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Food insecurity and cardiovascular health: Findings from a statewide population health survey in Wisconsin

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ABSTRACT

Background. The social and economic environment has become a major area of interest regarding the determinants of cardiovascular health. Among markers of economic distress, food insecurity has been found associated with metabolic disorders, dyslipidemia, and obesity, but no previous studies have examined its association with overall cardiovascular health.

Methods and results. We conducted a cross-sectional analysis among 2935 participants in the Survey of the Health of Wisconsin (SHOW), a statewide population-based representative sample. The presence of food insecurity was determined by an affirmative answer to the question "In the last 12 months, have you been concerned about having enough food for you or your family?" Cardiovascular health (CVH) was defined based on the American Heart Association Life's Simple 7 criteria and classified as "poor," "intermediate," or "ideal" using previously published criteria. "Good" CVH was defined as having no poor in any of the seven criteria (any amount of intermediate or ideal). Crude and adjusted odds ratios (OR) of good CVH according to presence of food insecurity were calculated using logistic regression models. Overall, food insecurity was associated with a decreased likelihood of good CVH (OR 0.53; 95% Confidence Interval 0.31 to 0.92; $p = 0.02$). This association persisted in models controlling for age, gender, race, and urbanization.

Conclusions. Participants who were food insecure were significantly less likely to have good CVH compared to participants who were food secure. Even though this study cannot confirm causality, these results suggest that food insecurity might be one of several socio-economic barriers contributing to poor CVH.

1. Introduction

Cardiovascular disease is a multifactorial disease. Abundant research has demonstrated that the social and economic environment has an important influence on a person's cardiovascular health (Diez Roux et al., 2001; Streel et al., 2015). The new challenge is now to try to sift through the complexities and numerous components of the socioeconomic environment to narrow in and focus on the specific aspects that may affect cardiovascular health.

The American Heart Association's (AHA's) Strategic Impact Goals for 2020 and Beyond (Lloyd-Jones et al., 2010) set a new goal of improving the cardiovascular health of all Americans by 20% while reducing deaths from cardiovascular disease and stroke by 20%. This report introduced a new metric to evaluate progress in cardiovascular health promotion that focuses on seven well established modifiable factors, including both behaviors and objective measures: physical activity, diet, body mass index (BMI), smoking, blood pressure, serum glucose, and total serum cholesterol (Lloyd-Jones et al., 2010). The term Life's Simple 7 was later introduced by AHA to designate this index of cardiovascular health. To date, several studies have examined the association of the achievement of these cardiovascular health goals with the risk of cardiovascular disease (CVD) and other CVD-related end points such as kidney disease, depression, incident thromboembolism, cognitive impairment, and mortality; all demonstrating decreased adverse outcomes with improved cardiovascular health (Folsom et al., 2011; Kronish et al., 2012; Muntner et al., 2013; Thacker et al., 2014; Olson et al., 2015). Additionally, several studies have examined the disparities in cardiovascular health that exist in relation to education, income, and race (Eggen et al., 2014; Abeyta et al., 2012; Dong et al., 2012).

Food insecurity is another marker of socioeconomic distress that has been associated with cardiovascular disease risk factors and other outcomes in recent years (Liu et al., 2015; Sirotin et al., 2014; Ford, 2013). The United States Department of Agriculture (USDA) defines food security as "access by all members at all times to enough food for an active, healthy life." (United States Department of Agriculture. Econcomic Research Service, 2015) The most recent data from the 2013 Current

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Population Survey showed that, nationally, 15.8% of people were food insecure (Coleman-Jensen et al., 2014). Studies have shown that the prevalence of diabetes is higher among food-insecure adults than food-secure adults (Seligman et al., 2007, 2010). In a recent population-based study, we showed that food insecurity was associated with dyslipidemia (Shin et al., 2015). Additionally, it has been demonstrated in the literature that food-insecure adults tend to have lower quality diet and higher prevalence of smoking than food-secure adults (Rose and Oliveira, 1997; Armour et al., 2008; Cutler-Triggs et al., 2008; Xu et al., 2011). Other studies, in contrast, have not found any differences in diastolic blood pressure, hyperlipidemia, total cholesterol, blood glucose, or hemoglobin A1c (HbA1c) in association with food security status (Seligman et al., 2010; Holben and Pheley, 2006).

