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Article *in* Nutrition and health (Berkhamsted, Hertfordshire) · August 2019

DOI: 10.1177/0260106019869069

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nutrition and health

Original Article

Nutrition and Health
1–8

DOI: 10.1177/0260106019869069
journals.sagepub.com/home/nah
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Abstract

Background: Food insecurity is known to be a major public health issue. There is limited data on food insecurity and chronic disease in the general population. **Aim:** We aimed to assess effect of food insecurity on mortality of individuals with chronic disease like cardiorenal syndrome (CRS). **Methods:** The study was conducted on participants aged 20 years or older in the United States living below the 130% Federal Poverty Level. We assessed food insecurity utilizing the Household Food Security Survey Module in NHANES survey for the years 1999 to 2010 with mortality follow-up. Prospective analysis was performed using complex samples Cox regression with adjustment for known confounders to determine the relationship of food insecurity and CRS. **Results:** Prevalence of food insecurity among the low-income population was 16.1% among males and 21.7% among females. The mean follow-up was 6.5 years. For all-cause mortality, the overall unadjusted hazard ratio (HR) of food insecurity to no food insecurity was 1.28 (95% confidence interval [CI], 1.18–1.37, $p < 0.001$). Adjusted HR was elevated, 2.81 (CI 1.57–5.05, $p < 0.001$), among participants who were CRS-positive and food insecure but closer to 1.0 (2.48 CI 1.73–3.55, $p < 0.001$) among those who were CRS-positive and food secure, after controlling for medical and demographic risk factors. **Conclusions:** Food insecurity is associated with higher mortality than food security. Food insecurity also may modify the effect of CRS on all-cause mortality in a representative general population. Social policy, when addressing food insecurity, should be inclusive among those with specific chronic diseases.

Keywords

Food insecurity, cardiorenal syndrome, chronic disease, social disparities, poverty, hunger

Introduction

Food insecurity is a serious public health problem and has been associated with poor mental health and poor physical health in adults (Crews et al., 2014; Gundersen & Ziliak, 2018; Jones, 2017; Leung et al., 2015) While a key cause of food insecurity is related to income status and poverty, other determinants such as education level, physical asset ownership, financial skills, access to credit, and lower education level also contribute to being food insecure (Gundersen & Ziliak, 2018). Lack of reliable access to adequate food for an active, healthy life is a major component of food insecurity and is an important consideration of food science (Hawkins, 2018; USDA, 2018). The USDA categorizes food insecurity within two broad categories, low food security and very low food security, and includes reports of multiple indications of disrupted eating patterns and reduced food intake at times during the year encompassing reduced quality, variety or desirability of diet for one or more household members (USDA, 2018). According to the most recent data from the 2017 Current Population Survey Food Security Supplement, in the U.S.A. nationally 11.8% of people were considered to be food insecure, including 4.5% in the severe range with very low food security (Coleman-Jensen et al., 2018). The latest Economic Research Service summary report suggests 15 million households were food insecure at some point during 2017 making this a major public health issue and challenge (Oliveira, 2019) and perhaps the leading nutrition-related health care issue in the United States (Gundersen & Ziliak, 2018).

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Food insecurity has been associated with chronic diseases. It contributes to poor health outcomes among individuals with diabetes, cardiovascular disease and chronic kidney disease individually (Abdurahman et al., 2018; Lee et al., 2018; Silverman et al., 2015) and is a predictor of higher body weight (Hernandez et al., 2017; Nettle et al., 2017). In those with diabetes and food insufficiency, increases in medical care utilization were greater and they were more likely to report poor or fair health status than those who were not food insufficient (Suarez et al., 2015). Poor glycemic control and higher HbA1c has also been associated in adults who are diabetic and are food insecure (Froissart et al., 2005; NCHS, 2013).

Low income compounds the effect of chronic disease and food insecurity. Increased out-of-pocket costs healthcare costs from chronic disease may disproportionately impact individuals in a low socioeconomic status (Chilton & Rose, 2009). It is well known that food insecurity is associated with chronic disease among low income individuals (McCullough et al., 2008) and is a leading cause of depression (Gundersen & Ziliak, 2018).

Cardiorenal syndrome (CRS) is interconnected with multiple chronic diseases and can also be viewed as a proxy for chronic diseases. More specifically, CRS is a condition which describes disease involvement of both the heart and kidneys, while cardio metabolic and renal disease independently have been associated with food insecurity (Jih et al., 2018; Nelson et al., 2001; Palar et al., 2018). CRS has not collectively been investigated in food insecure populations. An integrative, multi-organ approach to chronic disease through CRS may allow for better management of diet and help establish the potential connection with disease management (Burke et al., 2017; CDC, 2018).

Social disparities have only been partially studied in the context of CRS (USDHHS, 1988). Diet is a critical component of management of these specific chronic diseases. Food insecurity is associated with increased health care expenditures and Berkowitz et al. (2018) suggest poor diet quality, food–medication trade-offs, and reduced ability to manage complex chronic conditions may contribute to the increased costs. One study estimated that individuals with food insecurity incurred an additional $1800 annually in health care expenditures (Berkowitz et al., 2018).

Defining food insecurities

Having a food-secure household is important in order to maintain a healthy and active life. Not only must food be socially and culturally acceptable, but also the food must be considered safe to consume and nutritionally adequate in order to be considered food secure (Steiner et al., 2018). Typically, the households that have incomes below the Federal Poverty Line (FPL) have limited health literacy and lack economic stability. The U.S. Census Bureau assesses the prevalence of food insecurity according to household experiences in the past 12 months (Hanson & Connor, 2014).

In this study, we used a nationally representative sample to evaluate associations between food insecurity and all-cause mortality among economically disadvantaged individuals. The combination of examination, laboratory and interview data allowed us to assess objectively the morality rates among individuals with both cardiovascular and renal dysfunction when food insecurity was involved.

