# Examining Changes in Food Security, Perceived Stress, and Dietary Intake in a Cohort of Low-Wage Workers Experiencing an Increase in Hourly Wage

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Objective. *To determine whether an increase in hourly wages was associated with changes in food security and perceived stress among low-wage workers. We also determined whether changes in food security and stress were associated with changes in diet.* Setting. *Wages is a prospective cohort study following 974 low-wage workers in Minneapolis, MN, where an ordinance is incrementally increasing minimum wage to US$15/hr from 2018 to 2022, and a comparison community with no minimum wage ordinance (Raleigh, NC). Interaction models were estimated using generalized estimating equations.* Participants. *Analyses used two waves of data (2018 [baseline], 2019) and included 219 and 321 low-wage workers in Minneapolis and Raleigh (respectively).* Results. *Average hourly wages increased from US$9.77 (SD US$1.69) to US$11.67 (SD US$4.02). Changes in wages were not associated with changes in food security (odds ratio = 1.05, 95% confidence interval [CI] [0.89, 1.23], p = .57) or stress (β = −0.01, 95% CI [−0.04, 0.03], p = .70) after 1 year of policy implementation. Changes in food security were not associated with changes in diet. However, we found significant changes in the frequency of fruit and vegetable intake across time by levels of stress, with decreased intake from Wave 1 to 2 at low levels of stress, and increased intake at high levels of stress (incidence rate ratio = 1.17, 95% CI [1.05, 1.31], p = .01).* Conclusions. *Changes in wages were not associated with changes in food security or stress in a sample of low-wage workers. Future research should examine whether full implementation of a minimum wage increase is associated with changes in these outcomes.*

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## INTRODUCTION

Disparities in dietary intake between various segments of the population have become a major focus of public health research, practice, and policy in the United States (U.S.). For example, on average, low-income Americans consume less fruits and vegetables (F&V) and have lower quality diets than higher income Americans (Fang Zhang et al., 2018; Lee-Kwan et al., 2017). Numerous factors may contribute to these disparities in dietary intake, including high costs of healthier foods (Darmon & Drewnowski, 2015; Pechey & Monsivais, 2016; Satia, 2009). A study from the U.S. Department of Agriculture indicated that based on a 2,000-calorie diet, it costs between US$2.10 and US$2.60 per person per day to satisfy the U.S. *Dietary Guidelines for Americans* F&V recommendations (Stewart et al., 2016). For a family of four, this equates up to US$72.80 per week on F&V, which may exceed what some families can afford to spend. Thus, policies that increase lower income Americans' hourly wage, such as minimum wage ordinances, may increase household income. This, in turn, may lead to improvements in relevant mediators (such as stress or food security), thereby increasing one's ability to purchase and consume healthier and more costly foods such as F&V. The authors previously published a conceptual model (which was created using the above information and other information reported in the literature) that displays various hypothesized relationships between a minimum wage ordinance and improvements in health, including dietary intake (Chapman et al., 2021). In addition, conceptual models linking minimum wage increases to food security, stress, and dietary intake have been developed and reported in the literature (Caspi, De Marco, Durfee, et al., 2021).

Several studies have examined associations between minimum wage increases and F&V consumption, but results from these studies have been mixed. A study by Horn et al. (2017) analyzed data from the 1993 to 2014 Behavioral Risk Factor Surveillance Survey (BRFSS). The authors found no association between minimum wage increases and the daily number of F&V consumed in lesser-skilled female workers and found an inverse association among lesser-skilled male workers (Horn et al., 2017). Similarly, a repeated cross-sectional study by Andreyeva and Ukert (2018) analyzed BRFSS data from 1993 to 2015 and found that a 1$ wage increase was associated with a 0.17% reduction in F&V consumption. Clark et al. (2020) used repeated cross-sections of BRFSS merged with monthly U.S. minimum wages and F&V prices for the years 1990–2017 and found daily F&V increased by 0.08 daily servings when the minimum wage increased by 1$. Based on these mixed findings, additional examination of minimum wage policies' impacts on dietary intake and other health indicators, such as food security and stress, is warranted. Although there are other potential mediators of the wage-diet association, this study focused specifically on food security and perceived stress because of their well-established relationships with wages, income, and dietary intake in the literature. For example, numerous studies have shown that income is inversely associated with stress, and that decreases in wages can worsen stress and other mental health indicators (Burgard & Lin, 2013; Mucci et al., 2016). In addition, stress can negatively affect diet quality through multiple pathways. Stress may be a marker for a lack of time and capacity for meal planning and cooking, which are two behaviors that are strongly linked to consuming a healthier diet (Ducrot et al., 2017; Mills et al., 2017). Stress may also promote irregular eating patterns and consuming food for pleasure in the absence of caloric need (Yau & Potenza, 2013).

