

Association Between Food Allergy, Psychological Stress, and Allostatic Load

Western Journal of Nursing Research
1–9

© The Author(s) 2021

Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/01939459211019042

journals.sagepub.com/home/wjn

Anne L. Ersig¹ , Roger L. Brown¹, and Kristen Malecki²

Abstract

Allostatic load (AL), the cumulative biological burden of persistently high stress exposure, influences adult health and well-being across the lifespan, and can be measured with clinical indicators, such as BMI, blood pressure (BP), and waist–hip ratio. Adverse childhood events and other stressors contribute to AL, but stress from other sources, such as previously diagnosed chronic health conditions, has been overlooked. We hypothesized that adults with these conditions would have more stress exposures, higher perceived stress, worse mental health, and higher AL, compared to controls. A secondary analysis of deidentified data from cases with self-reported food allergies and controls found that individuals with chronic health conditions reported more stress exposures, higher levels of perceived stress, and had higher AL, compared to controls. However, other results did not support the study hypotheses. Future studies should examine additional AL measures, such as biomarkers of stress response, in individuals with existing chronic health conditions.

Keywords

Allostatic load, Chronic health conditions, Stress exposure, Perceived stress, Health outcomes

Adult health and well-being are the product of dynamic interactions among social, behavioral, and biological factors across the lifespan (Haas & Oi, 2018; Harris & McDade, 2018). Starting in childhood and continuing throughout the life course, exposures to biological, psychological, and social phenomena affect health and wellness trajectories, making early life a critical determinant of biological function and later-life health (Haas & Oi, 2018; Harris & McDade, 2018). Multiple studies have examined the relationship between chronic psychosocial stressors or adverse childhood experiences and later-life health and well-being (Epel & Prather, 2018; Evans, 2003; Felitti et al., 1998; Kalmakis & Chandler, 2015); however, the contribution of other chronic stressors has been overlooked in life course research.

Stress Experiences and Allostatic Load

Experiencing different stress exposures throughout the life course can affect these trajectories: stressors accumulate over time and increase risks of poor mental and physical health (Harris & McDade, 2018). The allostatic load (AL) model provides a framework for examining relationships among and the impact of cumulative stress exposures, individual perceptions of those stressors, psychological, behavioral, and physiological stress responses, and health outcomes (Epel et al., 2018; Juster et al., 2010). AL reflects the cumulative biological burden on the body due to persistently high

stress exposure. These results in the repeated activation of the stress response system, including the hypothalamic–pituitary–adrenal (HPA) axis, and sustained dysregulation (Epel et al., 2018; Juster et al., 2010; McEwen, 2005; Seeman et al., 2001). AL is quantified using an AL index. High AL is associated with poor later-life mental and physical health outcomes, including diminished cognitive performance, changes in memory, increased risk of cardiovascular disease, suppressed immune function, and higher mortality (Juster & Lupien, 2012; McEwen, 2005).

The AL index is based on biological and clinical data and provides a quantitative measure of AL. Multiple indicators have been included in AL indices since the original index was developed in 2001, often due to the mechanism of interest in a particular study. Ideally, an AL index will incorporate indicators representing all major systems, including the neuroendocrine, cardiovascular, immunologic, and metabolic systems (Li & Rosemberg, 2020). The original AL index includes cortisol, epinephrine, norepinephrine, and

¹School of Nursing, University of Wisconsin-Madison, Madison, WI, USA²Department of Population Health Sciences, University of Wisconsin-Madison, Madison, WI, USA

Corresponding Author:

Anne L. Ersig, School of Nursing, University of Wisconsin-Madison, RN, 701 Highland Ave., Madison WI 53705, USA.

Email: anne.ersig@wisc.edu

DHEA-S, which reflect the neuroendocrine stress response. Systolic blood pressure (BP), diastolic BP, waist–hip ratio, hemoglobin A1C, total cholesterol, and high-density lipoprotein (HDL) cholesterol are used to index cardiovascular and metabolic physiological activity. Additional metabolic indicators include body–mass index (BMI), waist circumference, insulin, and fasting glucose (Seeman et al., 2001). Later studies incorporated other biomarkers of AL, including immune and inflammatory markers such as cytokines, C-reactive protein, white blood cell count, and Epstein–Barr virus (Juster et al., 2010; King et al., 2019; Slavich, 2020). Studies have also evaluated relationships between stress exposures and individual measures of AL when a complete index cannot be obtained (Eddington et al., 2012; Kuo et al., 2019).

Cumulative stress results from the combination of current and historical exposure to adverse environmental, social, and personal experiences across the life course. Multiple studies have found that sustained high cumulative stress, due to chronic psychosocial stressors or adverse childhood experiences, is associated with high AL (Fava et al., 2019). However, the relationship between high cumulative stress from chronic health conditions often diagnosed early in life, such as food allergies, and high AL has not been explored. From the time of diagnosis, individuals with food allergies experience general stressors in addition to those related to their condition (Ersig & Williams, 2018). They report significant condition-related psychological stress and anxiety, which may be higher among those at risk of life-threatening allergic reactions (Ersig & Williams, 2018; Peniamina et al., 2016; Primeau et al., 2000).

