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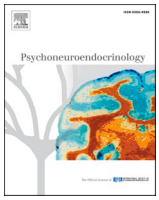

Perceived income inadequacy is associated with Epstein-Barr Virus latency and mental health outcomes in informal caregivers who are also employed in the healthcare industry

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ABSTRACT

Finances are a prevalent source of stress. In a sample of 799 nursing home workers measured multiple times over 18 months, we found that higher perceived income inadequacy, the perception that one's expenses exceeds one's incomes, was associated with poorer self-reported mental health indicators and Epstein-Barr Virus antibody titers (a marker of cell-mediated immune function). Perceived income inadequacy predicted outcomes over and above the role of other socioeconomic status variables (objective household income and education). Mental health variables were not related to Epstein-Barr Virus antibody titers. Additionally, we found an interaction between perceived income inadequacy and informal caregiver status on our mental health outcomes; informal caregivers with higher perceived income inadequacy had poorer mental health than non-caregivers with the same perceived income inadequacy. Our findings may add nuance to the reserve capacity model, which states that those at lower socioeconomic levels are at higher risk of adverse health outcomes partly because they have fewer resources to address demands and strain. Perceived income inadequacy may significantly predict mental and physical well-being beyond other socioeconomic status variables, especially among lower-income employees. Caregiving stress and perceived income inadequacy may have synergistic effects on mental health.

1. Introduction

A higher income is associated with a longer life expectancy at every income level across the income distribution (Adler and Rehkopf, 2008). Much work shows that objective income is inversely associated with morbidity and premature mortality; this inverse association is monotonic such that health disparities exist across income ranges and are not just the result of poverty and healthcare access (Bosworth, 2018; Stringhini et al., 2017). People are exposed to acute and chronic stressors more frequently at lower incomes than higher incomes; exposure to more stressors is thought to partially explain the income-health link (Adler and Rehkopf, 2008). Along with the inimical impact stress exposure has on people's health behaviors, exposure to stressful experiences can dysregulate multiple aspects of the immune system in clinically meaningful ways (Fagundes et al., 2013). Several studies have shown that objective income is negatively associated with various markers of immune dysregulation (Friedman and Herd, 2010).

In the broader health disparities literature, researchers have increasingly argued that people's perceptions of their current context uniquely impact their physical health over and above objective indices of that context. For example, regardless of people's actual income, education, or job status (the three most common objective markers of socioeconomic status or SES), people's perceptions of their social status relative to others are associated with several biomarkers related to physical health (Cundiff and Matthews, 2017). In addition to people's perceptions of status relative to others, the perception of one's financial status may be associated with physical health over and above their actual income. In the current investigation, our first aim is to examine whether perceived income inadequacy (that one's expenses exceed one's income) is associated with markers of cellular immune dysregulation over and above actual income levels.

Partial latent herpesvirus reactivation is a well-established function index of cell-mediated immunity. Epstein-Barr virus (EBV) is a type of herpesvirus that most people have been infected with by early adulthood

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(approximately 95% of adults are seropositive for EBV; Grinde, 2013); people at lower SES levels are likely to be infected with herpesviruses earlier than those at higher SES levels (Stowe et al., 2010). Like all herpesviruses, after initial infection, EBV exists in latently-infected cells throughout the lifespan (Glaser and Kiecolt-Glaser, 1994). EBV seroprevalence increases with age up to about 24 years of age (Winter et al., 2020). Although EBV infection is often asymptomatic, some people who are initially infected develop symptoms of infectious mononucleosis (IM), including sore throat, neck swelling, body aches, and fatigue (Dunmire et al., 2015). Under most conditions, the EBV infection is dormant (Glaser and Kiecolt-Glaser, 1994; Steptoe et al., 2007). However, when the cell-mediated immune system is dysregulated, such as in conditions of high psychological strain or depression, the virus partially reactivates in latently infected cells. The degree to which antibodies are produced to EBV indexes the degree of latent EBV reactivation (Glaser and Kiecolt-Glaser, 1994; Steptoe et al., 2007).

1.1. Informal Caregivers

Perceived income inadequacy may make family obligations more stressful. In the broader chronic stress literature, the cumulative impact of several stressors can have an additive or even multiplicative effect on the immune system (Evans and Kim, 2010; Miller et al., 2011). Balancing informal caregiving and paid work is highly stressful (Plaisier et al., 2015). Perceived income inadequacy puts caregivers at a higher risk of depression (Brehaut et al., 2009; Robison et al., 2009). Our second aim is to investigate whether the stress associated with informal caregiving has synergistic effects with perceived income inadequacy on caregivers' mental health and cell-mediated immune dysregulation.

In this study, we evaluated the role that subjective and objective indicators of people's financial position associated with a functional marker of cell-mediated immune function in 799 adults employed in various roles within the nursing home sector of the healthcare industry; about 25% of these health care employees were informal family caregivers for someone outside of work. We expect that higher perceived income inadequacy will be associated with poorer mental health outcomes and a marker of cell-mediated immune function. Specifically, we hypothesize that higher perceived income inadequacy will be related to higher self-reported distress (H1a), higher self-reported perceived stress (H1b), and higher EBV antibody titers (H1c). We further focus on the unique intersection between perceived income inadequacy and informal caregiving. As the effects of stressors are often additive, we hypothesize that caregivers, relative to non-caregivers, will have stronger associations between perceived income inadequacy and self-reported distress (H2a), self-reported perceived stress (H2b), and EBV antibody titers (H2c).

2. Methods

2.1. Participants and Procedure

Data in this study represent secondary analyses from a larger study examining how workplace policies and practices impact work, family, and health outcomes (Bray et al., 2013). Participants in this study were employees working in nursing homes (called by the pseudonym Leef). The larger study also examined employees in information technology (called by the pseudonym Tomo). We examined Leef participants alone for three reasons: to capture an understudied population, reduce unwanted heterogeneity, and focus on jobs that are a good fit for studying markers of cell-mediated immune function and caregiver status. By limiting our sample to people who work in the human service industry, we can restrict job heterogeneity to capitalize on the within-group heterogeneity of interest—that is, heterogeneity in perceived income inadequacy and informal caregiver status. As is typical for those in human service professions, our sample is primarily comprised of women and of people at lower or middle levels of SES who are understudied in the literature (Kossek et al., 2011). Nursing home workers often have some physical demands as part of their jobs, but their work is not dangerous; likewise, their work typically does not involve regular travel. Nursing home workers may be less likely than those in other professions to have compromised cell-mediated immunity due to injury or travel. As women do most of the informal family caregiving and those in healthcare professions do a disproportionate amount of informal caregiving, our sample is also ideal for capturing people who must balance work and informal caregiving duties (Caregiving in the U.S, 2020; de Lange et al., 2020).