In June 2017, Minneapolis, Minnesota passed an ordinance that incrementally increases the minimum wage above the state level to US$15 an hour, from US$9.50 per hour for all businesses with greater than 100 employees, and from US$7.75 per hour in smaller businesses (MinneapolisMN.gov, n.d.). The incremental annual wage increase must be fully implemented by July 1, 2022 for large businesses and 2 years later for small businesses (Supplemental Figure 1; MinneapolisMN.gov, n.d.).

The Wages Study follows a cohort of low-wage workers over the 4.5-year implementation period of the Minneapolis minimum wage increase (2018–2022). The study collects annual measures of economic and health indicators and behaviors in a sample of low-wage workers in Minneapolis and in a control site (Raleigh, North Carolina) to determine whether the ordinance improves earnings and health outcomes for workers. A previous analysis using the first two waves of Wages Study data determined that, after 1 year, the policy was associated with increased hourly wages but was not associated with changes in diet (Chapman et al., 2021). These results may have been null because the ordinance had not yet been fully implemented, and wages had not increased enough to significantly affect diet. Thus, as a follow-up analysis, the authors examined changes in potential mediators of the wage-diet relationship: food security (defined as “access by all people at all times to enough food for an active, healthy life”) and perceived stress (Economic Research Service, 2020).

The primary aim of this study was to examine whether changes in hourly wages are associated with changes in food security and changes in perceived stress in a cohort of low-wage workers. In addition, this study examined whether changes in food security and changes in perceived stress are associated with changes in frequency of consumption of three food groups: F&V, whole grain-rich foods (in which a food’s first ingredient is a whole grain), and foods high in added sugars (>5 g of sugar per serving) among low-wage workers. These food groups were selected because they are associated with both weight gain and chronic disease risk in the literature, and they were feasible for the research team to create based on the dietary data we collected. We hypothesized that increases in hourly wages would be associated with increased food security and decreased levels of perceived stress. In addition, we hypothesized that increases in food security and decreases in perceived stress would be associated with increased intake of F&V and whole grain-rich foods, and decreased intake of foods high in added sugars.

## METHODS

### *Study Population*

The Wages Study is a prospective cohort study. In January 2018, the Wages Study began following a cohort of 974 low-wage workers (those earning ≤US$11.50 an hour at baseline) in Minneapolis ($n$ = 495) and low-wage workers in a comparison city with no minimum wage increase (Raleigh, North Carolina, $n$ = 479). Raleigh was selected as the comparison city because of its similarity on 12 demographic indicators (e.g., population size, percent foreign-born residents) and other indicators such as obesity rates in comparison to Minneapolis. Appendix 1 presents the study inclusion and exclusion criteria (see Supplemental Material). Wages Study participants were recruited in person at Minneapolis and Raleigh community organizations, as well as using passive strategies such as fliers, bus/light rail advertisements, online and social media advertisements; this type of community-based recruitment assisted with recruiting participants from a variety of job sectors. Additional recruitment methods are described in detail elsewhere (Shanafelt et al., 2021).

The study described in this manuscript uses the first two waves of longitudinal data (Wave 1 [baseline], 2018 and Wave 2, 2019) from the ongoing Wages Study ($n$ = 655). After Wave 2 loss-to-follow-up and exclusions, data from 540 Wages Study participants were available for analyses (Supplemental Figure 2). The study was approved by the institutional review boards of The University of North Carolina at Chapel Hill and the University of Minnesota and participants gave written informed consent to participate.

### *Hourly Wage Assessment*

Wages Study participants attend one in-person data collection appointment each year (held at community partner locations or a centrally located and accessible university-based clinical research center in Minneapolis) in which wages are verified and a computer-based survey is administered. Participants bring a recent pay stub or other documents from their primary employer to verify their hourly wage at the annual data collection appointment.