Food allergies generate chronic and acute stressors related to living in fear of potential exposure and, at times, limited capacity to avoid exposures. Condition-related chronic stressors include daily food allergy management, unpredictability, and the need to maintain constant vigilance in daily life (Ersig & Williams, 2018; Peniamina et al., 2016; Primeau et al., 2000). Acute stressors also occur, with the most common being unanticipated exposures to the allergen that lead to life-threatening reactions and require an emergent response (Shaker et al., 2017; Teufel et al., 2007). This combination of chronic and acute stress increases risk of sustained high cumulative stress, dysregulated stress responses, and high AL. However, individuals vary in their response to chronic health condition-specific stressors. Some will experience high stress while others will not. These differences in reported stress could influence the impact of stress on AL in individuals with chronic health conditions.

In addition, food allergies are frequently diagnosed in childhood, and individuals with chronic conditions diagnosed earlier in life are at increased risk of poor later-life mental and physical health (Blackwell et al., 2001; Pavea & Latham, 2016). High AL could be a mechanism underlying the relationships among chronic health condition diagnosis, high cumulative stress, and poor health outcomes. However,

few studies have examined AL or physiological stress responses in individuals with chronic health conditions diagnosed earlier in life (Eddington et al., 2012; Epel et al., 2018). In contrast, most studies of AL and chronic illness in adults examine the association of high AL from childhood stress exposures with diagnosis of chronic illnesses in adulthood (Juster et al., 2010). This limits our understanding of stress exposures, stress response, and AL in adults living with chronic conditions diagnosed earlier in life.

Purpose

The current analysis used a nested case–control design to address this gap by comparing stress exposures, perceived stress, mental health, and clinical measures of AL in adults with and without food allergy. Food allergy was selected as it has the potential to generate high cumulative stress in affected individuals, and is frequently diagnosed in childhood. This supports analysis of the association of stress and AL in individuals living with a chronic health condition diagnosed earlier in life, rather than examining whether high AL increases risks for later diagnosis of a chronic health condition. Due to variability in individual response to chronic health condition-specific stressors, additional comparisons examined whether the interaction of case status and stress-related measures was associated with clinical measures of AL. We hypothesized that adults with food allergy would have higher stress exposure, higher perceived stress, worse mental health, and higher AL, compared to controls. We also hypothesized that individuals with food allergies and high stress would have higher AL, compared to individuals with food allergies and lower stress, and controls with high or low perceived stress.

Methods

This study consists of a secondary analysis of deidentified data from cases with a self-reported diagnosis of food allergies and controls. Data were from the Survey of the Health of Wisconsin (SHOW), an ongoing health examination study that obtains data on health determinants from statewide population-based samples of adults. The SHOW protocol and informed consent are approved by the University of Wisconsin–Madison Health Sciences Institutional Review Board, and data are collected under a Certificate of Confidentiality from the US Department of Health and Human Services (Nieto et al., 2010). Details of the SHOW protocol have been previously published (Nieto et al., 2010). Analyses reported here were approved by the Minimal-Risk Health Sciences IRB at UW–Madison.

Sample

The current SHOW cohort includes over 6,000 Wisconsin residents, and is largely representative of the state population.

To achieve this, SHOW uses a two-stage probability-based cluster sampling approach. In the first stage, Census Blocks Groups (CBGs) are selected, followed by the second stage, in which individual households are selected within the CBGs (Nieto et al., 2010). The analysis reported here included 476 individuals from Waves 1 and 2 (2008–2016). SHOW obtains data on adults 21–74 years old who are able to communicate answers to interview questions. SHOW does not include adults who live in nursing homes, hospitals, mental institutions, penal institutions, jails, halfway houses, or college dormitories, are fulltime members of the armed forces or activated units of the National Guard stationed away from home, spend less than half their nights at the selected residence, or voluntarily disclose a diagnosis of mental incapacity and do not identify a proxy respondent (Nieto et al., 2010).

We completed a secondary analysis of deidentified data from cases with a self-reported diagnosis of food allergy and controls matched to cases on gender, age, and race/ethnicity. The SHOW dataset included measures of stress exposure, stress response, and mental health. It also included measures of body composition that reflect AL, but did not include biomarkers of AL or age at diagnosis. However, simultaneous collection of case status and other study measures ensured that data were collected from cases diagnosed earlier in life with food allergy.

Measures of Perceived Stress and Mental Health

Stress exposures in the last year were measured with the social readjustment rating scale (SRRS; Holmes & Rahe, 1967). The global perceived stress scale (GPSS) was used to assess perceived stress over the last 12 months. We also included a specific question from the GPSS, which assessed perceived stress related to medical problems (Payne et al., 2005). Post-traumatic stress disorder (PTSD) symptoms were assessed with the 6-item PTSD civilian checklist (Lang & Stein, 2005). Anxiety was measured with the anxiety subscale of the 21-item Depression, Anxiety and Stress Scale (DASS-21; Henry & Crawford, 2005).