In summary, previous literature suggests that food insecurity might be associated with some but not all cardiovascular disease risk factors. To our knowledge, no published studies to date have examined the association between food insecurity and overall cardiovascular health. The purpose of our study was to examine the associations between food security status, cardiovascular risk factors, and overall cardiovascular health as defined by the Life's Simple 7 model in a representative statewide population-based sample of adults while attempting to control for confounding variables such as social and economic environments.

2. Methods

2.1. Data collection

We used data from the 2008–2014 waves of the Survey of the Health of Wisconsin (SHOW) to investigate the association between food security and cardiovascular health using a cross-sectional observational framework. The SHOW is an examination-based health survey of a representative sample of Wisconsin residents. The SHOW study rationale and methods have been previously described (Nieto et al., 2010). Briefly, a 2-stage cluster sampling method was used to randomly select census block groups and households in order to recruit study participants age 21–74 years. Participants were surveyed about their health, demographics, behaviors, and lifestyle. Participants also completed a physical exam measuring anthropometrics and blood pressure, and provided blood and urine samples.

2.2. Food insecurity

The presence of food insecurity was defined based on the participant's affirmative answer to the question "In the last 12 months, have you been concerned about having enough food for you or your family?" This question is aligned with items included in the USDA Food Security Survey Module used in the National Health and Nutrition Examination Survey (NHANES) to estimate individuals with low and very low food security. The question examines strictly whether the perceived quantity of food available is adequate as perceived by the study participants. Starting in 2012, the SHOW participants answered additional questions that allowed us to classify food insecurity groups with the USDA Food Security Module in addition to the above question regarding concern about having enough food. Using the USDA Food Security Survey Module as the gold standard in this subsample of SHOW participants, the SHOW question had a specificity of 96% (95% CI 93–97%), a sensitivity of 69% (95% CI 60–77%), a positive predictive value of 75%, and a negative predictive value of 95%. We chose to use the SHOW survey question for analysis rather than the USDA Food Security Survey Module in order to maximize sample size. After excluding those participants who did not answer the SHOW food security question, the sample size for these analyses was 2935. However, we additionally performed the analyses using the USDA definition of food insecurity (United States Department of Agriculture. Economic Research Service, 2015). This analysis among the more restricted subset of participants who responded to the USDA module (n = 779) demonstrated similar point estimates (results not shown).

2.3. Predictors and covariates

Sociodemographic information collected from the participants included age, sex, race, income, level of education, area of residence, military service, and marital status. Age was categorized as 21–39, 40–59, and 60–74 years. Race was categorized into white and non-white (including non-Hispanic African-American, Hispanic, and other). Household income was categorized into less than $20k, $20–$45k, and greater than $45k per year. Education was categorized into less than high school degree, high school degree or equivalent, and greater than high school degree. Area of residence was categorized into three urbanicity categories (urban, suburban, or rural) based on the University of Washington Rural–urban Commuting Area (RUCA) Code corresponding to their census block group (Morrill et al., 1999). Urban core describes a location in or very near the center of a largely populated area and urban other describes a location that is suburban and distinct from primarily rural or urban core area. All other RUCA code groups were placed in a single rural category. Military service was categorized based on whether a participant reported any military service or not. Military service in previous literature has been shown to affect nutritional behavior and food security status (Smith et al., 2009). Consistent with previous literature (Hanson et al., 2007; Hernandez and Ziol-Guest, 2009), marital status was categorized as married or other than married (including widowed, divorced, separated, never married, or living with partner).

Information about participants' cardiovascular health was assessed using a modified version of the seven Simple 7 metrics of smoking, body mass index, physical activity, healthy diet score, total cholesterol, blood pressure, and HbA1c. Table 1 shows the criteria used to classify each component into one of three levels ("poor," "intermediate," and "ideal"); these criteria are similar to the originally proposed by the AHA (Lloyd-Jones et al., 2010), except for two small modifications: 1) percent of daily energy intake form saturated fat substituted for sodium consumption; and 2) HbA1C, a valid marker of insulin resistance and diabetes (American Diabetes Association, 2012) substituted for fasting glucose—the latter as a result of the fact that not all SHOW participants were fasting at the time of their exam. Overall, cardiovascular health was categorized as "poor" if *any* of the participant's seven cardiovascular health metrics were poor and "ideal" if *all* seven components were in the ideal category. However, due to low prevalence of ideal overall cardiovascular health in our population (<2%—a result consistent with other general population-based studies (Folsom et al., 2011), cardiovascular health status was made into a binary variable by comparing participants who had "good" cardiovascular health (combining intermediate and ideal) versus "poor." Further analysis also examined food security status in relation to binary definitions of each of the ideal Life's Simple 7 components (combining ideal and intermediate into "good" vs. "poor").