Participants were recruited from study groups and work sites across the United States and were randomly assigned to either the intervention or the usual practice control group. Our analyses did not focus on participants in the intervention group, as we expected our outcomes of interest to be influenced by participation in the intervention. Participants completed data collection at baseline and at 6-month, 12-month, and 18-month follow-up visits after baseline, taking place in either research interviewers' homes or their own homes. Data collection included surveys, interviews, and physical health assessments to examine health risks based on selected biomarkers. We used data from all four data collection visits.

We examined the relationship between mental health, caregiver status, and EBV antibody titers in a sample of 799 nursing home workers ($M = 39.03$ years; 90.7% women; see Table 1 for more sample characteristics) participants. About half the participants worked in long-term care facilities (53.5%), some worked in short-term care facilities (16.4%), and some worked in both long-term care and short-term care facilities (30.1%). Most participants worked standard daytime schedules (50.4%), while some worked evening shifts (33.9%), and others worked variable schedules (10%) or other schedules (5.8%). The mean length of time participants worked for their company was 6.3 years; participants worked a mean of 36.9 h per week. Most participants lived with a spouse or domestic partner (62.9%); for those participants, they were partnered with an average of 11.7 years.

2.2. Measures

2.2.1. Caregiving Status and Roles

Participants self-reported their caregiver status. They were considered caregivers if they spent at least 3 hours of unpaid time per week caring for an adult relative, including shopping, medical care, or assistance in financial planning and budgeting. The care recipient may live inside or outside the caregiver's home. Caregiver status was asked at each of the four timepoints; therefore, participants may be considered caregivers at some but not all timepoints.

The number of caregiving roles represents a count of social roles that participants filled, with three possible roles (professional caregiver, parent, and/or informal caregiver for adult relative) used in exploratory post-hoc analyses. Participants were considered professional caregivers if they were employed as a nurse, nurse assistant, or nurse aide, as opposed to being employed in a supervisory role or as a member of the support staff (administrators, staff educators, cooks); 85.86% of participants were professional caregivers at baseline. Participants were coded as having a caregiving role if they reported being a parent; 77.10% were parents at baseline. Participants were coded as having a caregiving role if they reported providing informal (unpaid) care for an adult relative outside of work at least three hours per week; 27.91% of participants were informal caregivers at baseline.

2.2.2. Objective Household Income

Objective household income was self-reported using ordinal brackets. The brackets represented values from 1 (*less than $4999*) to 13 (*more than $60,000*). Participants were instructed to report the total household income over the past 12 months before taxes and social security but without including benefits.

Table 1
Sample characteristics at baseline.

Variable	Count (%) or *M* (*SD*)			
	Overall (*N* = 799)	Informal caregiver (*n* = 223)	Non-Caregiver (*n* = 576)	*p*-value
Age	39.03 (12.27)	39.80 (11.83)	38.73 (12.43)	.27
Sex [1] (female)	725 (90.74%)	204 (91.48%)	521 (90.45%)	.65[a]
Race / ethnicity	–	–	–	.80[b]
White	521 (65.21%)	142 (63.68%)	379 (65.80%)	–
American Indian or Alaskan Native	4 (0.50%)	2 (0.90%)	2 (0.35%)	–
Black or African American	102 (12.77%)	33 (14.80%)	69 (11.98%)	–
Asian or Pacific Islander	32 (4.01%)	10 (4.48%)	22 (3.82%)	–
Hispanic, all races	119 (14.89%)	31 (13.90%)	88 (15.28%)	–
More than one race	21 (2.63%)	5 (2.24%)	16 (2.78%)	–
Hispanic specified ***(of 119)***	–	–	–	.18[b]
Mexican or Chicano	2 (1.68%)	0 (0%)	2 (2.27%)	–
Dominican	44 (36.97%)	12 (38.71%)	32 (36.36%)	–
Puerto Rican	46 (38.66%)	9 (29.03%)	37 (42.05%)	–
Central American	5 (4.20%)	3 (9.68%)	2 (2.27%)	–
South American	13 (10.92%)	2 (6.45%)	11 (12.50%)	–
Spanish or Portuguese	4 (3.36%)	2 (6.45%)	2 (2.27%)	–
Other	3 (2.52%)	3 (9.68%)	0 (0%)	
Education	–	–	–	.44[b]
Grade 1–8	6 (0.75%)	2 (0.90%)	4 (0.69%)	–
Some high school	40 (5.01%)	8 (3.59%)	32 (5.56%)	–
High school graduate	247 (30.91%)	75 (33.63%)	172 (29.86%)	–
Some college	398 (49.81%)	114 (51.12%)	284 (49.31%)	–
College graduate	107 (13.39%)	24 (10.76%)	83 (14.41%)	–
Number of caregiving roles	1.91 (0.70)	–	–	–
Parenting	616 (77.10%)	–	–	–
Informal caregiving for adult relative	223 (27.91%)	–	–	–
Professional caregiver	686 (85.86%)	–	–	–
Zero total caregiving roles	13 (1.63%)	–	–	–
One total caregiving role	196 (24.53%)	–	–	–
Two total caregiving roles	440 (55.07%)	–	–	–
Three total caregiving roles	149 (18.65%)	–	–	–
Poor sleep quality	2.36 (0.81)	2.42 (0.83)	2.33 (0.80)	.19
Body mass index	29.51 (7.13)	30.05 (7.03)	29.29 (7.17)	.18
Comorbidities	0.17 (0.42)	0.19 (0.45)	0.16 (0.40)	.31
Medications	0.01 (0.14)	.02 (0.27)	0 (0)	.11
Smoking status [2] (smoker)	251 (31.41%)	77 (34.53%)	174 (30.21%)	.24[a]
Distress	11.77 (4.40)	12.66 (4.88)	11.42 (4.15)	< .001***
Perceived stress	9.45 (3.11)	9.66 (3.08)	9.37 (3.12)	.25
Household income	–	–	–	.64[b]
Less than $4,999	4 (0.50%)	0 (0%)	4 (0.69%)	–
$5,000 – $9,999	5 (0.63%)	1 (0.45%)	4 (0.69%)	–
$10,000 – $14,999	12 (1.50%)	3 (1.35%)	9 (1.56%)	–
$15,000 – $19,999	20 (2.50%)	6 (2.69%)	14 (2.43%)	–
$20,000 – $24,999	58 (7.26%)	10 (4.48%)	48 (8.33%)	–
$25,000 – $29,999	63 (7.88%)	22 (9.87%)	41 (7.12%)	–
$30,000 – $34,999	75 (9.39%)	26 (11.66%)	49 (8.51%)	–
$35,000 – $39,999	44 (5.51%)	12 (5.38%)	32 (5.56%)	–
$40,000 – $44,999	52 (6.51%)	15 (6.73%)	37 (6.42%)	–
$45,000 – $49,999	54 (6.76%)	17 (7.62%)	37 (6.42%)	–
$50,000 – $54999	46 (5.76%)	14 (6.28%)	32 (5.56%)	–
$55000 – $59999	42 (5.26%)	10 (4.48%)	32 (5.56%)	–
More than $60,000	245 (30.66%)	62 (27.80%)	183 (31.77%)	–
Perceived income inadequacy	2.39 (0.88)	2.43 (0.93)	2.37 (0.86)	.44
EBV antibody titer (log-transformed AU/mL)	4.99 (0.53)	5.04 (0.50)	4.97 (0.54)	.19
EBV antibody titer (untransformed; AU/mL)	89.93 (1.70)	88.23 (1.65)	82.27 (1.72)	.19