Clinical Measures of Allostatic Load

Eight clinical measures from the original AL index were available: systolic and diastolic BP, BMI, waist–hip ratio, HbA1C, total cholesterol, and HDL cholesterol (Seeman et al., 2001). Data were obtained under established SHOW protocols described in detail in an earlier publication (Nieto et al., 2010). After a 5-min rest period, three seated BP measurements were obtained 1 min apart using a digital monitor. Weight was measured using digital scales with subjects wearing light clothing or surgical scrubs. Height, hip circumference, and waist circumference were measured in duplicate. Waist circumference was measured at the uppermost lateral border of the ilium using a medical retracting measuring tape, and hip circumference was measured with the tape

placed below the iliac crest and at the widest point around the buttocks when viewed from the side (Nieto et al., 2010). Measured weight, height, waist circumference, and hip circumference were used to calculate BMI and waist–hip ratio. Venous blood samples were analyzed for HbA1C and total and HDL cholesterol.

Covariates

Covariates were self-reported age, gender, race, education, socioeconomic status, and number of other chronic conditions. Age was the age at consent, gender was categorized as male or female, and race was collapsed into White vs. all other categories (Black/African American, Asian, American Indian/Alaska Native, and Other). Education was the highest level of school completed or the highest degree received. Socioeconomic status was assessed by categorizing the midpoint of the reported annual combined family income as above or below 150% of federal poverty guidelines. Finally, participants reported diagnoses of the following chronic conditions: cardiovascular disease (myocardial infarction or angina), stroke or a transient ischemic attack, types 1 or 2 diabetes, asthma, and COPD. The number of chronic conditions (0 vs. 1–4) was used in this analysis.

The effect of food allergy diagnosis on outcomes of interest was modeled using propensity weighted regression models in order to balance covariates between groups. This is an accepted approach for comparing groups using observational data, as differences between cases and controls could be due to pre-existing differences in covariates. Propensity weighting for the structural model was obtained using a generalized boosted model (McCaffrey et al., 2004). Estimation of this model is an iterative process with multiple regression trees to capture complex and non-linear relationships between group assignment and the covariates without over-fitting the data. Analysis of covariate balance indicated the majority of covariates were balanced between groups, with absolute standard differences <0.10. The only covariate that differed between groups was number of other chronic conditions, with cases reporting more than controls; accordingly, propensity weighting was used to balance this covariate for analysis.

Data Analysis

Initial propensity weighted regression models compared cases and matched controls on measures of stress exposure, perceived stress, anxiety, and AL. Follow-up analyses included covariates of interest. Subsequent analyses examined the association of the interaction of food allergy case status and stress or anxiety with AL. Four groups were compared: (a) food allergy cases with higher self-reported stress or anxiety, (b) food allergy cases with lower self-reported stress or anxiety, (c) controls with higher self-reported stress or anxiety, and (d) controls with lower self-reported stress or

anxiety. Measures of stress and anxiety included the SRRS, GPSS, one question assessing stress related to medical problems from the GPSS, the PTSD 6-item civilian checklist, and the anxiety subscale of the DASS-21.

AL was calculated by dividing the sample into quartiles for each AL measure, then identifying the number of measures for which participants were in the highest-risk quartile (Seeman et al., 2001). For HDL cholesterol only, higher values indicate lower risk. Thus, the quartile with subjects who had the lowest HDL values was the highest-risk quartile. For all other measures, the highest-risk quartile included subjects with the highest values. Rather than identifying a cutoff value for high AL, analyses used three approaches for modeling AL: a binary variable indicating whether participants had at least one upper-quartile measure of AL; the sum of the number of upper-quartile AL measures; and values for individual measures of AL, examined as continuous variables. A logistic regression model was used to evaluate associations with having any upper-quartile AL measure. Linear regression models were used for the sum of the number of upper-quartile measures and individual measures of AL. Significance was set at $p < 0.05$.

Results

Data were available on 476 adults (334 female, 70.17%). Eligible cases were 18 years of age and older, had a self-reported diagnosis of food allergy, and had available data on at least one clinical measure of AL. Controls were matched to cases on age, race, and sex. There were 228 cases with food allergy and 248 controls. Participants had a mean age of 45.89 ± 15.10 years at the time of data collection (range, 18–94). The majority of the sample was White (83.61%), with smaller percentages identifying as Black or African American (10.08%), Asian (2.94%), and Native Hawaiian or Pacific Islander (3.36%). The midpoint of the family income in the last year was below 150% of the federal poverty guidelines for 21.22% of subjects. Although the majority of subjects (60.71%) did not have other chronic conditions, 30.17% reported having one other condition, and 8.61% had two to four other chronic conditions (Table 1). Cases were more likely to report other chronic conditions than controls ($p < 0.001$), a difference that was balanced using propensity weighting. There were no significant differences between groups on other demographic measures (Table 2).

Measures of stress exposure, perceived stress, anxiety, and PTSD were compared between cases and controls (Table 3). Compared to controls, adults with food allergy had more stressful events in the last year ($p = 0.005$), higher anxiety ($p = 0.018$), and higher perceived stress ($p = 0.005$). There was a trend for cases to report more stress related to medical problems, but results were not statistically significant ($p = 0.054$). There was no significant difference between groups for PTSD.