### *Food Security Assessment*

At each annual data collection appointment, food security is assessed via the computer survey using the United States Department of Agriculture’s 6-item U.S. Household Food Security Survey Module (Economic Research Service, 2012). Participants respond to statements such as “The food that (I/we) bought just didn’t last, and (I/we) didn’t have money to get more” with either “often true,” “sometimes true,” or “never true for (you/your household) in the last 12 months.” An affirmative response to three or more items indicates food insecurity versus no food insecurity, in accordance with standard scoring practices for a dichotomous outcome for this instrument (Economic Research Service, 2012).

### *Perceived Stress Assessment*

The computer-administered survey measures participants’ perceived stress using Cohen’s Perceived Stress Scale (PSS-4), a widely used measure found to be valid and reliable (Vallejo et al., 2018). Participants are asked four questions about the frequency of stressful feelings over the past 30 days. Response options range from 0 (*never*) to 4 (*very often*), and scale scores were the average of the responses to the four items (range 0–4).

### *Dietary Assessment*

To assess dietary intake, the computer-administered survey includes 22 questions from the validated 26-item National Cancer Institute’s (NCI) Dietary Screener Questionnaire (DSQ) (Division of Cancer Control & Population Sciences, 2018; Thompson et al., 2017). We used the DSQ frequency data to estimate participants’ daily frequency of intake of three different food groups to be used as the study's dependent variables: F&V, whole grain-rich foods (in which the first ingredient is a whole grain), and foods high in added sugars (>5 grams of sugar per serving). A detailed description of the Wages Study's dietary intake assessment and food groupings methodology is described elsewhere (Chapman et al., 2021).

***Covariate Assessment***

The computer-administered survey provided data on demographic, economic, and additional health-related factors. Appendix 2 provides the details on the assessment and operationalization of these variables (see Supplemental Material).

## STATISTICAL ANALYSES

The research team conducted the analyses in two steps for both food security and perceived stress. In Step 1, we tested whether changes in hourly wages over time were associated with changes in food security (or perceived stress). In Step 2, we tested whether changes in food security status (or perceived stress) over time were associated with changes in frequency of intake of F&V, whole grain-rich foods, and foods high in added sugars. All analyses were conducted in Stata/IC (version 16.0, 2019, StataCorp LLC, College Station, Texas).

***Food Security Analyses***

*Step 1: Hourly Wage and Food Security.* In Step 1, we estimated a regression model to test whether changes in wages over time were associated with changes in food security (Model 1). The model included a time-by-hourly wage interaction term, and inference was based upon this term. We adjusted for the following covariates: age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in household, number of children living in household, whether the participant is a food service worker, whether the participant has a physical disability, whether the participant has a mental disability, self-reported health status, health insurance status, vehicle access, whether the participant lives in Minneapolis or Raleigh, and the timing (in weeks) of the participant's data collection appointment relative to the wage increase. We adjusted for these covariates in our analyses because they were factors that may have influenced diet-related outcomes.

Data were analyzed with longitudinal regression analysis (generalized estimating equations [GEEs] with clustering by the individual), using the Huber/White/sandwich estimator of variance and an autoregressive correlation matrix to account for repeated measures within individuals (Diggle et al., 1994). Sensitivity analyses were performed, and results did not change when alternative correlation matrices were specified.

*Step 2: Food Security and Dietary Intake.* In Step 2, we estimated a regression model with a time-by-food security interaction term to test whether changes in food security status over time were associated with changes in frequency of F&V intake (Model 2), whole grain-rich foods (Model 3), and foods high in added sugars (Model 4). Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, whether the participant is a food service worker, whether the participant has a physical disability, whether the participant has a mental disability, general self-reported health, health insurance status, vehicle access, whether the participant lives in Minneapolis or Raleigh, the timing (in weeks) of the participant's data collection appointment relative to the minimum wage increase, body mass index (BMI), pregnancy status, and smoking status.

The models were estimated using negative binomial regression, as the dietary outcomes were over-dispersed count data. Likelihood ratio tests that the dispersion parameter was equal to zero revealed that negative binomial models were a better fit than Poisson models (Cameron & Trivedi, 1986). Data were analyzed with GEE with clustering by the individual, using the Huber/White/sandwich estimator of variance and an autoregressive correlation matrix.

***Perceived Stress Analyses***

*Step 1: Hourly Wage and Perceived Stress.* To test whether changes in hourly wage over time were associated with changes in levels of perceived stress (Model 5), we estimated a linear regression model with a time-by-hourly wage interaction term. The model was adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, job classification, whether the participant has a physical disability, health insurance status, whether the participant lives in Minneapolis or Raleigh, the timing of the participant's data collection appointment relative to the wage increase, pregnancy status, smoking status, physical activity. The models were estimated using GEE with clustering by the individual, using the Huber/White/sandwich estimator of variance and an autoregressive correlation matrix.