2.4. Data analysis

SAS version 9.3 software (SAS Institute, Cary, North Carolina) was used to conduct the data analyses. Weighted statistical analyses were conducted in order to account for the complex survey design used by the SHOW study. Logistic regression models (PROC SURVEYLOGISTICS) were used to estimate crude and adjusted odds ratios (OR) and 95% confidence intervals (CI) of good cardiovascular health according to food insecurity and sociodemographic variables.

Table 1
Definitions of poor, intermediate, ideal for each of the seven components of cardiovascular health.[a]

Goal/metric	Poor	Intermediate	Ideal
Smoking status[b]	Currently smoking	Former ≤12 months	Never or quit >12 months ago
Body mass index	≥30 kg/m^2	25–29.9 kg/m^2	<25 kg/m^2
Physical activity[b]	No physical activity	1–149 min/week moderate intensity or 1–74 min/week vigorous intensity or 1–149 min/week moderate + vigorous	≥150 min/week moderate intensity or ≥75 min/week vigorous intensity or combination
Diet[b,c]	0–1 healthy diet components	2–3 healthy diet components	4–5 healthy diet components
Total serum cholesterol	≥240 mg/dl	200–239 mg/dl or treated to goal	<200 mg/dl
Blood pressure	Systolic ≥140 mm Hg or diastolic ≥90 mm Hg	Systolic 120–139 mm Hg or diastolic 80–89 mm Hg or treated to goal	Systolic <120 mm Hg and diastolic <80 mm Hg
HbA1c	≥6.5%	<6.5%	<6.0%

[a] Based on modified criteria from the cardiovascular health index proposed by the American Heart Association (see text and reference no. 3).
[b] Based on self-report and structured interviews; all other measures based on physical or laboratory values.
[c] Based on self-reported consumption of each of the following five "health diet components:" 1) average daily consumption of fruits and vegetables (cups per day) ≥4.5; 2) average daily consumption of fiber (grams per day) ≥12.5; 3) average weekly consumption of fish (oz servings per week) ≥3.5; 4) average daily consumption of "added sugar" (grams per day) ≤36 if male or ≤24 if female; and 5) percent of daily energy intake from saturated fat <14.

3. Results

3.1. Sociodemographic

A total of 2935 participants in the SHOW answered the food security question. Table 2 demonstrates the sociodemographic characteristics of the SHOW participants who answered the food security question. Mean age for a food insecure individual was 41.4 years compared to a mean age of 47 years for a food secure individual (p-value < 0.01). When grouped, the prevalence of food insecurity among participants younger than 40 years was more than three times that of participants 60 years or older. There was more food insecurity among females (13%) than among males (11%), but the difference was not statistically significant. One in every five non-white participants were food insecure, a prevalence more than twice that of whites, who constituted about 85% of the sample (p-value < 0.01). Not unexpectedly, the prevalence of food insecurity was also significantly higher among the low income and low education level participants—remarkably, about 25% of participants reporting income of <$20,000 per year reported food insecurity.

According to type of neighborhood, food insecurity prevalence was highest in urban neighborhoods (around 14%) and lowest in suburban neighborhoods (7%), with rural areas somewhere in between (11%). In our sample, food insecurity was less common among those having served in the armed forces than in those who hadn't, but the difference was not statistically significant (p = 0.19). Married participants were significantly less likely to be food insecure than unmarried subjects (p-value < 0.0001).

Table 2
Sociodemographic characteristics of eligible SHOW participants and food insecurity prevalence; Survey of the Health of Wisconsin 2008–2014.