Analyses of clinical measures of AL found that cases had higher diastolic BP ($p = 0.023$) and BMI ($p = 0.002$) and larger waist–hip ratio ($p = 0.025$) than controls. There were no significant differences between cases and controls for systolic BP, cholesterol levels, or HbA1C (Table 4). Further analyses of AL controlled for stress-related measures. Cases had significantly higher BMI than controls when controlling for perceived stress ($p = 0.022$), and had significantly higher systolic ($p = 0.023$) and diastolic BP ($p = 0.021$), and BMI ($p = 0.010$) when controlling for stress from medical problems.

Cases and controls did not differ in the number of upper-quartile measures of AL, or the odds of having at least one upper-quartile measure of AL. Analyses of the interaction of case status and stress and anxiety found no significant differences in the number of upper-quartile measures of AL when controlling for stressful life events in the last year, perceived stress, or PTSD symptoms. However, compared to controls, adults with food allergy had more upper-quartile measures of AL when controlling for anxiety ($p = 0.009$) and stress due to medical problems ($p = 0.010$). They were also more likely to have at least one upper-quartile measure of AL than controls when controlling for anxiety ($p = 0.008$) and perceived stress ($p = 0.004$). For analyses examining the relationship of the interaction of case status and measures of stress, mental health, perceived stress, anxiety, and PTSD with the number of upper-quartile measures of AL, none of the interaction terms were significant.

Discussion

This analysis examined whether stress exposures, perceived stress, mental health, and AL differed between adults with food allergy, a chronic health condition often diagnosed early in life, and controls. We hypothesized that adults with food allergy would have more stress exposures, higher perceived stress, worse mental health, and higher AL than controls.

Initial analyses supported the study hypothesis: compared to controls, individuals with food allergy reported more stress exposures and higher levels of perceived stress, as well as higher AL, assessed with individual clinical measures. Additional analyses also supported the study hypothesis. Controlling for anxiety, cases had more upper-quartile measures of AL and were more likely to have at least one upper-quartile measure of AL. Cases were also more likely to have more upper-quartile measures of AL and at least one upper-quartile measure of AL when controlling for stress due to medical problems and perceived stress, respectively.

Other analyses did not support study hypotheses. The interaction of case status with stress-related measures was not associated with higher AL assessed with individual clinical measures. Other measures of AL reflecting the neuroendocrine, immune/inflammatory, and epigenetic impact of stress and anxiety should be prioritized in future studies of

Table 1. Demographic Data.

Variable	All Subjects N (%)	Food Allergy Cases N (%)	Controls N (%)	Case–Control Comparison (p-Value)
Gender				
Female	334 (70.17)	158 (69.30)	176 (70.97)	0.69
Race/ethnicity				0.996
White	398 (83.61)	190 (83.33)	208 (83.87)	
Black/African-American	48 (10.08)	23 (10.09)	25 (10.08)	
Asian	14 (2.94)	7 (3.07)	7 (2.82)	
Native Hawaiian/Pacific Islander	16 (3.36)	8 (3.51)	8 (3.23)	
Education				0.91
≤12 years	17 (3.57)	8 (3.51)	9 (1.61)	
13–16 years	239 (50.21)	116 (50.87)	123 (49.59)	
>16 years	220 (46.22)	104 (45.62)	116 (46.77)	
Number of other chronic conditions				<0.001
0	289 (60.71)	116 (50.88)	173 (69.76)	
1	145 (30.46)	86 (37.72)	59 (23.80)	
2	33 (6.93)	18 (7.9)	15 (6.05)	
3–4	8 (1.68)	7 (3.1)	1 (0.4)	
Income				0.31
Below 150% of federal poverty guidelines	101 (21.22)	46 (20.18)	55 (22.18)	
Above 150% of federal poverty guidelines	360 (75.63)	172 (75.44)	188 (75.81)	

The p-values refer to the level of significance (<0.05).

stress experiences in individuals with previously diagnosed chronic health conditions (Li & Rosemberg, 2020). These measures may provide further insights into the physiological response to chronic health condition-specific cumulative stress in this population.

Results highlight the potential importance of assessing anxiety and medically-related stress in individuals with food allergy and other chronic health conditions (Chung et al., 2011; Peniamina et al., 2016; Polloni & Muraro, 2020; Shaker et al., 2017). Individuals with food allergy experience increased distress, including persistent anxiety, depressive symptoms, stress, and social isolation (Ferro, Van Lieshout, Ohayon, et al., 2016; Ferro, Van Lieshout, Scott, et al., 2016; Peniamina et al., 2014, 2016). Experiencing recent life-or-death situations, such as anaphylaxis or other severe allergic reactions, may place individuals at increased risk of anxiety. Past history of anaphylactic reactions should be included in future studies of stress and mental health in individuals with food allergy (Polloni & Muraro, 2020).