*Step 2: Perceived Stress and Dietary Intake.* In Step 2, we estimated a regression model with a time-by-perceived stress interaction term to test whether changes in perceived stress were associated with changes in daily frequency of F&V consumption (Model 6), whole grain-rich foods (Model 7), and foods high in added sugars (Model 8).

Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, job classification, whether the participant has a physical disability, health insurance status, whether the participant lives in Minneapolis or Raleigh, the timing (in weeks) of the participant's data collection appointment relative to the minimum wage increase, BMI, pregnancy status, smoking status, and physical activity. The models were estimated using negative binomial regression with GEE with clustering by the individual, using the Huber/White/sandwich estimator of variance and an autoregressive correlation matrix.

## RESULTS

The present study uses the first two waves of longitudinal data from the currently ongoing Wages Study ($n$=655); after exclusions, data from 540 Wages Study participants were available for analyses (Supplemental Figure 2). Baseline demographic information is presented in Table 1. Most participants were black or African American, non-Hispanic, and had received at least a high school diploma or higher. Supplemental Table 1 displays the descriptive statistics about economic indicators for participants at Waves 1 and 2. The average hourly wage at Wave 1 was US$9.77 and increased to US$11.67 at Wave 2. On average across the sites, the most common job type among participants was "Food Preparation and Serving," and the distribution of the different job types remained relatively constant between Waves 1 and 2. For both sites, the average number of hours worked each week increased from Wave 1 to Wave 2. Finally, for both sites, the percent of participants who worked more than one job decreased from Wave 1 to Wave 2.

### *Food Security Results*

Supplemental Table 2 presents the descriptive statistics on food security prevalence in our sample. Overall, the proportion of food insecurity in our sample was high, with 72.41% of participants at Wave 1 and 65.37% of participants at Wave 2 being food insecure. The percent of participants who were food insecure decreased in Minneapolis from Wave 1 to Wave 2 (70.32% vs. 66.21%), and also in Raleigh from Wave 1 to Wave 2 (73.83% vs. 64.80%). However, the decrease in food insecurity was 4.92% greater in Raleigh than in Minneapolis (9.03% vs. 4.11%). A formal test of comparison using unadjusted difference-in-difference regression determined that these differences were not significantly different from each other ($p$ = .71).

Table 2 presents the results from Step 1 in our food security analysis; we found no association between changes in hourly wage and changes in food security in our sample (odds ratio [OR] = 1.05, 95% confidence interval [CI] [0.89, 1.23], $p$=.57). In addition, in Step 2, we found that the change in frequency of consumption for F&V, whole grain-rich foods, and foods high in added sugars from Wave 1 to Wave 2 did not vary by food security status (Table 3).

### *Perceived Stress Results*

Supplemental Table 2 presents the descriptive statistics for levels of perceived stress in our sample. On average, the levels of perceived stress were fairly low in both cities in both waves (ranging between 1 [*almost never*] and 2 [*sometimes*]). Average PSS-4 decreased in both Minneapolis from Wave 1 to Wave 2 (1.66 vs. 1.55) and in Raleigh from Wave 1 to Wave 2 (1.87 vs. 1.67), but the decrease was 0.35 points greater in Raleigh than Minneapolis (0.20 vs. 0.11). However, a formal test of comparison using unadjusted difference-in-difference regression showed that these differences were not significantly different from each other ($p$ = .20).

Table 4 presents the results from Step 1 in our perceived stress analysis; we found no association between changes in hourly wage and changes in perceived stress in our sample ($\beta$ = −0.01, 95% CI [−0.04, 0.03], $p$ = .70).

Table 5 presents the results from Step 2, in which we found no association between changes in perceived stress and changes in frequency of consumption of whole grain-rich foods and foods high in added sugars. However, we found a significant difference in the effect of time on daily frequency of F&V consumption across levels of stress (incidence rate ratio [IRR] = 1.17, 95% CI [1.05, 1.31], $p$ = .01). To assist in the interpretation of our model, we calculated the differences in the adjusted means of daily F&V frequency of consumption between Waves 1 and 2 at each value of the PSS-4, and their associated $p$ values and 95% CIs (Supplemental Table 3). As displayed in this table, the mean daily frequency of F&V intake decreased for participants with lower levels of stress and increased for participants with higher levels of stress.