Note. Values represent the count and percentage or mean and standard deviation. *p*-values derived from one-way ANOVA except where otherwise specified.
[a] *p*-value derived from chi-square test of independence.
[b] *p*-value derived from Wilcoxon-Mann-Whitney test.
*** indicates $p < .001$.
[1] Sex is coded so 1 = male and 2 = female.
[2] Smoking status is coded so 0 = non-smoker and 1 = smoker.

2.2.3. Perceived Income Inadequacy

Perceived income inadequacy was measured with one item about income inadequacy as a response to the question, "Which of the following four statements describes your ability to get along on your income?" on a four-point scale. Participants responded with 1 (*we always have money left over*), 2 (*we have enough with a little extra sometimes*), 3 (*we have just enough, no more*), or 4 (*we can't make ends meet*).

2.2.4. Mental Health

Mental health outcomes were measured as psychological distress and perceived stress. Psychological distress refers to non-specific symptoms of mental health disorders, such that high levels of distress symptoms may meet criteria for anxiety, depression, or other mental health concerns (Kessler et al., 2002; Viertiö et al., 2021). In contrast, perceived stress focuses on understanding how people appraise their lives as stressful (unpredictable, uncontrollable, or overloading; Cohen, 1986). Measures of distress are designed to assess one's likelihood of psychopathology, while measures of stress are designed to predict psychological or physical health while accounting for psychopathological symptoms (Cohen, 1986; Kessler et al., 2002). We include both distress and stress as distinct metrics of mental health.

Psychological distress is measured by the Kessler (K-6) scale, which consists of six items that ask participants about mental illness symptoms during the last 30 days (Kessler et al., 2003). Participants responded on a scale of 1 (*all of the time*) to 5 (*none of the time*). An example item reads, "During the past 30 days, how much of the time did you feel so sad nothing could cheer you up?" Items were reverse-coded and summed so that higher scores were associated with higher distress levels ($\alpha = .85$).

Perceived stress was measured using the short Perceived Stress Scale (PSS-4), which consists of 4 items that ask participants to report their stress appraisals during the last 30 days (Cohen et al., 1983). Participants responded on a scale of 1 (*very often*) to 5 (*never*). One example item reads, "During the past 30 days, how often have you felt that you were unable to control the important things in your life?" Items were reverse coded as needed and summed so that higher scores were associated with higher perceived stress ($\alpha = .75$).

2.2.5. Epstein-Barr Virus Antibody Titer

Epstein-Barr Virus (EBV) antibody titers were analyzed using dried

blood spot (DBS) samples. Participants consented to receive finger sticks and provided up to five blood spots placed on filter paper. Blood spots were allowed to air dry and were packaged in biohazard specimen bags before being placed in a secured storage cooler in preparation for analysis. Prior research indicates strong correlations between EBV antibody titers from dried blood spots collected via finger pricks and EBV antibody titers from plasma (Eick et al., 2016; McDade et al., 2000). Collected dried blood spots were assayed for EBV IgG antibodies using an enzyme-linked immunoassay (ELISA) technique for measuring EBV titers adapted from previously-published methods (McDade et al., 2000). The lower limit of detection was 9 AU/mL. The within-assay imprecision (CV%) was 8.1%, and the between-assay imprecision was 11%. EBV antibody titers were only available at the baseline visit, six months after baseline, and twelve months after baseline. All data represents seropositive participants, as defined by the ELISA kit specifications (seropositivity is equal to or greater than 23 AU/mL; McDade et al., 2000). Only two participants were seronegative and were excluded from analyses (99.75% were seropositive). The intraclass correlation coefficient for EBV antibody titers was.85, indicating that 85% of the variance between data collection points was associated with the individual. Finally, the distribution of our EBV antibody titer data aligns with distributions reported in the literature (Slopen et al., 2013; Sorensen et al., 2009).

2.2.6. Covariates

Based on methods from prior studies, demographic and inflammation-related information were included as covariates in our analyses (e.g., Fagundes et al., 2014). Participants self-reported age, sex, and education. Participants reported their smoker status as part of the National Health Interview Survey (National Center for Health Statistics, 2011). Participants' height and weight were taken through in-person measurements and used to calculate body mass index (BMI). Poor sleep quality was measured with 1 item from the Pittsburgh Sleep Quality Index (Buysse et al., 1989). Participants reported comorbidities (myocardial infarction, cerebrovascular disease, diabetes, cancer) by answering questions about their physical health that were developed by the Framingham Study (Taylor et al., 1993). We also included a count of inflammation-related medications (i.e., antihypertensives, heart medications, cholesterol medications, insulin, and medications for diabetes).

2.3. Analyses

All analyses were conducted in R using the nlme package. We conducted linear mixed-effect models that accounted for multiple observations for each participant for each variable. Prior to running the analyses, we examined intra-class correlations, ICC(1). We found that our variables had ICCs ranging from .42–.99, indicating that a minimum of 42% of the variance in the data was associated with the participant. Therefore, a between-person analysis was a good fit for the data. Next, we natural log-transformed the EBV antibody titers to account for expected skewness; please note we report log-transformed and untransformed values in Table 1. Additionally, we ran model comparisons without fixed effects to determine the optimal random effects prior to testing the hypotheses. The model with two random intercepts was the best fit according to Akaike information criterion (AIC). The lowest AIC value represents the lower relative mean squared error of the estimate (Vrieze, 2012). Therefore, we included random intercepts for participant identifiers and for visit number. Covariates for distress and stress analyses include household income, age, biological sex, education, and poor sleep quality. Covariates for analyses with EBV antibody titers include household income, age, biological sex, education, poor sleep quality, BMI, comorbidities (a count of myocardial infarction, cerebrovascular disease, diabetes, and cancer), medications (a count of heart medication, high blood pressure medication, cholesterol medication, oral medications for diabetes, and insulin for diabetes), smoking status, distress, and stress. All models were estimated using restricted maximum likelihood estimations.

