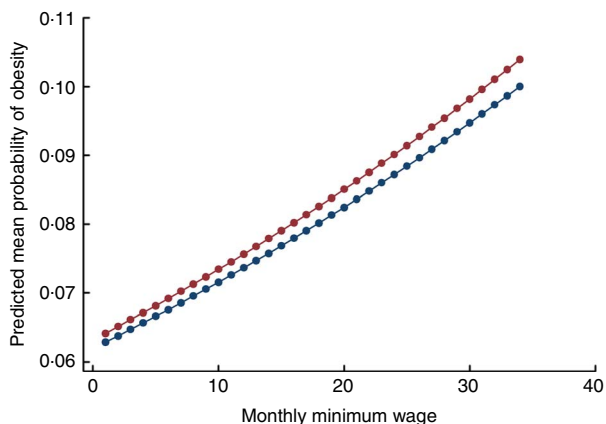


Fig. 3 (colour online) Main association of monthly minimum wage and predicted probability of obesity among 145 622 adult non-pregnant women in twenty-four low-income countries in 2000 (—●—) and 2013 (—●—). Minimum wage was converted to 2011 constant US dollar values and adjusted for purchasing power parity

remains a substantial prevalence. Our findings further indicate that improving minimum wages may need to be paired with parallel policies that address obesogenic environments.

The role of labour market policy as a social determinant of health is only beginning to be studied⁽⁵⁾ and evidence on employment conditions affecting weight is particularly limited^(10,19). Only one recent cross-sectional study of twenty-seven low- and middle-income countries examined minimum wage and weight status among women, while accounting for several individual socio-economic variables⁽²⁰⁾. That study reported an average increase of 0.03 percentage points in women's obesity associated with a 1% increase in minimum wage in sixteen LIC, which is similar to our finding of 0.1 percentage points greater obesity prevalence associated with a \$10 rise in monthly minimum wage in twenty-four LIC. Importantly, this relationship is unlikely to be sustained as LIC develop economically because minimum wage was inversely associated with women's obesity among middle-income countries. Indeed, the change in direction from an increase in overweight to a decrease across economic development was observed in another study of economic globalization and weight status in young and adult

women. Moreover, although findings are mixed with regard to obesity^(21,22), other research on selected middle-income countries further points to the potential for improved weight, nutritional and health outcomes when economic policies are amended to better support citizens financially^(23–26). Additional longitudinal data on middle-income countries are needed to examine whether raising minimum wage slows the growth in obesity among women as countries develop economically.

Our study revealed a relationship between minimum wage and underweight in women in a development context. More specifically, we showed that a \$10 rise in monthly minimum wage was associated with lower prevalence of underweight among adult women that strengthened over time and remained after several robustness checks. Previous work has examined minimum wage in low- and middle-income countries in relation to child malnutrition within a household resource allocation framework. One longitudinal study found an overall harmful association with child stunting from gestational exposure to minimum wage, but underweight and overweight were grouped on a continuous Z score and there were regional differences in results, with adverse outcomes found in South Asia and improved outcomes in Latin America⁽¹²⁾. In another multi-country longitudinal study, countries with a 10% or more increase in PPP-adjusted minimum wage showed a significant decline in stunting, and anthropometric failure (and a non-significant decline in underweight and wasting), compared to countries without a policy change⁽¹³⁾. Future research should assess whether our findings for underweight persist in middle-income countries.

Our results have several potential explanations. The decrease in underweight prevalence is likely due to a reduction in food penury and extreme poverty. Additional dollars from raised minimum wage would enable women in a poor and malnourished context to purchase more kilojoules, thereby providing adequate energy to increase body weight⁽²⁷⁾. A rise in minimum wage would directly affect women if they or other household members are working at minimum wage, but also indirectly affect households with earners earning just above the minimum wage who would also receive raises as a 'ripple effect'⁽²⁸⁾. Moreover, there are studies indicating that shadow

minimum wages in the informal economy increase after national minimum wages rise^(29,30). In addition, an increase in wages could affect body weight through improved psychosocial well-being and reduced income inequality⁽²⁸⁾. In terms of obesity prevalence, the observed increase from higher minimum wage might be explained by rising wages contributing to increased energy consumption, to changes in physical activity levels, or to broad external factors (e.g. technological change, infrastructure availability and others) that could each affect both changes in minimum wage and changes in obesity^(20,31).