**TABLE 1**
**Baseline Characteristics of Wages Participants in Minneapolis, Minnesota, and Raleigh, North Carolina, That Will Be Used in Analyses ($n$ = 540)**

| | *Minneapolis* | | *Raleigh* | | *Total* | |
|---|---|---|---|---|---|---|
| *Sample Characteristics* | *N or M* | *% or SD* | *N or M* | *% or SD* | *N or M* | *% or SD* |
| Total sample | 219 | 40.56 | 321 | 59.44 | 540 | 100.00 |
| Age | | | | | | |
| 18–29 | 42 | 19.18 | 103 | 32.09 | 145 | 26.85 |
| 30–39 | 40 | 18.26 | 91 | 28.35 | 131 | 24.26 |
| 40–49 | 42 | 19.18 | 56 | 17.45 | 98 | 18.15 |
| 50–59 | 63 | 28.77 | 54 | 16.82 | 117 | 21.67 |
| 60+ | 32 | 14.61 | 17 | 5.30 | 49 | 9.07 |
| Missing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Sex | | | | | | |
| Male | 99 | 45.21 | 99 | 30.84 | 198 | 36.67 |
| Female | 116 | 52.97 | 221 | 68.85 | 337 | 62.41 |
| Nonbinary | 1 | 0.46 | 1 | 0.31 | 2 | 0.37 |
| Missing | 3 | 1.37 | 0 | 0.00 | 3 | 0.56 |
| Race | | | | | | |
| White alone | 51 | 23.29 | 37 | 11.53 | 88 | 16.30 |
| Black or African American alone | 130 | 59.36 | 264 | 82.24 | 394 | 72.96 |
| Asian alone | 2 | 0.91 | 2 | 0.62 | 4 | 0.74 |
| Native Hawaiian or Pacific Islander alone | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Native American or Alaskan Native alone | 10 | 4.57 | 2 | 0.62 | 12 | 2.22 |
| More than one race | 15 | 6.85 | 8 | 2.49 | 23 | 4.26 |
| Other | 7 | 3.20 | 8 | 2.49 | 15 | 2.78 |
| Missing | 4 | 1.83 | 0 | 0.00 | 4 | 0.74 |
| Ethnicity | | | | | | |
| Hispanic/Latino | 10 | 4.57 | 18 | 5.61 | 28 | 5.19 |
| Non-Hispanic/Latino | 203 | 92.69 | 302 | 94.08 | 505 | 93.52 |
| Missing | 6 | 2.74 | 1 | 0.31 | 7 | 1.30 |
| Education | | | | | | |
| Less than high school | 6 | 2.74 | 3 | 0.93 | 9 | 1.67 |
| Some high school | 37 | 16.89 | 34 | 10.59 | 71 | 13.15 |
| High school diploma | 60 | 27.40 | 138 | 42.99 | 198 | 36.67 |
| Associate/technical degree | 33 | 15.07 | 29 | 9.03 | 62 | 11.48 |
| Some college | 56 | 25.57 | 86 | 26.79 | 142 | 26.30 |
| Bachelor’s degree or higher | 27 | 12.33 | 30 | 9.35 | 57 | 10.56 |
| Missing | 0 | 0.00 | 1 | 0.31 | 1 | 0.19 |
| SNAP usage | | | | | | |
| Receiving SNAP | 129 | 58.90 | 138 | 42.99 | 267 | 49.44 |

*Note.* SNAP = Supplemental Nutrition Assistance Program.

**TABLE 2**

**Food Security Analysis Step 1: Regression Model Displaying the Longitudinal Relationship Between Changes in Hourly Wage and the Probability of Being Food Secure Among Wages Participants (*n* = 540) in Minneapolis, Minnesota, and Raleigh, North Carolina, From Wave 1 (Baseline, 2018) to Wave 2 (2019)**

| *Model Type* | *Time × Wage odds ratio* | *95% CI* | *p value* |
|---|---|---|---|
| Step 1: Hourly wage and food security[a] | | | |
| Unadjusted model | 1.01 | [0.88, 1.15] | .91 |
| Adjusted model[b] | 1.05 | [0.89, 1.23] | .57 |

*Note.* CI = confidence interval.
[a]Models were estimated using generalized estimating equations. [b]Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in household, number of children living in household, whether the participant is a food service worker, whether the participant has a physical disability, whether the participant has a mental disability, general self-reported health, health insurance status, vehicle access, whether the participant lives in Minneapolis or Raleigh, and the timing (in weeks) of the participant's data collection appointment relative to the wage increase. [c]Time was coded as 0 for Wave 1 and 1 for Wave 2.