Finally, we included exploratory post-hoc analyses regarding the association of the number of caregiving roles on mental health outcomes (distress and stress) and EBV antibody titers. For exploratory post-hoc analyses, we examined the interactions of the number of caregiving roles with perceived income inadequacy.

3. Results

Sample descriptive statistics can be found in Table 1; correlations between study variables are in Table 2. All adjusted models are reported in Table 3.

3.1. Mental health results

Mental health outcomes were measured as psychological distress and perceived stress. In the unadjusted model testing Hypothesis 1a (the effect of perceived income inadequacy on distress), higher perceived income inadequacy was associated with higher distress when accounting for household income ($B = 0.78$, $SE = 0.10$, $p < .001$). In the adjusted model testing Hypothesis 1a, we accounted for household income, age, biological sex, education, and poor sleep quality. Higher perceived income inadequacy was associated with higher distress ($B = 0.75$, $SE = 0.10$, $p < .001$). In the model testing Hypothesis 2a (the effect of perceived income inadequacy and caregiving on distress), we adjusted for household income, age, biological sex, education, and poor sleep quality. The interaction term representing caregiving status and perceived income inadequacy was significantly associated with distress ($B = -0.67$, $SE = 0.18$, $p < .001$; see Fig. 1). In the simple slopes analysis, we found that perceived income inadequacy was positively associated with distress for caregivers and non-caregivers, but the positive association was stronger for caregivers ($B = 1.21$, $SE = 0.17$, $p < .001$) compared to non-caregivers ($B = 0.54$, $SE = 0.11$, $p < .001$). According to the linear contrasts, at high levels (one standard deviation above the mean; $B = 0.85$, $SE = 0.18$, $p < .001$) and mean levels ($B = 0.57$, $SE = 0.17$, $p = .001$) of perceived income inadequacy, caregivers have higher levels of distress than non-caregivers. Therefore, the results support Hypotheses 1a and 2a.

In the unadjusted model testing Hypothesis 1b (the effect of perceived income inadequacy on perceived stress), higher perceived income inadequacy was associated with higher stress when accounting for household income ($B = 0.86$, $SE = 0.07$, $p < .001$). In the adjusted model testing Hypothesis 1b, we accounted for household income, age, biological sex, education, and poor sleep quality. Higher perceived income inadequacy was associated with higher stress ($B = 0.83$, $SE = 0.07$, $p < .001$). In the model testing Hypothesis 2b (the effect of perceived income inadequacy and caregiving on stress), we adjusted for household income, age, biological sex, education, and poor sleep quality. The interaction term representing caregiving status and perceived income inadequacy was significantly associated with stress ($B = -0.32$, $SE = 0.13$, $p = .014$; see Fig. 2). In the simple slopes analysis, perceived income inadequacy was positively associated with stress for caregivers and non-caregivers. Still, the positive association was stronger for caregivers ($B = 1.06$, $SE = 0.12$, $p < .001$) compared to non-caregivers ($B = 0.74$, $SE = 0.08$, $p < .001$). According to the linear contrasts, at high levels (one standard deviation above the mean; $B = 0.48$, $SE = 0.16$, $p = .003$) of perceived income inadequacy, caregivers have higher levels of stress than non-caregivers. Therefore, the results support Hypothesis 1b and 2b.

3.2. EBV antibody titer results

In the unadjusted model testing Hypothesis 1c (the effect of perceived income inadequacy on EBV antibody titers), higher perceived income inadequacy was associated with higher EBV antibody titers when accounting for household income alone ($B = 0.05$, $SE = 0.02$,

Table 2
Correlations Between Study Variables.

Variable	ICC	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	.99													
2. Sex[a]	.98	.05*												
3. Education	.99	.01	-.08**											
4. Poor sleep quality	.50	-.13**	.02	-.05*										
5. Body mass index	.96	.06**	-.02	-.06**	.04*									
6. Comorbidities	.91	.20**	.01	.01	-.01	.16**								
7. Medications	.83	.07**	.02	.02	-.05*	.02	.12**							
8. Smoking status[b]	.86	-.14**	5.52△*	-.13**	.11**	-.06**	.07**	.03						
9. Caregiver status[c]	.42	-.04*	3.62△	.04*	-.04*	-.07**	-.05**	-.01	4.06△*					
10. Distress	.60	-.16**	.05*	-.11**	.29**	.02	.04	.01	.12**	-.12**	(.85)			
11. Perceived stress	.57	-.19**	.08**	-.10**	.29**	.01	.01	.01	.13**	-.06**	.69**	(.75)		
12. Household income	.82	.21**	-.03	.36**	-.03	-.02	.00	.01	-.14**	.02	-.20**	-.18**		
13. Perceived income inadequacy	.59	-.05*	.04*	-.11**	.13**	.06**	-.00	-.01	.08**	-.06**	.27**	.35**	-.30**	
14. EBV antibody titer	.85	.16**	-.01	-.04	-.02	.03	.09*	.07*	.06	-.08*	-.02	.00	-.01	.08*

Note. ICC = intraclass correlation coefficient. Values in the diagonal represent Cronbach's alpha reliability when applicable. △Chi-square value rather than correlation.
* indicates $p < .05$.
** indicates $p < .01$.
[a] Sex is coded so 1 = male and 2 = female.
[b] Smoking status is coded so 0 = non-smoker and 1 = smoker.
[c] Caregiver status is coded so 1 = caregiver and 2 = non-caregiver.

$p = .02$); higher perceived income inadequacy was associated with higher EBV antibody titers when accounting for household income, distress, and stress ($B = 0.05$, $SE = 0.02$, $p = .02$). When adjusting for covariates of household income, age, biological sex, education, poor sleep quality, BMI, comorbidities, medications, smoking status, distress, and stress, higher perceived income inadequacy was associated with higher EBV antibody titers ($B = 0.05$, $SE = 0.02$, $p = .03$). In the model testing Hypothesis 2c (the effect of perceived income inadequacy and caregiving on EBV antibody titers), we adjusted for household income, age, biological sex, education, poor sleep quality, BMI, comorbidities, medications, smoking status, distress, and stress. The interaction term representing caregiving status and perceived income inadequacy was not significantly associated with EBV antibody titers ($B = 0.00$, $SE = 0.04$, $p = .99$). Therefore, the results support Hypotheses 1c but not 2c.