		Prevalence of food insecurity		
	Number*	Percent	95% confidence interval	p-Value
Overall	2935	12.0	[10.8, 13.2]	–
Age				0.02
21–39	1025	15.0	[11.6, 18.6]	
40–59	1335	11.9	[9.0, 14.7]	
60–74	575	4.4	[2.8, 6.2]	
Sex				0.08
Female	1467	12.9	[10.6, 15.2]	
Male	1468	10.6	[8.4, 12.7]	
Race				<0.0001
White	2588	10.2	[8.4, 12.0]	
Non-white	347	21.4	[14.9, 27.3]	
Income				<0.0001
<$20k	375	25.7	[19.1, 31.7]	
$20k–45k	717	16.5	[12.5, 20.2]	
>45k	1843	6.3	[4.5, 8.2]	
Education				0.0008
<High school	200	19.0	[12.3, 26.2]	
HS	498	11.4	[7.5, 15.2]	
>HS	2237	11.0	[9.1, 13.0]	
Neighborhood				0.01
Rural	892	10.6	[6.8, 14.6]	
Suburban	506	6.6	[2.3, 11.2]	
Urban	1537	13.9	[10.9, 16.7]	
Armed forces				0.19
Yes	343	8.5	[4.3, 13.2]	
No	2592	12.1	[10.2, 14.1]	
Marital status				<0.0001
Married	1991	9.4	[7.1, 11.6]	
Not married	944	16.2	[12.5, 19.7]	

* The number shown in the first column represents raw data. The prevalence statistics in the second column have been weighted to account for the cluster sampling method, as described in the methods section.

3.2. Cardiovascular health and Life's Simple 7

Table 3 displays the prevalence of poor, intermediate, and ideal classifications of overall cardiovascular health as well as each of Life's Simple 7 components. The prevalence of the "ideal" level of each of the seven components ranged from 27.6% (BMI) to 78.9% (smoking), but the prevalence of overall ideal CVH was only 1.2%. The combined prevalence of ideal and intermediate cardiovascular health (termed "good" cardiovascular health herein) was 27.8%.

Table 4 portrays the association between food security status and good overall cardiovascular health as well as with ideal or good levels of each of its seven components. After controlling for demographic and socioeconomic variables, food insecurity was associated with being almost half as likely to be in "good" cardiovascular health compared to those who were food secure (OR 0.53, 95% CI 0.31–0.92). When looking at single components, food insecurity was least likely to be associated with "good" or "ideal" levels of BMI and smoking. It was also significantly associated with healthy levels of diet and physical activity, but only when the ideal cutoff was used. Contrary to our a priori hypothesis, food insecurity appeared to be significantly associated with an "ideal" level of both blood pressure and total cholesterol.

4. Discussion

Our results demonstrated that over one in ten Wisconsin residents surveyed between 2008 and 2014 reported food insecurity defined as being "concerned about having enough food" for themselves or their family at some point in the previous year. As previously discussed (Guerrero et al., 2014), this percentage may be an underestimate to the true prevalence of food insecurity as the USDA Household Food

Table 3
Adjusted prevalence[a] of poor, intermediate, and ideal overall cardiovascular health (CVH) and Life's Simple 7. Survey of the Health of Wisconsin 2008–2014.

	Overall CVH	Blood pressure	BMI[c]	Smoking	Physical activity	Diet	HbA1c	Total cholesterol
Level[b]	Percent							
Poor	72.2	18.2	39.3	18.4	4.7	27.3	6.4	10.5
Intermediate	26.6	45.6	33.1	2.7	21.2	60.5	34.6	41.9
Ideal	1.2	36.2	27.6	78.9	74.1	12.2	59.0	47.6

[a] Adjusted for sociodemographic variables (age, sex, income, race, education, neighborhood, military service, marital status); Survey of the Health of Wisconsin 2008–2014.
[b] See definitions in Table 1.
[c] Body mass index.

Security Questionnaire determined food insecurity to be at 15.8% in Wisconsin (McGuire et al., 2011). The discrepancy is likely due to the broader definition to include individuals with potentially limited food access, i.e., that the USDA defines as "marginal food security." (McGuire et al., 2011) As mentioned earlier, the definition of food insecurity used in the analyses herein was highly concordant with that based on the USDA Household Food Security Questionnaire, allowing the greater sampling of the Wisconsin population while maintaining validity. As discussed in more detail elsewhere in a previous report (Guerrero et al., 2014), food insecurity was most frequent in urban areas, probably reflecting the higher prevalence of poverty in this environments; however, it is far from an exclusively urban problem, as demonstrated by the substantial proportions of the rural and suburban respondents facing food insecurity in our survey (11% and 7%, respectively).