**TABLE 3**

**Food Security Analysis Step 2: Regression Model Displaying the Longitudinal Relationship Between Changes in Food Security and Frequency of Consumption of Various Food Groups Among Wages Participants (*n* = 540) in Minneapolis, Minnesota, and Raleigh, North Carolina, From Wave 1 (Baseline, 2018) to Wave 2 (2019)**

| | *Fruits and vegetables* | | | *Whole grain-rich foods* | | | *Foods high in added sugars* | | |
|---|---|---|---|---|---|---|---|---|---|
| *Model Type* | *Time × Food Security IRR* | *95% CI* | *p value* | *Time × Food Security IRR* | *95% CI* | *p value* | *Time × Food Security IRR* | *95% CI* | *p value* |
| Step 2: Food security and diet[a] | | | | | | | | | |
| Unadjusted model | 0.98 | [0.83, 1.16] | .85 | 1.16 | [0.88, 1.51] | .29 | 1.17 | [0.94, 1.45] | .17 |
| Adjusted model[b] | 1.05 | [0.85, 1.29] | .68 | 1.36 | [0.97, 1.90] | .08 | 1.17 | [0.85, 1.62] | .33 |

*Note.* CI = confidence interval; IRR = incidence rate ratio; BMI = body mass index.
[a]Models were estimated using negative binomial regression and generalized estimating equations. [b]Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, whether the participant is a food service worker, whether the participant has a physical disability, whether the participant has a mental disability, general self-reported health, health insurance status, vehicle access, whether the participant lives in Minneapolis or Raleigh, the timing (in weeks) of the participant's data collection appointment relative to the minimum wage increase, BMI, pregnancy status, and smoking status. [c]Time was coded as 0 for Wave 1 and 1 for Wave 2.

## DISCUSSION

This study found that changes in hourly wages were not associated with changes in food security or changes in perceived stress in our sample of low-wage workers following 1 year of policy implementation. In addition, we found that changes in food security were not associated with changes in dietary intake over the same time period. Similarly, changes in perceived stress were not associated with changes in frequency of consumption of whole grain-rich foods and foods high in added sugars. However, we found that participants with lower levels of perceived stress decreased their daily frequency of F&V consumption from Wave 1 to Wave 2, whereas participants with higher levels of perceived stress increased their F&V consumption from Wave 1 to Wave 2. These results were not consistent with our hypothesis, as we hypothesized that participants with lower levels of stress would increase their F&V consumption across time.

There are several potential reasons as to why our results from the perceived stress analysis were not as hypothesized for the F&V food group. First, it is likely that many factors, not just hourly wages, are influencing stress in our sample of low-wage workers. Perhaps a different factor, such as physical health, improved among Wages Study participants from Wave 1 to Wave 2,

**TABLE 4**

**Perceived Stress Analysis Step 1: Regression Model Displaying the Longitudinal Relationship Between Changes in Hourly Wage and Perceived Stress Among Wages Participants (*n* = 540) in Minneapolis, Minnesota, and Raleigh, North Carolina, From Wave 1 (Baseline, 2018) to Wave 2 (2019)**

| *Model Type* | *Time × Wage Coefficient* | *95% CI* | *p value* |
|---|---|---|---|
| Step 1: Hourly wage and perceived stress[a] | | | |
| Unadjusted model | 0.01 | [–0.03, 0.04] | .66 |
| Adjusted model[b] | –0.01 | [–0.04, 0.03] | .70 |

*Note.* CI = confidence interval.
[a]Models were estimated using linear regression and generalized estimating equations. [b]Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, job classification, whether the participant has a physical disability, health insurance status, whether the participant lives in Minneapolis or Raleigh, the timing of the participant's data collection appointment relative to the wage increase, pregnancy status, smoking status, and physical activity. [c]Time was coded as 0 for Wave 1 and 1 for Wave 2.