3.3. Post-hoc results

For all exploratory post-hoc analyses, results can be found in Table 4. In the model testing the effect of perceived income inadequacy and the number of caregiving roles on distress, we adjusted for household income, age, biological sex, education, and poor sleep quality. The interaction term representing the number of caregiving roles (i.e., up to three roles based on professional caregiving, parenting, and/or informal caregiving for an adult relative) and perceived income inadequacy was significantly associated with distress ($B = 0.34$, $SE = 0.13$, $p = .006$; see Fig. 3). In the simple slopes analysis, we found that perceived income inadequacy was positively associated with distress for those with at least one caregiving role: one caregiving role ($B = 0.40$, $SE = 0.16$, $p = .01$), two caregiving roles ($B = 0.75$, $SE = 0.10$, $p < .001$), three caregiving roles ($B = 1.09$, $SE = 0.17$, $p < .001$). There was no significant association between perceived income inadequacy and distress for those with zero caregiving roles ($B = 0.07$, $SE = 0.27$, $p = .82$). At all levels of income inadequacy, those with three caregiving roles have higher distress than those with zero or one caregiving role.

In the model testing the effect of perceived income inadequacy and the number of caregiving roles on stress, we adjusted for household income, age, biological sex, education, and poor sleep quality. The interaction term representing the number of caregiving roles (i.e., up to three roles based on professional caregiving, parenting, and/or informal caregiving for an adult relative) and perceived income inadequacy was not significantly associated with perceived stress ($B = 0.02$, $SE = 0.09$, $p = .84$).

In the model testing the effect of perceived income inadequacy and caregiving on EBV antibody titers, we adjusted for household income, age, biological sex, education, poor sleep quality, BMI, comorbidities, medications, smoking status, distress, and stress. The interaction term representing the number of caregiving roles (i.e., up to three roles based on professional caregiving, parenting, and/or informal caregiving for an adult relative) and perceived income inadequacy was not significantly associated with EBV antibody titers ($B = -0.01$, $SE = 0.03$, $p = .63$).

4. Discussion

Results from our research demonstrate the association between higher perceived income inadequacy and poorer psychological and cell-mediated immunity outcomes. Greater perceived income inadequacy was associated with higher perceived stress, psychological distress, and Epstein-Barr virus (EBV) antibody titers. Additionally, we found that perceived income inadequacy was disproportionately related to mental health outcomes for caregivers compared to non-caregivers. That is, while higher perceived income inadequacy was associated with poor mental health outcomes across the entire sample, at high levels of perceived income inadequacy (one standard deviation above the mean), caregivers had poorer mental health outcomes than non-caregivers in the same subjective financial situation. One standard deviation above the mean level of perceived income inadequacy sits between two anchors: *we have just enough, no more* and *we can't make ends meet*, representing a serious financial state. Next, caregivers had higher distress than non-caregivers at mean levels of perceived income inadequacy. The mean level of perceived income inadequacy sits between two anchors: *we have enough with a little extra sometimes,* and *we have just enough, no more*. Finally, from our post-hoc analyses, we found that those who were in three caregiving roles (professional caregiving, parenting, and informal caregiving for an adult relative) had higher distress at all income levels than those in one caregiving role only.

The current study makes two primary contributions to research on financial stress and physical health indicators. First, our results replicated extant findings about the detrimental effects of perceived income inadequacy and low SES on mental health across many social contexts (Tan et al., 2020). We demonstrated that perceived income inadequacy remains a relevant predictor of poor mental health among a sample of lower- to middle-income workers. This effect was stable over four visits, totaling 18 months apart. Second, we add to the literature on the biological outcomes of perceived income inadequacy. Prior findings indicate that perceived income inadequacy can affect several biomarkers of physical health. Other researchers found that higher perceived income

Table 3
Results of Regressions on Distress, Perceived Stress, and EBV Antibody Titers.

	Distress		Perceived Stress		EBV Antibody Titers	
Predictors	*B (SE B)*	*B (SE B)*	*B (SE B)*	*B (SE B)*	*B (SE B)*	*B (SE B)*
(Intercept)	-1.65 (1.09)	-1.23 (1.09)	-2.71 *** (0.74)	-2.50 *** (0.75)	4.07 *** (0.24)	4.07 *** (0.24)
Perceived income inadequacy	0.75 *** (0.10)	0.54 *** (0.11)	0.83 *** (0.07)	0.74 *** (0.08)	0.05* (0.02)	0.05* (0.02)
Household income	-0.11 *** (0.03)	-0.11 *** (0.03)	-0.06* (0.02)	-0.06* (0.02)	-0.00 (0.01)	-0.00 (0.01)
Age	-0.04 *** (0.01)	-0.04 *** (0.01)	-0.04 *** (0.01)	-0.04 *** (0.01)	0.01 *** (0.00)	0.01 *** (0.00)
Sex[1]	0.53 (0.39)	0.51 (0.39)	0.69* (0.27)	0.68* (0.27)	-0.04 (0.07)	-0.04 (0.07)
Education	-0.20 (0.15)	-0.19 (0.15)	-0.06 (0.10)	-0.06 (0.10)	-0.02 (0.03)	-0.02 (0.03)
Poor sleep quality	0.93 *** (0.10)	0.93 *** (0.10)	0.72 *** (0.07)	0.71 *** (0.07)	-0.02 (0.02)	-0.02 (0.02)
Body mass index	–	–	–	–	0.00 (0.00)	0.00 (0.00)
Comorbidities	–	–	–	–	0.05 (0.06)	0.05 (0.06)
Medications	–	–	–	–	0.42 (0.27)	0.42 (0.27)
Smoking status[2]	–	–	–	–	0.08 (0.05)	0.08 (0.05)
Distress	–	–	–	–	0.00 (0.00)	0.00 (0.00)
Perceived stress	–	–	–	–	0.00 (0.01)	0.00 (0.01)
Caregiver status[3]	–	-1.01* (0.48)	–	-0.55 (0.34)	–	0.01 (0.10)
Perceived income inadequacy × caregiver status	–	0.67 *** (0.18)	–	0.32* (0.13)	–	0.00 (0.04)
Random Effects						
σ^2	7.12	7.08	3.81	3.81	0.04	0.04
τ_{00}	7.96 Person	7.76 Person	3.44 Person	3.40 Person	0.26 Person	0.26 Person
	0.01 Visit	0.01 Visit	0.01 Visit	0.01 Visit	0.01 Visit	0.01 Visit
ICC	0.53	0.52	0.47	0.47	0.88	0.88
N	784 Person	784 Person	785 Person	785 Person	532 Person	532 Person
	4 Visit	4 Visit	4 Visit	4 Visit	3 Visit	3 Visit
Observations	2463	2463	2464	2464	709	709
Marginal R^2 / Conditional R^2	.11 /.58	.12 /.58	.16 /.56	.16 /.56	.04 /.88	.04 /.88