Results of our analyses align with findings from the limited number of studies on stress, mental health, and AL in adults with food allergy. College students with food allergy and their parents reported that the constant vigilance required to avoid allergenic foods generates high perceived stress and affects all aspects of daily life (Ersig & Williams, 2018). A qualitative study of adults with severe food allergy also identified constant vigilance as a substantial source of stress due to a number of issues, including difficulty accessing safe foods, interpreting food labels, and obtaining

appropriate health care (Peniamina et al., 2016). Participants also highlighted financial and time costs, the need to limit social activities and interactions, and a lack of knowledge among restaurant staff and the general public as stressors (Peniamina et al., 2016). Stress, anxiety, and depression could contribute to worse social functioning, vitality, quality of life, and general health in adults with food allergy, compared to the general population (de Blok et al., 2007). Many different chronic health conditions lead to similar stress experiences, but important differences in their characteristics, management, and impact on daily life could influence perceived stress and quality of life, supporting future studies in other populations.

Some clinical measures of AL in this analysis reflected higher AL in cases. Prior studies have not used clinical measures or biomarkers to examine AL in adults with food allergy. One study evaluated cardiovascular risk factors in parents of children with food allergy, based on the hypothesis that chronic stress associated with managing the child's food allergy would have a negative impact on BP, BMI, and waist-hip ratio (Walker et al., 2016). Mothers of young (<5 years) children with severe food allergy had higher BP and higher perceived stress than mothers of young children without food allergy, and mothers of children with more severe food allergy at risk of anaphylaxis had the highest values (Walker et al., 2016). This study was not designed to assess AL, but it does provide some support for examining similar measures and incorporating additional AL biomarkers in studies of individuals with chronic health conditions diagnosed earlier in life.

Table 2. Covariate Imbalance.

	Cases Mean	Cases SD	Controls Mean	Controls SD	Effect Size	Z-Value	p-Value
Unweighted							
Subject age	45.83	15.11	45.94	15.1	-0.008	-0.082	0.93
Highest level of education completed	16.18	2.282	16.157	2.256	0.01	0.109	0.914
Gender							
Male	0.307	0.461	0.29	0.454	0.036	0.158	0.691
Female	0.693	0.461	0.71	0.454	-0.036		
Race						0.019	0.996
White	0.833	0.373	0.839	0.368	-0.015		
Black or African American	0.101	0.301	0.101	0.301	0.00		
Asian	0.031	0.173	0.028	0.166	0.015		
Native Hawaiian/Pacific Islander	0.035	0.184	0.032	0.177	0.016		
Poverty						1.169	0.311
Income < 150% of federal poverty guidelines	0.202	0.401	0.222	0.415	-0.049		
Income > 150% of federal poverty guidelines	0.754	0.43	0.758	0.428	-0.009		
Number of chronic conditions						9.191	<0.001
No other chronic conditions reported	0.487	0.5	0.302	0.459	0.378		
1–4 other chronic conditions reported	0.509	0.5	0.698	0.459	-0.387		
Weighted							
Subject age	45.777	14.938	45.966	15.21	-0.013	-0.134	0.894
Highest level of education completed	16.17	2.291	16.159	2.213	0.005	0.054	0.957
Gender							
Male	0.302	0.459	0.302	0.459	0	0	0.999
Female	0.698	0.459	0.698	0.459	0		
Race							
White	0.828	0.378	0.837	0.37	-0.025	0.056	0.982
Black or African American	0.103	0.304	0.099	0.299	0.013		
Asian	0.033	0.179	0.035	0.183	-0.008		
Native Hawaiian or other Pacific Islander	0.036	0.187	0.03	0.17	0.036		
Poverty							
Income < 150% of federal poverty guidelines	0.206	0.404	0.208	0.406	-0.006	0.352	0.703
Income > 150% of federal poverty guidelines	0.754	0.431	0.766	0.423	-0.029		
Number of chronic conditions							
No other chronic conditions reported	0.39	0.488	0.388	0.487	0.004	0.479	0.619
1–4 other chronic conditions reported	0.606	0.489	0.612	0.487	-0.012		

There were several limitations to this analysis, primarily due to relying on existing, cross-sectional data collected from a general health examination survey. While the data are extensive and the population is well-characterized, there was a limited set of AL measures available. As a result, analyses did not include biomarkers of the stress response or additional measures of AL, such as epinephrine and norepinephrine (Seeman et al., 2001). The length of time an individual has been living with a chronic health condition is an important factor to consider, as longer duration may influence perceived stress and AL. However, age at diagnosis for food allergy was not available, so we were unable to examine whether length of time living with a chronic condition affects perceived stress and AL. In addition, the mean age of cases in our sample was approximately 46 years. This does not reflect the current demographics of food allergy in the United

States, in which children and younger adults, ages 18–40 years, are more likely to report food allergies, compared to adults over 40 years (Gupta et al., 2019). Self-reported diagnosis of food allergy was not confirmed with medical records. General measures of stress exposures, perceived stress, PTSD, and anxiety were obtained, but stress specific to food allergy was not assessed. Finally, measures of activity and diet and medications for stress-related conditions were not included as covariates.

Continued research on stress exposure, perceived stress, mental health, and AL in individuals with chronic health conditions typically diagnosed earlier in life, such as food allergy, is important, as they are already at increased risk of poor mental and physical health outcomes later in life. Objective measures of stress response (e.g., biomarkers, AL) provide a useful adjunct to subjective measures in

Table 3. Comparison of Stress Measures Between Cases and Controls.