**TABLE 5**

**Perceived Stress Analysis Step 2: Regression Model Displaying the Longitudinal Relationship Between Changes in Perceived Stress and Frequency of Consumption of Various Food Groups Among Wages Participants (*n* = 540) in Minneapolis, Minnesota, and Raleigh, North Carolina, From Wave 1 (Baseline, 2018) to Wave 2 (2019)**

| | *Fruits and vegetables* | | | *Whole grain-rich foods* | | | *Foods high in added sugars* | | |
|---|---|---|---|---|---|---|---|---|---|
| *Model Type* | *Time × Stress IRR* | *95% CI* | *p value* | *Time × Stress IRR* | *95% CI* | *p value* | *Time × Stress IRR* | *95% CI* | *p value* |
| Step 2: Perceived stress and diet[a] | | | | | | | | | |
| Unadjusted model | 1.06 | [0.97, 1.16] | .21 | 1.02 | [0.86, 1.20] | .81 | 0.92 | [0.80, 1.05] | .20 |
| Adjusted model[b] | 1.17* | [1.05, 1.31] | .01 | 1.10 | [0.91, 1.34] | .31 | 0.92 | [0.78, 1.08] | .30 |

*Note.* CI = confidence interval; IRR = incidence rate ratio; BMI = body mass index.
[a]Models were estimated using negative binomial regression and generalized estimating equations. [b]Models were adjusted for age, sex, race, ethnicity, birthplace, educational attainment, marital status, number of adults living in the household, number of children living in the household, job classification, whether the participant has a physical disability, health insurance status, whether the participant lives in Minneapolis or Raleigh, the timing (in weeks) of the participant's data collection appointment relative to the minimum wage increase, BMI, pregnancy status, smoking status, and physical activity. [c]Time was coded as 0 for Wave 1 and 1 for Wave 2.
*Significant at the < .05 level.

leading to decreased stress, causing participants to be less stringent about their F&V intake.

Several factors may also explain our null results from our food security analyses. First, wages may not have increased enough to significantly affect food security. In addition, the null food security results may be attributable to a decrease in Supplemental Nutrition Assistance Program (SNAP) benefits among participants at Wave 2. SNAP benefits inversely track with household income; given that wages increased for our sample in both cities at Wave 2, some loss of SNAP benefits among participants was expected, which could have counteracted the effects of increased wages on improved food security (Food and Nutrition Services, 2019). However, we found that the amount of SNAP benefits received did not significantly change between Waves 1 and 2 overall or when stratified by city (data not shown). We did measure the amount of SNAP benefits received categorically; it is possible that our categories did not capture small changes in SNAP benefits that may have occurred, and even small changes could affect food purchasing and dietary intake for low-wage workers. Future research should examine how increased wages affect usage of and eligibility for government food assistance programs, and how this, in turn, affects stress and food security.

The results from our food security analyses are dissimilar to those from previously conducted studies. For example, The Century Foundation estimated that raising the minimum wage would increase food security (Rodgers, 2016). Our results are most likely dissimilar because the Minneapolis minimum wage ordinance has not yet been fully implemented and the follow-up period was only 1 year; therefore, wages, food security, and subsequent dietary behaviors may not have significantly changed yet.

The results from our perceived stress analyses are dissimilar from previously conducted studies such that we found no association between changes in stress and intake of sugary foods, whereas Jääskeläinen et al. found that stress was positively associated with consumption of chocolate, sweets, and light sodas (Jääskeläinen et al., 2014). In addition, we found that lower levels of perceived stress were associated with decreased consumption of F&V from Wave 1 to Wave 2, whereas the majority of experimental and observational studies have found that lower stress is associated with higher F&V intake (Epel et al., 2001). Again, our results are most likely discordant from previously conducted studies because the Minneapolis minimum wage ordinance has not yet been fully implemented; analyses should be re-run at the study's midpoint and conclusion to draw firmer conclusions. In addition, behavior change rarely happens in isolation, and multilevel, multipronged health interventions may be needed in addition to a minimum wage increase to change health behaviors among low-wage workers.