Note. [1]Sex is coded so 1 = male and 2 = female. [2]Smoking status is coded so 0 = non-smoker and 1 = smoker. [3]Caregiver status is coded so 1 = caregiver and 2 = non-caregiver. σ^2 = level 1 residual variance; τ_{00} = level 2 residual variance. * *indicates $p < 0.01$.
* indicates $p < 0.05$.
*** indicates $p < 0.001$.

inadequacy predicted higher circulating pro-inflammatory cytokine interleukin-6 through psychological well-being (Sturgeon et al., 2016). In conjunction with other factors, perceived income inadequacy has been shown to affect glucocorticoid resistance in children (Jiang et al., 2021). Our paper is the first to demonstrate that perceived income inadequacy was associated with a marker of cell-mediated immune function through EBV antibody titers. Our findings add to the literature on psychosocial influences on EBV antibody titers; caregiving for a family member with Alzheimer's disease, medical school exams, relative socioeconomic status, discrimination, and childhood adversity are all associated with dysregulated cell-mediated immunity (Borders et al., 2010; Christian et al., 2012; Glaser et al., 1994; Kiecolt-Glaser et al., 1987; McClure et al., 2010; McDade, 2002; Slopen et al., 2013; Sorensen et al., 2009).

Chronically high EBV antibody titers reflect poorer cellular immune system control over the latent virus by T-cells and can trigger chronically elevated inflammation and increase health risk for age-related disorders (Glaser and Kiecolt-Glaser, 1994; Steptoe et al., 2007). Importantly, high EBV antibody titers, do not indicate the virus's complete reactivation (Glaser and Kiecolt-Glaser, 1994). We found the effect on EBV antibody titers while accounting for mental health variables and two forms of objective SES: household income and education. Additionally, this effect was stable over three visits. Taken together, perceived income inadequacy may be a more appropriate predictor of mental and physical health outcomes than other SES variables, as it captures financial resources, financial demands, and psychological evaluation of one's financial state. Finally, it is important to note that we did not find significant effects when examining the caregiver status interaction with perceived income inadequacy on EBV antibody titers. This study did not include a measure of caregiver burden; perhaps using a caregiver burden measure would allow researchers to find significant effects. Researchers should consider examining the intersection of EBV antibody titers and financial burden among caregivers.

This research has several implications for healthcare workers, caregiver burden, and health outcomes. According to the reserve capacity model, people at lower SES levels have more negative psychosocial experiences, such as stressors, strains, or demands (Gallo and Matthews, 2003). Informal caregivers may have less access to the resources that assist with caregiving and may have greater caregiver burden. In fact, perceived income inadequacy is considered a key component of caregiver burden (Adelman et al., 2014) that predicts increased psychological distress (Sun et al., 2009). For example, at lower income levels, hiring a health aide may be unaffordable – therefore grocery shopping, errands, and meal planning may be done primarily by family members. Some research suggests that professional caregivers, such as nurses, are disproportionately expected to assist in informal caregiving for relatives (Boumans and Dorant, 2014). In families that are not financially comfortable, it may be a reasonable decision to ask a professional caregiver in the family to be an informal caregiver rather than using the limited financial resources to pay for the caregiving expertise from another professional caregiver. Alternatively, professional caregivers may feel torn between the need to pick up more shifts to gain more resources for their family and do the informal caregiving work (Jacobs and Gerson, 2005).

Over 80% of the participants in our sample worked in a caregiving (nursing or nursing aide) capacity. Such professional caregivers are disproportionately charged with informal caregiving as well. If informal caregiving duties fall disproportionately on professional caregivers within a family, there may not be sufficient opportunities to recover from paid and unpaid caregiving. Research on work recovery indicates that employees must have the opportunity to rest and replenish the resources they use throughout their workday to avoid burnout and related adverse health consequences (Bennett et al., 2018; Sonnentag et al., 2022). Work recovery involves after-work activities and psychological experiences that promote rest, recuperation, and positive nonwork experiences that build up one's resources lost throughout the workday; engaging in work-related activities after work is counterproductive to recuperating one's energy and other psychosocial resources (Bennett et al., 2018; Steed et al., 2021). Drawing from the same skills and pools of resources during their paid work and informal caregiving may have deleterious health consequences (Boumans and Dorant, 2014). In our post-hoc analyses, we found evidence that the number of caregiving roles has an additive effect on distress, such that those who were professional caregivers, informal caregivers for adults, and parents had more distress than those who had one of those roles. People who are paid *and* informal caregivers report feeling they have no time for exercise, hobbies, or social engagements, activities that promote work recovery (Boumans and Dorant, 2014; Detaille et al., 2020). They experience

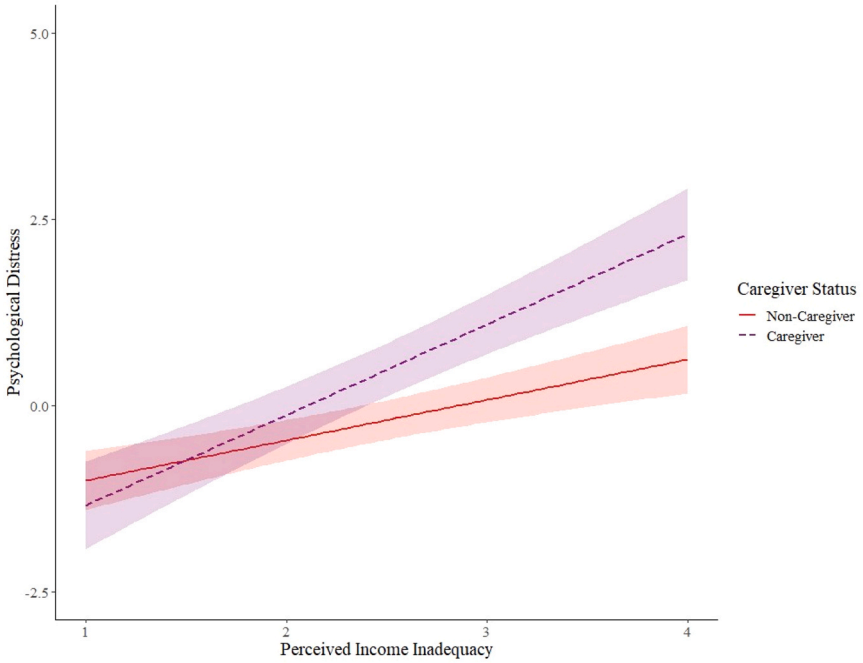

Fig. 1. Interaction between perceived income inadequacy and caregiver status on psychological distress. Shading represents the 95% confidence intervals.