Limitations

Our measure of national minimum wage is not without limitations since we lacked information on policy enforcement and implementation reach. Moreover, minimum wage may not be binding for large parts of the female working population who are not salaried, particularly women who are self-employed or employed in the informal sector. The smaller size of the impact, relative to the magnitude of the problem, is likely indicative of the fact that many of the poorest in LIC remain out of reach of the formal-sector minimum wage. Nevertheless, we included ILO information on the share of a country's female workforce that is waged or salaried to account for between-group differences in the proportion of women who might be unaffected by a minimum wage protection. It was also not possible to interrogate gender differences because DHS surveys rarely measure BMI in men; nor could we assess differences between mandated minimum and prevailing market wage. The observational nature of our longitudinal study means that we also cannot conclude causality, although reverse causality was diminished by using a lagged predictor.

Our modeling approach was able to detect an association of minimum wage with adult women's anthropometric outcomes, which had an underlying global trend of rising obesity and declining underweight. Although our models controlled for micro-level and macro-level background socio-economic conditions in each country that might affect weight status, our models do not account for other potential external influences. In particular, we lacked data on coincident changes in social safety interventions, such as cash transfer, agriculture and micro-finance programmes, that could affect weight outcomes. Thus, there is potential for residual confounding from individual income not measured in the DHS, as well as from unobserved country factors (e.g. technology change, infrastructure availability, etc.) that change over time. It is possible that within each country the change in minimum wage may be a repercussion of changes in the ruling political party or vice versa. However, we have addressed some important confounding by including four economic development factors that may explain some unmeasured labour market features.

Loss of adult women from the eligible sample who were dropped from analyses due to missing anthropometry and covariate data could have induced non-response/selection bias. The anthropometric data, available for only two or three time points for each country, were relatively sparse to support our conclusions about time trends and hence our results should be interpreted with caution. Finally, the sample of non-pregnant women aged 24 years or more in LIC limits generalizability of findings to similar sub-populations in similar development settings.

Strengths

Our study has several strengths favouring the validity of our findings, including: nationwide probabilistic samples and the large number of individual observations; comparability of measured outcomes; range of country economic development level and geographical regions; highly standardized data collection procedures; multiple potential confounders; and multilevel one-year time-lagged analyses. Multilevel statistical techniques provide a technically robust framework to address some unobserved natural heterogeneity across countries and are pertinent when predictor variables are measured simultaneously at different levels. Moreover, results were robust to alternative model specifications.

Conclusion

The present longitudinal study revealed that a modest increase in minimum wage appeared to accelerate the reduction in underweight, but did not alter obesity trends, among adult women in twenty-four LIC examined over 14 years. Findings suggest that this policy lever might help reduce underweight among LIC where this health outcome is of particular concern. Future natural experiments such as from a phased implementation design could better establish a causal relationship of the potential role of this labour market policy on a key Sustainable Development Goal.

Acknowledgements

Acknowledgements: The authors wish to thank José M. Mendoza Rodríguez for preparing and linking the data files for analysis. They also appreciate statistical support and expertise from the UCLA IDRE Statistical Consulting Group. *Financial support:* This work was supported by the Canadian Institute for Health Research Postdoctoral Fellowship Award (MFE-135520); the Canadian Institutes of Health Research Operating Grant, 'Examining the impact of social policies on health equity' (ROH-115209); and the Hilton postdoctoral scholars programme at the WORLD Policy Analysis Center of UCLA. No sponsors participated in the study design, data analysis, interpretation of results or manuscript submission. *Conflict of interest:* The authors declare no conflict of interest.

Authorship: Contributed essential policy database: A.N., J.H. and J.F. Acquired necessary funding: A.I.C. and J.H. Conceived and designed the project: A.I.C., J.H. and N.A.P. Conceived and designed the analysis: A.I.C. and C.M.C. Conducted the research and performed statistical analysis: A.I.C. Analysed and interpreted the data: A.I.C., N.A.P. and C.M.C. Drafted original manuscript: A.I.C. Edited and revised the paper: A.I.C., N.A.P., C.M.C., J.F. and J.H. *Ethics of human subject participation:* Not applicable.

Supplementary material

To view supplementary material for this article, please visit <https://doi.org/10.1017/S1368980017003433>