Consistent with our hypothesis, food insecurity was associated with lower prevalence of "good" cardiovascular health (defined by combining the ideal and intermediate categories of the AHA definition). (The prevalence of "ideal" cardiovascular health was too low (1.2%) for meaningful analyses.) This is important because it has been demonstrated in the literature that different levels of cardiovascular health are associated with varied prospective short-term and long-term cardiovascular and non-cardiovascular outcomes. This includes all-cause mortality; CVD, coronary, stroke mortality; end stage renal disease; nonfatal CVD events; incident cancer, venous thromboembolism, depression, quality of life, compression of morbidity, overall cognitive function, and Medicare charges (Folsom et al., 2011; Thacker et al., 2014; Olson et al., 2015; Dong et al., 2012; Laitinen et al., 2012; Yang et al., 2012; Kulshreshtha et al., 2013; Rasmussen-Torvik et al., 2013; Reis et al., 2013; Wilkins et al., 2012). It is important to note also that each of the components of the measure of cardiovascular health used in this study is actionable by design, can change at any time with proper behavioral intervention or treatment, and that even small changes, such as improvement in exercise or diet that moves a person from one category to the next, can have an impact (Liu et al., 2012; Spring et al., 2014; Laitinen et al., 2013).

Table 4
Adjusted odds ratios (OR)* and 95% confidence intervals (CI) of good cardiovascular health (CVH) and good or ideal Simple 7 components based on food insecurity status. Survey of the Health of Wisconsin 2008–2014.

	Level	Adjusted OR*	95% CI
Overall CVH	Good	0.53	0.31–0.92
Blood pressure	Good	1.18	0.79–1.76
	Ideal	1.47	1.20–1.90
Body mass index (BMI)	Good	0.64	0.43–0.94
	Ideal	0.75	0.56–1.00
Diet	Good	0.81	0.60–1.10
	Ideal	0.52	0.33–0.83
Smoking	Good	0.42	0.30–0.59
	Ideal	0.27	0.21–0.35
HbA1c	Good	0.83	0.40–1.74
	Ideal	1.09	0.83–1.43
Physical activity	Good	1.19	0.64–2.21
	Ideal	0.74	0.57–0.96
Total cholesterol	Good	1.40	0.81–2.41
	Ideal	1.40	1.10–1.80

* Adjusted for sociodemographic variables (age, sex, income, race, education, neighborhood, military service, marital status); Survey of the Health of Wisconsin 2008–2014. "Good" is equal to "Intermediate" and "Ideal" categories combined as described in text. Inversely, "Good" category can be defined as not being in "Poor" category.

Food security status has been associated with a number of health outcomes, including poor nutrition, chronic kidney disease, diabetes, anemia, acute infection, chronic illness, and mental health problems (Seligman et al., 2010; Crews et al., 2014; Weinreb et al., 2002; Kursmark and Weitzman, 2009; Sarlio-Lähteenkorva and Lahelma, 2001; Whitaker et al., 2006; Park et al., 2009; Rose-Jacobs et al., 2008). In our study, the food insecure individuals were more likely to be younger, minority, lower-income, lower educational attainment, and non-married than food secure participants, observations that are consistent with previous literature (Pan et al., 2012; Gooding et al., 2012). Among all the Simple 7 components, food insecurity was least likely to be associated with "good" or "ideal" BMI and smoking. The relationship between food insecurity and these two risk factors has been previously documented (Cutler-Triggs et al., 2008; Rose-Jacobs et al., 2008; Pan et al., 2012). In addition, food insecurity was significantly associated with lower odds of "ideal" diet and physical activity, but had no significant relation with other factors. Our finding that food insecure individuals are less likely to have a healthy diet is consistent with previous literature (Mello et al., 2010) as well as with our own previous findings showing its association with obesity and dyslipidemia (Shin et al., 2015).