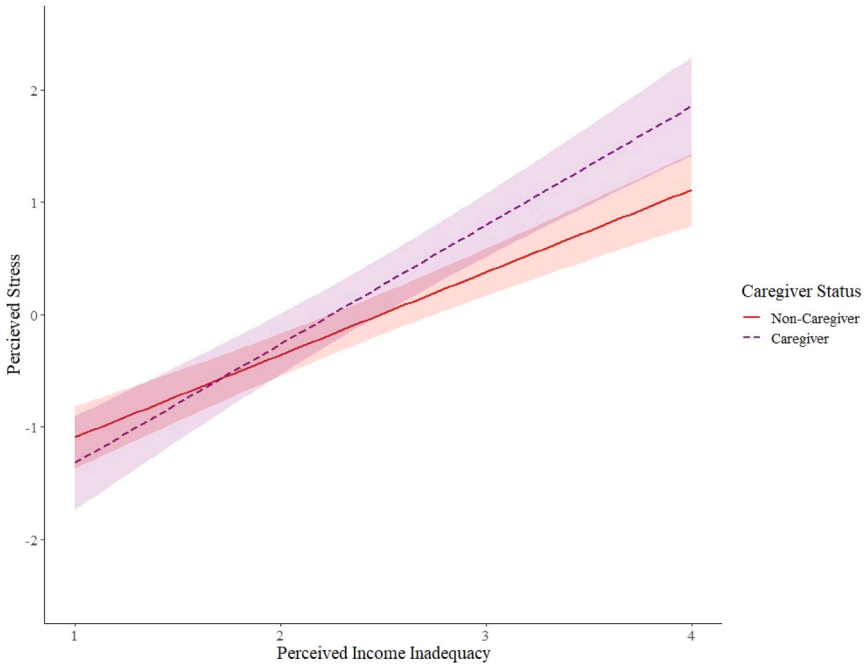

Fig. 2. Interaction between perceived income inadequacy and caregiver status on perceived stress. Shading represents the 95% confidence intervals.

chronic strain from paid *and* informal caregiving; in our study, these strains exist under broader financial challenges. There may even be a feedback loop such that engaging in paid and informal caregiving may interfere with a caregiver's ability to accrue future income via raises or promotions (Lee and Tang, 2015). Based on the results of our study, we can conclude that perceived income inadequacy and caregiving stress synergistically affect mental health, perhaps driven by overtaxing caregiving skills and abilities without the opportunity for proper recovery.

These compounding individual-level effects may negatively affect the healthcare system. Specifically, the disproportionate dependency on healthcare workers to provide informal caregiving may contribute to widespread healthcare worker burnout (de Lange et al., 2020; Detaille et al., 2020). Burnout refers to employees' chronic mental and emotional exhaustion that reduces their ability and willingness to conduct their work (Maslach et al., 2001). In a country (i.e., the U.S.) where most people experience perceived income inadequacy and job stress (American Psychological Association, 2022), burnout is on the rise — especially among healthcare workers (including those who are also informal family caregivers; Rehder et al., 2021). Healthcare worker burnout is particularly concerning given that they provide essential and specialized care to others; broader society may experience the negative effects of

Table 4
Results of Post-hoc Regressions on Distress, Perceived Stress, and EBV Antibody Titers.

	Distress	Perceived Stress	EBV Antibody Titers
Predictors	*B (SE B)*	*B (SE B)*	*B (SE B)*
(Intercept)	-0.92 (1.26)	-2.99*** (0.87)	3.98*** (0.27)
Perceived income inadequacy	0.06 (0.27)	0.79*** (0.19)	0.07 (0.05)
Household income	-0.11*** (0.03)	-0.05* (0.02)	-0.00 (0.01)
Age	-0.04*** (0.01)	-0.04*** (0.01)	0.01*** (0.00)
Sex[1]	0.46 (0.39)	0.65* (0.27)	-0.05 (0.07)
Education	-0.13 (0.15)	-0.03 (0.10)	-0.01 (0.03)
Poor sleep quality	0.93*** (0.10)	0.71*** (0.07)	-0.02 (0.02)
Body mass index	–	–	0.00 (0.00)
Comorbidities	–	–	0.05 (0.06)
Medications	–	–	0.42 (0.27)
Smoking status[2]	–	–	0.08 (0.05)
Distress	–	–	0.00 (0.00)
Perceived stress	–	–	0.00 (0.01)
Number of caregiving roles	-0.37 (0.33)	0.15 (0.23)	0.05 (0.07)
Perceived income inadequacy × Number of caregiving roles	0.34* (0.13)	0.02 (0.09)	-0.01 (0.03)
Random Effects			
σ^2	7.08	3.80	0.04
τ_{00}	7.88 $_{Person}$ 0.01 $_{Visit}$	3.44 $_{Person}$ 0.01 $_{Visit}$	0.26 $_{Person}$ 0.01 $_{Visit}$
ICC	0.53	0.48	0.87
N	784 $_{Person}$ 4 $_{Visit}$	785 $_{Person}$ 4 $_{Visit}$	532 $_{Person}$ 3 $_{Visit}$
Observations	2461	2462	709
Marginal R^2 / Conditional R^2	.12 /.58	.16 /.56	.04 /.88

Note. [1]Sex is coded so 1 = male and 2 = female. [2]Smoking status is coded so 0 = non-smoker and 1 = smoker. σ^2 = level 1 residual variance; τ_{00} = level 2 residual variance. * *indicates $p < 0.01$.
* indicates $p < 0.05$.
*** indicates $p < 0.001$.

healthcare worker burnout, such as decreased quality of care (Shanafelt et al., 2002). When healthcare workers are experiencing greater levels of perceived income inadequacy and the additional duties of informal caregiving, their distress may have ramifications for those that need their care.