Our study has several limitations. First, the diet measure we used, the NCI DSQ dietary screener, assumes a standard portion size for all participants. Although portion sizes could vary among participants, validation studies have shown close agreement when comparing mean values from nutrients and food groups between the NCI DSQ and 24-hr recall data (gold standard) for both males and females (Thompson et al., 2017). An additional limitation is that the Wages Study had considerable attrition from Wave 1 to Wave 2. However, this attrition rate is similar to attrition rates in other nonclinical cohort studies containing low-income study populations with high rates of racial/ethnic minorities (Teague et al., 2018). In addition, other area-level changes in Minneapolis and Raleigh (e.g., other social or economic programs and policies besides the minimum wage increase) could be affecting diet or health and therefore the Wages Study's results. However, the study team is monitoring potential area-level changes and will continue to track this through the end of the study period. A qualitative analysis based on a sample of Wages Study participants was recently published examining workers' lived experiences regarding their employment, financial planning, and spending decisions to better understand the individual, family, and community factors that may be affecting the study's results (Caspi, De Marco, Durfee, et al., 2021; Caspi, De Marco, Welle, et al., 2021). An additional limitation of this study is that the interplay of factors that affect social determinants of health is complex and can be difficult to measure quantitatively; further qualitative analyses may be instrumental in identifying the potential impacts of minimum wage increases on dietary intake, food insecurity, and stress to supplement quantitative research.

A final limitation of our study is that the research team did not schedule a participant's Wave 2 appointment based on the timing of their Wave 1 appointment; study participants could therefore complete their Waves 1 and 2 appointments at different times of the year. Thus, seasonality may have affected their responses to various DSQ items between waves. However, most of the data collection occurred during the summer at both sites in both waves, so the season effect is likely minimal.

This study also has several strengths. First, few prospective longitudinal studies have evaluated the impact of changes in hourly wages and changes in dietary intake among adults. Our longitudinal data from a natural experiment design allow us to track the same participants over time throughout the phased implementation of the Minneapolis ordinance and examine the changes in dietary intake throughout the phased implementation. In addition, few studies looking at the impact of wage increases on dietary quality have measured and assessed changes in relevant mediators. By examining potential mediators such as food security and stress in the context of wage increases, researchers and policymakers may be aided in understanding how economic policies affect dietary intake. In addition, the research team collected data on individual wages using an objective measure, pay stubs, for the majority of our sample. We could, therefore, calculate the precise "wage dose" received for each participant in the study.

## CONCLUSIONS AND FUTURE POLICY IMPLICATIONS

Despite its mostly null findings, this study has several important implications. First, a policy change may not lead to significant changes in a targeted outcome during its first year (or even the first several years) of implementation. However, it is important not to "give up" on a policy if the anticipated changes are not immediately observed, as health behaviors can take months to years to change (Bishop, 2018). It is, therefore, important to track and report data over time to monitor if, when, and how behaviors change in response to interventions and policies.

It is important to track data and report results at the beginning of a policy change (even if the targeted indicator or behavior change has not yet occurred) because unanticipated results or events may occur later in a study, and earlier data may help researchers and practitioners better understand the unanticipated result or event. For example, suppose that a longitudinal study found no significant changes in dietary intake after study participants received an intervention that increased their SNAP benefits (assuming there is a causal effect of income on diet). Without understanding all of a participant's sources of income (e.g., income from wages and government transfers like SNAP), this may be hard to explain. But if despite an increase in SNAP benefits, there was no change or even a decrease, in income from all sources (e.g., the individuals may simultaneously experience a reduction in work hours or job loss), then this would be understandable. By tracking both income from various sources and diet over time throughout the study period, this could help researchers and practitioners better understand their results at the end of the study.

In addition, a lesson learned from the Wages Study is the importance of triangulating data. After analyzing quantitative data from the Wages Study, the research team observed interesting trends that warranted additional examination, such as better understanding of SNAP benefits in the context of a minimum wage policy. This prompted the research team to conduct a qualitative substudy, which provided the research team with rich interview data from Wages participants (Caspi, De Marco, Durfee, et al., 2021; Caspi, De Marco, Welle, et al., 2021). Thus, collecting and analyzing various sources of both quantitative and qualitative data can help researchers and practitioners better understand and contextualize their study results.

A final lesson learned from the Wages Study is that the ways policies interact with one another often make assessing the impact of a single policy on an outcome challenge. For example, the Wages research team has been examining the interaction between SNAP policies and minimum wage policies (Caspi, De Marco, Durfee, et al., 2021; Caspi, De Marco, Welle, et al., 2021). If a SNAP recipient experiences a wage increase and thereby increases their earnings, this may also cause SNAP benefits to decrease, blunting any impact of increased wages on diet. Such interrelationships call for both nuance in interpreting findings related to any particular policy change and work to align public policies to best promote healthy behaviors.

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## Supplemental Material

Supplemental material for this article is available online at https://journals.sagepub.com/home/hpp.

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