Stress Measure	B (SE)	95% CI	p-Value
Life events checklist score (SRRS)	33.94 (12.03)	10.29, 57.58	0.005
Perceived stress (GPSS)	0.14 (0.05)	0.04, 0.23	0.005
Stress related to medical problems	0.21 (0.11)	-0.004, 0.43	0.054
Anxiety (DASS21)	0.62 (0.26)	0.11, 1.13	0.018
PTSD checklist total score	2.27 (1.26)	-0.20, 4.75	0.072

Table 4. Clinical Outcome Measures of Allostatic Load: Case–Control Comparison.

Clinical Outcome Measures of Allostatic Load*	B (SE)	95% CI	p-Value
Systolic BP	0.41 (1.48)	-2.5, 3.31	0.784
Diastolic BP	2.17 (0.95)	0.31, 4.03	0.023
BMI	2.32 (0.74)	0.86, 3.78	0.002
Waist–hip ratio	0.02 (0.01)	0.002, 0.04	0.025
Hemoglobin A1C	0.02 (0.05)	-0.07, 0.12	0.639
Total cholesterol	4.02 (4.02)	-3.90, 11.93	0.319
HDL cholesterol	0.45 (0.37)	-0.26, 1.17	0.211
<i>Controlling for Perceived Stress</i>			
Systolic BP	2.77 (2.86)	-2.86, 8.40	0.344
Diastolic BP	2.77 (1.79)	-0.74, 6.28	0.121
BMI	3.51 (1.53)	0.50, 6.51	0.022
Waist–hip ratio	0.03 (0.02)	-0.01, 0.06	0.106
Hemoglobin A1C	0.05 (0.10)	-0.14, 0.24	0.599
Total cholesterol	3.23 (7.39)	-11.31, 17.76	0.663
HDL cholesterol	1.33 (3.09)	-4.74, 7.41	0.666
<i>Controlling for Stress from Medical Problems</i>			
Systolic BP	8.19 (3.58)	1.15, 15.22	0.023
Diastolic BP	5.05 (2.18)	0.77, 9.34	0.021
BMI	4.48 (1.73)	1.09, 7.87	0.010
Waist–hip ratio	0.02 (0.02)	0.03, 0.06	0.445
Hemoglobin A1C	0.07 (0.11)	-0.14, 0.29	0.506
Total cholesterol	13.10 (9.10)	-4.80, 31.00	0.151
HDL cholesterol	3.39 (3.87)	-4.23, 11.00	0.382

*Each row was run as an individual model. All models have been propensity weighted. The number of subjects with usable data varied between measures; all subjects with usable data were included in analyses.

identifying individuals at high risk of poor health outcomes due to elevated stress. Future studies should evaluate additional measures of AL, including biomarkers and epigenetic modifications, to identify those at higher risk of poor health outcomes. Interventions could then be designed to improve stress management in these individuals, with biomarkers as objective outcome measures.

Careful attention to stress definition and measurement is also needed (Crosswell & Lockwood, 2020). Future studies of individuals with early-onset chronic conditions should incorporate condition-specific measures of stress exposures, which would provide important information on the extent to which stressors related to living with an early-onset chronic health condition may contribute to AL and health outcomes. Evaluating whether participants have experienced past crisis situations related to their conditions, such as anaphylaxis, is

also important: extreme anxiety or PTSD could influence AL and health outcomes. Early identification of factors increasing risk of poor later-life health could lead to nursing interventions to mitigate their effects on the growing population of adults living with chronic health conditions diagnosed earlier in life who experience related stressors throughout the life course (Blackwell et al., 2001; Haas & Oi, 2018; Pavela & Latham, 2016).

Acknowledgments

The authors would also like to thank members of the SHOW staff who supported and provided consultation regarding the use of SHOW data including Tamara LeCaire, the University of Wisconsin Survey Center, SHOW administrative, field, and scientific staff, as well as all the SHOW participants for their contributions to this study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: University of Wisconsin-Madison School of Nursing Research Pilot Grant to Anne L. Ersig. Funding for SHOW was provided by the Wisconsin Partnership Program PERC Award (233 AAG9971, TL).