References

- NCD Risk Factor Collaboration (2016) Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. *Lancet* **387**, 1377–1396.
- Popkin BM & Slining MM (2013) New dynamics in global obesity facing low- and middle-income countries. *Obes Rev* **14**, 11–20.
- Kanter R & Caballero B (2012) Global gender disparities in obesity: a review. *Adv Nutr* **3**, 491–498.
- Subramanian S & Smith GD (2006) Patterns, distribution, and determinants of under- and overnutrition: a population-based study of women in India. *Am J Clin Nutr* **84**, 633–640.
- Braveman P, Egerter S & Williams DR (2011) The social determinants of health: coming of age. *Annu Rev Public Health* **32**, 381–398.
- McLaren L (2007) Socioeconomic status and obesity. *Epidemiol Rev* **29**, 29–48.
- Conklin AI, Forouhi NG, Brunner EJ *et al.* (2014) Persistent financial hardship, 11-year weight gain and health behaviors in the Whitehall II study. *Obesity (Silver Spring)* **22**, 2606–2612.
- Smith TG (2009) Reconciling psychology with economics: obesity, behavioral biology, and rational overeating. *J Bioecon* **11**, 249–282.
- McCarrier KP (2006) Exploring the relationship between state-level minimum wage policies and health-related outcomes: an analysis of 2004 BRFSS data. Recorded presentation at *APHA 134th Annual Meeting and Exposition*, Boston, MA, USA, 4–8 November 2006.
- Meltzer DO & Chen Z (2011) The impact of minimum wage rates on body weight in the United States. In *Economic Aspects of Obesity*, pp. 17–34. Chicago, IL: University of Chicago Press.
- Conklin AI (2014) Gender, diet quality and obesity: economic and social determinants, and their interactions, in older adults. PhD Thesis, University of Cambridge.
- Majid MF, Mendoza Rodríguez JM, Harper S *et al.* (2016) Do minimum wages improve early life health? Evidence from developing countries. *Soc Sci Med* **158**, 105–113.
- Ponce N, Shimkhada R, Raub A *et al.* (2017) The association of minimum wage change on child nutritional status in LMICs: a quasi-experimental multi-country study. *Glob Public Health*. Published online: 2 August 2017. doi: 10.1080/17441692.2017.1359327.
- Conklin AI, Ponce N, Frank J *et al.* (2016) Minimum wage and overweight and obesity in adult women: a multilevel analysis of low and middle income countries. *PLoS One* **11**, e0150736.
- Vir SC (2016) Improving women's nutrition imperative for rapid reduction of childhood stunting in South Asia: coupling of nutrition specific interventions with nutrition sensitive measures essential. *Matern Child Nutr* **12**, 72–90.
- Sims J & World Health Organization Office of Global and Integrated Environmental Health (1994) *Women, Health and Environment: An Anthology*. Geneva: WHO.
- Kane P & Dennerstein L (1999) Women and occupational health: issues and policy paper for the Global Commission on Women's Health. http://www.who.int/occupational_health/publications/en/oehwomenandoh.pdf (accessed November 2017).
- Singer JD & Willett JB (2003) *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. New York: Oxford University Press.
- Friel S, Chopra M & Satcher D (2007) Unequal weight: equity oriented policy responses to the global obesity pandemic. *BMJ* **335**, 1241–1243.
- Goryakin Y, Lobstein T, James WP *et al.* (2015) The impact of economic, political and social globalization on overweight and obesity in the 56 low and middle income countries. *Soc Sci Med* **133**, 67–76.
- Fernald LCH, Gertler PJ & Hou X (2008) Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults. *J Nutr* **138**, 2250–2257.
- Leroy JL, Gadsden P, González de Cossío T *et al.* (2013) Cash and in-kind transfers lead to excess weight gain in a population of women with a high prevalence of overweight in rural Mexico. *J Nutr* **143**, 378–383.
- Case A (2001) *Does Money Protect Health Status? Evidence from South African Pensions*. NBER Working Paper no. 8495. Cambridge, MA: National Bureau of Economic Research.
- Duflo E (2003) Grandmother and granddaughters: old-age pensions and intrahousehold allocation in South Africa. *World Bank Econ Rev* **17**, 1–25.
- Macours K (2014) After the transfers stop. *J-PAL Policy Briefcase* June issue. https://www.povertyactionlab.org/sites/default/files/publications/Briefcase%20CCT%20Nicaragua%20Final_English.pdf (accessed May 2017).
- Galicia L, de Romaña DL, Harding KB *et al.* (2016) Tackling malnutrition in Latin America and the Caribbean: challenges and opportunities. *Rev Panam Salud Publica* **40**, 138–146.
- Deaton A (2003) Health, inequality, and economic development. *J Econ Lit* **41**, 113–158.
- Leigh J (2016) Could raising the minimum wage improve the public's health? *Am J Public Health* **106**, 1355–1356.
- Maloney WF & Nunez Mendez J (2003) *Measuring the Impact of Minimum Wages: Evidence from Latin America*. NBER Working Paper, no. 9800. Cambridge, MA: National Bureau of Economic Research.
- Boeri T, Garibaldi P & Ribeiro M (2011) The lighthouse effect and beyond. *Rev Income Wealth* **57**, S54–S78.
- Lakdawalla D & Philipson T (2009) The growth of obesity and technological change. *Econ Hum Biol* **7**, 283–293.