The results of this study have practical implications for researchers and those who must be professional *plus* informal caregivers. Our study demonstrated that perceived income inadequacy was a more useful predictor of EBV antibody titers and psychological outcomes compared to education and household income. There is predictive value in using subjective measures of SES in addition to objective measures of SES (Cundiff and Matthews, 2017). Perceived income inadequacy should not replace other metrics of SES; instead, it should be used when the research question and study design may benefit from a measurement that captures reactions to one's current financial situation as well as the financial situation itself. Of course, perceived income inadequacy can exist at all levels of SES, but it should have more frequent and larger effects on those of lower- and middle-levels of SES. Researchers should also consider accounting for current perceived income inadequacy as it can sometimes impact reports of SES (Pu et al., 2011). Professional *plus* informal caregiving may be unavoidable, especially at lower income levels. Friends, family members, and coworkers for these caregivers should aim to provide practical and emotional support. This support should enable caregivers to exercise, sleep, and relax – activities that can increase recovery and benefit health outcomes (Boumans and Dorant, 2014; Detaille et al., 2020).

4.1. Limitations and Future Directions

This study adds to the literature on perceived income inadequacy and caregiver health. We leverage a sample of under-studied blue-collar workers in the literature (Kossek et al., 2011). Our sample is large, and our results represent stable effects from at least 18 months. To our knowledge, it is the first to examine how perceived income inadequacy directly affects a marker of cell-mediated immune function. Importantly, indexes of cell-mediated immune function are not direct measures and cannot capture the complexity of immune system functioning. For instance, we measure EBV antibody titers linearly, yet the effects of effects of EBV antibody titers may be nonlinear. This profile dysregulates

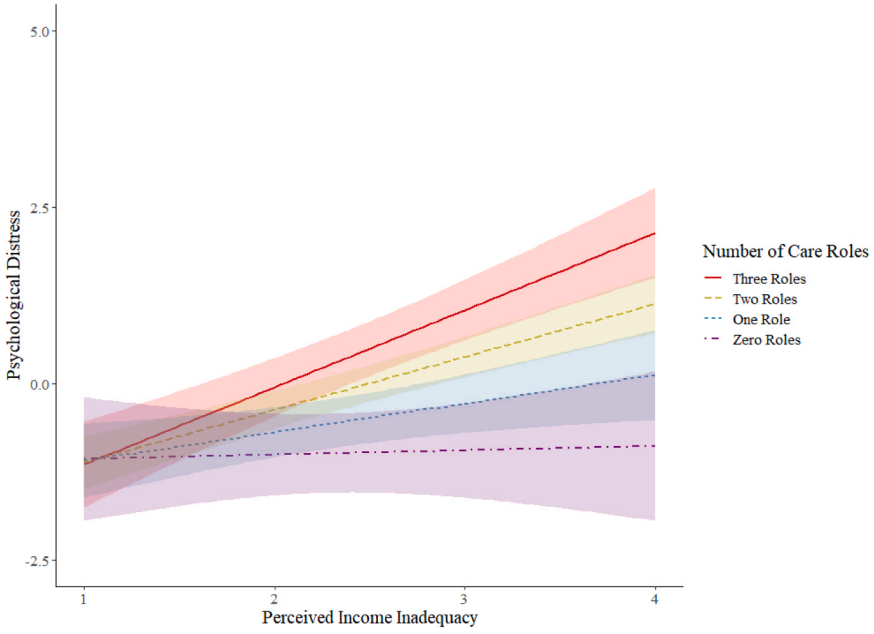

Fig. 3. Interaction between perceived income inadequacy and the number of caregiving roles on psychological distress. Shading represents the 95% confidence intervals.

EBV antibody titers, representing cell-mediated immune system dysregulation, in much the same way as childhood maltreatment or attachment anxiety (Fagundes et al., 2014; Slopen et al., 2013). These findings have implications at a population level, as cell-mediated immune function represents a risk factor for chronic inflammation and related disorders of older adulthood (Steptoe et al., 2007). As with any study, the results should be interpreted within the context of the broader literature, never in isolation. Of note, the effect size in our EBV antibody finding are aligned with effect sizes from prior research on psychosocial variables predicting EBV antibody titers (e.g., Slopen et al., 2013).

There are some drawbacks to the study that researchers may address in future research, namely, the financial measures, the sample type, and the lack of details about participants' caregiving behaviors. First, perceived income inadequacy was measured as one item, not a multi-item scale. While this is not ideal, the same perceived income inadequacy item has predicted depression, work-family conflict, and positive work-to-family spillover in another study, which adds to our confidence in our findings (Neal and Hammer, 2017). Additionally, information on objective family income is limited to a selection of 13 income brackets, from "less than $4999" in yearly household income to "more than $60,000" in annual household income. Participants were also allowed to self-report their family's exact household income, but as is expected in the literature, most participants chose not to disclose their precise household income (Sinclair and Cheung, 2016). Only 78 participants disclosed their exact household income; of those who disclosed, the mean was $65,502, suggesting that the bracketed options were an adequate fit for participant's household income.

Next, the participants in this study were nursing home workers. As expected, the sample is predominantly women (about 90%), and a minority of participants are college graduates. Because our sample is predominately women, and women disproportionately serve as informal caregivers (Caregiving in the U.S, 2020), our results may have been strengthened by our sample demographics. Our sample represents lower- and middle-class workers, which may have affected our results. In past research, upper-class employees did not have the same adverse health outcomes as lower-income workers (Paoletti et al., 2023). Similarly, it is possible that our results would be weaker if our sample represented high SES participants; it stands to reason that perceived income inadequacy is more impactful for those at lower and middle SES levels. Future research should examine how perceived income inadequacy impacts people at all SES levels.

Third, our study is limited to our information about caregiving behaviors. Data in this study represents secondary analyses from a survey of the effects of a workplace intervention on employee health; thus, caregiving was not the primary aim (Bray et al., 2013). This study did not have a measure of caregiver burden. Caregiver status was self-reported if participants spent at least three hours per week caring for an adult relative. However, the care recipient could live outside or inside the participant's home, and care recipients have varying levels of need. We do not know how much time or effort each caregiver spent with the care recipient or their relationship with the care recipient. Caregiver status could vary over the four visits (the ICC for the caregiver status variable was.42, indicating some variability).

5. Conclusion

Perceived income inadequacy is one mechanism through which low SES can negatively affect health. The present paper is the first to demonstrate the effects of perceived income inadequacy on a marker of cell-mediated immune function. It is also the first to demonstrate the interaction of caregiver status with perceived income inadequacy while accounting for objective measures of SES (income and education). Perceived income inadequacy is distinct from objective SES and many types of subjective SES – it reflects one's current evaluation of financial demands and resources. This study demonstrates that perceived income inadequacy was associated with a marker of cell-mediated immune function and two mental health variables over at least 12 months. High perceived income inadequacy was especially harmful when our participants were also caregivers. Our results support the notion that stressors work synergistically such that strain in multiple domains has an outsized negative effect on health outcomes. We also add to the body of evidence that suggests informal caregiving may be a risk factor for downstream adverse health outcomes.

Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

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