The association between food insecurity and more likely "ideal" levels of blood pressure and total cholesterol were present even after controlling for sociodemographic variables (including race, urbanicity, education, and income). However, we cannot rule out the possibility of residual confounding by other socio-economic factors not captured in our database. Additionally, some of the unexpected associations reported here may be an artifact stemming from the definitions of the cut-off values for these variables. For example, the physical activity cut-off is no physical activity at all, so individuals who performed even 1 min of physical activity a week were considered to have at least an "intermediate" level of physical activity. The same may hold true for the cutoffs for blood pressure and cholesterol. This results in an abnormally small group of individuals being considered poor with respect to physical activity.

Biological hypotheses exist to explain the associations between food insecurity and cardiovascular risk factors. For example, food selection that accentuates inexpensive but energy-dense foods, overconsumption when food is available due to likely future food shortages, and the "thrifty gene hypothesis," which suggests that it is adaptive to more efficiently accumulate fat when food is unpredictable, may explain the association with obesity (Polivy, 1996; Dixon et al., 2001; Neel, 1962). Consistent food shortages leads to nutritional deficiency and low-energy states affecting physical activity capability. Furthermore, risk of hypertension is increased due to the high sodium and low potassium elements of inexpensive highly processed food; however a lack of food may represent lack of ability to maintain hydration or essential minerals (Adrogué and Madias, 2007). Also, the thrifty gene hypothesis suggests that peripheral insulin resistance, a precursor to diabetes, may

be adaptive in association with food insecurity as it allows for the preservation of muscle tissue during food deprivation (Reaven, 1998). Additionally, food insecurity is an emotionally and physiologically highly stressful state (Hamelin et al., 2002). This stress results in elevated cortisol which has been linked to adiposity, especially visceral adiposity which is a strong risk factor for diabetes and CVD (Hamelin et al., 2002). Finally, increases in dietary glycemic load from substitution of dietary fruits and vegetables with inexpensive carbohydrates contributes to development of diabetes (Gross et al., 2004).

The strength of our study is that it is the first to our knowledge to look at the relation between food security and cardiovascular health using the paradigm of the Simple 7. Furthermore, this analysis is carried out using a randomly selected study population that is representative of the State of Wisconsin in terms of sociodemographic and health characteristics. Limitations of our study include those inherent to a cross-sectional observational study including exposure-outcome temporal relationship identification and reverse causality, inability to measure incidence, and recall bias. Additionally, selection bias might be present as a result of the overall SHOW response rate (around 55%) as well as to the missing data on some SHOW participants (i.e., those who did not attend the last component of the exam where food insecurity questions and blood samples were obtained).

The importance of the socioeconomic and built environment as an aspect of a population's and individual's health cannot be understated. Where people live, their educational attainment, their habits, etc. all contribute to and influence their physical and mental health in a myriad of ways. Elucidating these social factors and their associations with people's health represents an ongoing challenge in modern medicine which will hopefully lead to collaborative efforts and solutions that extend beyond the boundaries of traditional clinical medicine. Food security might be one of the upstream risk factors that have an effect on cardiovascular health (Abeyta et al., 2012; Seligman et al., 2007, 2010; Shin et al., 2015). Given the impact of food security on an individual's health, health care organizations and providers, especially primary care providers, should consider screening and targeting food security as part of the standard of care, provided that this is done using a patient and family-centered approach and with consideration of available resources for referral to a social worker or social service program when appropriate (Garg et al., 2016). The Supplemental Nutrition Assistance Program (colloquially known as the Food Stamp Program or SNAP) is a well-established and highly successful infrastructure to reduce rates of food insecurity throughout the U.S. (Mabli and Ohls, 2015) Further research into the sociodemographic, cultural, and economic determinants of food insecurity is warranted. Additionally, controlled studies examining the effectiveness of screening programs to identify and address food insecurity in clinical practice should also be carried out.

In conclusion, our data suggest that food insecurity might be an upstream modifiable risk factor for cardiovascular health, even though the observational and cross-sectional nature of our analyses calls for caution on the causal interpretation of these results. Our analysis shows that food insecurity is associated with poor cardiovascular health in terms of the Life's Simple 7 framework regardless of other sociodemographic characteristics. If these associations were causal and if the AHA's Strategic Impact Goals for 2020 and Beyond are to be met, food insecurity will need to be addressed.

Conflict of interest

None declared.

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