ORCID iD

Anne L. Ersig  <https://orcid.org/0000-0002-4169-8287>

References

- Blackwell, D. L., Hayward, M. D., & Crimmins, E. M. (2001). Does childhood health affect chronic morbidity in later life? *Social Science and Medicine*, 52, 1269–1284. [https://doi.org/10.1016/S0277-9536\(00\)00230-6](https://doi.org/10.1016/S0277-9536(00)00230-6)
- Chung, M. C., Walsh, A., & Dennis, I. (2011). Trauma exposure characteristics, past traumatic life events, coping strategies, post-traumatic stress disorder, and psychiatric comorbidity among people with anaphylactic shock experience. *Comprehensive Psychiatry*, 52(4), 394–404. <https://doi.org/10.1016/j.compsych.2010.09.005>
- Crosswell, A. D., & Lockwood, K. G. (2020). Best practices for stress measurement: How to measure psychological stress in health research. *Health Psychology Open*, 7(2), 2055102920933072. <https://doi.org/10.1177/2055102920933072>
- de Blok, B. M., Vlieg-Boerstra, B. J., Oude Elberink, J. N., Duiverman, E. J., DunnGalvin, A., Hourihane, J. O., Cornelisse-Vermaat, J. R., Frewer, L., Mills, C., & Dubois, A. E. (2007). A framework for measuring the social impact of food allergy across Europe: A EuroPrevall state of the art paper. *Allergy*, 62(7), 733–737. <https://doi.org/10.1111/j.1398-9995.2006.01303.x>
- Eddington, A. R., Mullins, L. L., Byrd-Craven, J., & Chaney, J. M. (2012). An experimental examination of stress reactivity in adolescents and young adults with asthma. *Children's Health Care*, 41(1), 16–31. <https://doi.org/10.1080/02739615.2012.643287>
- Epel, E. S., Crosswell, A. D., Mayer, S. E., Prather, A. A., Slavich, G. M., Puterman, E., & Mendes, W. B. (2018). More than a feeling: A unified view of stress measurement for population science. *Frontiers in Neuroendocrinology*, 49, 146–169. <https://doi.org/10.1016/j.yfrne.2018.03.001>
- Epel, E. S., & Prather, A. A. (2018). Stress, Telomeres, and psychopathology: Toward a deeper understanding of a triad of early aging. *Annual Review of Clinical Psychology*, 14, 371–397. <https://doi.org/10.1146/annurev-clinpsy-032816-045054>
- Ersig, A. L., & Williams, J. K. (2018). Student and parent perspectives on severe food allergies at college. *Journal of Pediatric Health Care*, 32(5), 445–454. <https://doi.org/10.1016/j.pedhc.2018.03.006>
- Evans, G. W. (2003). A multimethodological analysis of cumulative risk and allostatic load among rural children. *Developmental Psychology*, 39(5), 924–933. <https://doi.org/https://psycnet.apa.org/doi/10.1037/0012-1649.39.5.924>
- Fava, G. A., McEwen, B. S., Guidi, J., Gostoli, S., Offidani, E., & Sonino, N. (2019). Clinical characterization of allostatic overload. *Psychoneuroendocrinology*, 108, 94–101. <https://doi.org/10.1016/j.psyneuen.2019.05.028>
- Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American Journal of Preventive Medicine*, 14(4), 245–258. [https://doi.org/10.1016/S0749-3797\(98\)00017-8](https://doi.org/10.1016/S0749-3797(98)00017-8)
- Ferro, M. A., Van Lieshout, R. J., Ohayon, J., & Scott, J. G. (2016). Emotional and behavioral problems in adolescents and young adults with food allergy. *Allergy*, 71(4), 532–540. <https://doi.org/10.1111/all.12829>
- Ferro, M. A., Van Lieshout, R. J., Scott, J. G., Alati, R., Mamun, A. A., & Dingle, K. (2016). Condition-specific associations of symptoms of depression and anxiety in adolescents and young adults with asthma and food allergy. *Journal of Asthma*, 53(3), 282–288. <https://doi.org/10.3109/02770903.2015.1104694>
- Gupta, R. S., Warren, C. M., Smith, B. M., Jiang, J., Blumenstock, J. A., Davis, M. M., Schleimer, R. P., & Nadeau, K. C. (2019). Prevalence and severity of food allergies among US adults. *JAMA Network Open*, 2(1), e185630. <https://doi.org/10.1001/jamanetworkopen.2018.5630>
- Haas, S. A., & Oi, K. (2018). The developmental origins of health and disease in international perspective. *Social Science and Medicine*, 213, 123–133. <https://doi.org/10.1016/j.socscimed.2018.07.047>
- Harris, K. M., & McDade, T. W. (2018). The biosocial approach to human development, behavior, and health across the life course. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, 4(4), 2–26. <https://doi.org/10.7758/rsf.2018.4.4.01>
- Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, 44(Pt. 2), 227–239. <https://doi.org/10.1348/014466505X29657>
- Holmes, T. H., & Rahe, R. H. (1967). The Social Readjustment Rating Scale. *Journal of Psychosomatic Research*, 11, 213–218. [https://doi.org/https://psycnet.apa.org/doi/10.1016/0022-3999\(67\)90010-4](https://doi.org/https://psycnet.apa.org/doi/10.1016/0022-3999(67)90010-4)
- Juster, R. P., & Lupien, S. J. (2012). Chronic stress and allostatic load. In K. Schenck-Gustafsson, P. R. DeCola, D. W. Pfaff, & D. S. Pisetsky (Eds.), *Handbook of clinical gender medicine* (pp. 70–81). Karger Publishers. <https://doi.org/10.1159/000336343>
- Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience and Biobehavioral Reviews*, 35(1), 2–16. <https://doi.org/10.1016/j.neubiorev.2009.10.002>
- Kalmakis, K. A., & Chandler, G. E. (2015). Health consequences of adverse childhood experiences: A systematic review. *Journal of the American Association of Nurse Practitioners*, 27(8), 457–465. <https://doi.org/10.1002/2327-6924.12215>
- King, A. L., Garnier-Villareal, M., Simanek, A. M., & Johnson, N. L. (2019). Testing allostatic load factor structures among adolescents: A structural equation modeling approach. *American Journal of Human Biology*, 31, e23242. <https://doi.org/10.1002/ajhb.23242>
- Kuo, W. C., Bratzke, L. C., Oakley, L. D., Kuo, F., Wang, H., & Brown, R. L. (2019). The association between psychological

- stress and metabolic syndrome: A systematic review and meta-analysis. *Obesity Reviews*, 20(11), 1651–1664. <https://doi.org/10.1111/obr.12915>
- Lang, A. J., & Stein, M. B. (2005). An abbreviated PTSD checklist for use as a screening instrument in primary care. *Behaviour Research and Therapy*, 43(5), 585–594. <https://doi.org/10.1016/j.brat.2004.04.005>
- Li, Y., & Rosemberg, M. (2020). The promise of allostatic load rests upon strategic operationalization, scoring, and targeted interventions. *Psychoneuroendocrinology*, 123, 104877. <https://doi.org/10.1016/j.psyneuen.2020.104877>
- McCaffrey, D. F., Ridgeway, G., & Morral, A. R. (2004). Propensity score estimation with boosted regression for evaluating causal effects in observational studies. *Psychological Methods*, 9(4), 403–425. <https://doi.org/10.1037/1082-989X.9.4.403>
- McEwen, B. S. (2005). Stressed or stressed out: What is the difference? *Journal of Psychiatry and Neuroscience*, 30(5), 315–318.
- Nieto, F. J., Peppard, P. E., Engelman, C. D., McElroy, J. A., Galvao, L. W., Friedman, E. M., Bersch, A. J., & Malecki, K. C. (2010). The Survey of the Health of Wisconsin (SHOW), a novel infrastructure for population health research: Rationale and methods. *BMC Public Health*, 10, 785. <https://doi.org/10.1186/1471-2458-10-785>
- Pavela, G., & Latham, K. (2016). Childhood conditions and multimorbidity among older adults. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 71(5), 889–901. <https://doi.org/10.1093/geronb/gbv028>
- Payne, T. J., Wyatt, S. B., Mosley, T. H., Dubbert, P. M., Guitierrez-Mohammed, M. L., Calvin, R. L., Taylor, H. A., Jr., & Williams, D. R. (2005). Sociocultural methods in the Jackson Heart Study: Conceptual and descriptive overview. *Ethnicity and Disease*, 15(6), S6–S38.
- Peniamina, R. L., Bremer, P., Conner, T. S., & Miroso, M. (2014). Understanding the needs of food-allergic adults. *Qualitative Health Research*, 24(7), 933–945. <https://doi.org/10.1177/1049732314539733>
- Peniamina, R. L., Miroso, M., Bremer, P., & Conner, T. S. (2016). The stress of food allergy issues in daily life. *Psychology & Health*, 31(6), 750–767. <https://doi.org/10.1080/08870446.2016.1143945>
- Polloni, L., & Muraro, A. (2020). Anxiety and food allergy: A review of the last two decades. *Clinical and Experimental Allergy*, 50(4), 420–441. <https://doi.org/10.1111/cea.13548>
- Primeau, M., Kagan, R., Joseph, L., Lim, H., Dufresne, C., Duffy, C., Prhcal, D., & Clarke, A. (2000). The psychological burden of peanut allergy as perceived by adults with peanut allergy and the parents of peanut-allergic children. *Clinical and Experimental Allergy: Journal of the British Society for Allergy and Clinical Immunology*, 30(8), 1135–1143. <https://doi.org/10.1046/j.1365-2222.2000.00889.x>
- Seeman, T. E., McEwen, B. S., Rowe, J. W., & Singer, B. H. (2001). Allostatic load as a marker of cumulative biological risk: MacArthur studies of successful aging. *Proceedings of the National Academy of Sciences*, 98(8), 4770–4775. <https://doi.org/10.1073/pnas.081072698>
- Shaker, M. S., Schwartz, J., & Ferguson, M. (2017). An update on the impact of food allergy on anxiety and quality of life. *Current Opinion in Pediatrics*, 29(4), 497–502. <https://doi.org/10.1097/MOP.0000000000000509>
- Slavich, G. M. (2020). Psychoneuroimmunology of stress and mental health. *The Oxford handbook of stress and mental health* (pp. 519–546). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780190681777.013.24>
- Teufel, M., Biedermann, T., Rapps, N., Hausteiner, C., Henningsen, P., Enck, P., & Zipfel, S. (2007). Psychological burden of food allergy. *World Journal of Gastroenterology*, 13(25), 3456–3465. <https://doi.org/10.3748/wjg.v13.i25.3456>
- Walker, S. O., Mao, G., Caruso, D., Hong, X., Pongracic, J. A., & Wang, X. (2016). Cardiovascular risk factors in parents of food-allergic children. *Medicine*, 95(15), e3156. <https://doi.org/10.1097/MD.00000000000003156>