Methods

We used data from the National Health and Nutrition Examination Survey (NHANES), cycles 1999 to 2010. The analysis sample is representative of noninstitutionalized U.S. adults aged 20 years and older. Since food insecurity predominantly affects the poor, we restricted our analysis to individuals living below the 130% Federal Poverty Level, due to the fact that many public assistance programs for the economically disadvantaged like the Supplemental Nutrition Assistance Program (SNAP) use this percentage as a cutoff point to provide benefits. Poverty level thresholds are updated annually according to the U.S. Census Bureau and definitions were established by the Social Security Administration.

Mortality outcome

Participants in NHANES 1999–2010 were prospectively followed up for mortality from the date of survey participation through to 31 December 2011 using probabilistic matching between NHANES and National Death Index death certificate records (NCHS, 2013). Additional sources of information used to determine the final mortality status of a NHANES survey participant include indication of deceased status from the Social Security Administration, Centers for Medicare and Medicaid Services, or death certificate review. We prospectively followed study participants from the survey participation interview date until the date of death or until 31 December 2011.

Food insecurity

The U.S. Department of Agriculture developed the Household Food Security Survey Module (HFSSM), a well validated questionnaire, in order to measure household food security over the prior 12 months (Berkowitz et al., 2018). In our study we only focused on adult health outcomes and therefore used responses to only the 10 household and adult items in the 18-item scale. The rest of the responses were not applicable to adults. In the HFSSM, more than 99% of the eligible sample participated. We dichotomized the HFSSM responses using validated cut-points. The respondent was deemed food secure if no items in the scale were answered affirmatively and food insecure. Those referred to as in marginal food security, low, and very low food security or if ≥ 1 items were answered affirmatively were deemed to be food insecure.

Cardiorenal syndrome

We used CRS as a proxy for a chronic disease in this study. We determined individuals to have CRS if they had both cardiovascular disease and chronic kidney disease (CKD). Glomerular filtration rate (GFR) was derived from the Cockcroft-Gault equation (Froissart et al., 2005). Even though, technically, a GFR less than 90 mL/min per 1.73 m^2 is considered CKD, the high number from advanced age places most people in this age group in either Stage I or Stage II CKD. Therefore, in ascertaining presence of CKD, in the CRS diagnosis, individuals had to have a GFR of less than 60 mL/min per 1.73 m^2 or a urine albumin-to-creatinine ratio (ACR) of less than 30 as previously validated (Inker et al., 2011). CVD was determined by the self-reported diagnosis of coronary heart disease, angina, stroke, congestive heart failure (CHF) or heart attack.

Covariates

All respondents over the age of 20 were asked "Other than during pregnancy, have you ever been told by a doctor or other health professional that you have diabetes or sugar diabetes?". For the purposes of this study, the participants who answered "borderline" or "yes" were considered to have diabetes. However, those participants who answered "no" were considered to be non-diabetic. The smoking data were subdivided into a trichotomous indicator as a smoker versus former smoker versus never smoker. Smoking status was determined by asking the questions "Have you smoked at least 100 cigarettes in your entire life?" and "Do you now smoke cigarettes . . . ?" The education level data was subdivided into a trichotomous indicator as "completed some High School" versus "High School graduate" versus "Some College or above." Finally, obesity data were subdivided into four categories according to body mass index (BMI) derived from measured height and weight. The categories were as follows: participants with BMI < 25 were considered normal weight; participants with a BMI $= 25$–29 were overweight; participants with a BMI $= 30$–39.9 were considered as obese; and participants with a BMI > 40 were considered severely obese. For the multivariate models, obesity was dichotomized and considered present for BMI ≥ 30 and absent for the rest.

Ethics compliance

Before data collection for NHANES, the NCHS received approval from the NCHS Research Ethics Review Board (changed from the Institute Review Board (IRB)), continuance of the protocol #2011-17. The NCHS complies strictly with the different laws and regulations which are written with the intent of protecting the specific participant's confidentiality and safety (NCHS, 2013). We received approval through Walden University IRB for secondary data analysis.

Statistical analysis

Continuous variables were described as both mean $\pm$ standard deviation (SD). Normal distributions of values were assessed by using the Shapiro-Wilk test. Categorical variables were expressed as percentage values. Bivariate analysis for categorical variables was conducted using Chi Square analysis. Multivariate analysis was performed using complex samples Cox regression to determine relationship of food insecurity on mortality. Additionally, Multiple Cox regression models were used to examine differences in food-secure and food-insecure participants after adjusting for sociodemographic and health factors. We considered all P-values < 0.05 as significant. All missing variables were excluded. All statistical analysis was performed in SAS v.9.4 (Carey, NC).

Results

Overall, 60,160 subjects were surveyed during the continuous NHANES cycles between 1999 and 2010. Our analysis included 9,245 subjects aged 20 years or older who reported earning less than 130% of the Federal Poverty Level Guidelines. Data were available for 57% females versus 43% males. Table 1 provides the data for the distribution of the demographic characteristics and medical risk factors of the participants by the status of food security using bivariate analysis. The weighted prevalence of food insecurity in the U.S. population with low socioeconomic status within the 20 years or older age group was 37.8% (n = 3,954), which is representative of 17,298,114 individuals in the U.S. population. The average age of the participants within the sample was 45.2 $\pm$ 0.29 years. There was a statistically significant ($P < 0.05$) association between age, race/ethnicity, education level, CRS, smoking status, obesity status and food security status. There were more females (21.7% versus 16.1%) with food insecurity than males, but this was not statistically significant. As shown in Table 1, the food insecure are statistically significantly younger (41.3 versus 47.4) in age than those that are food secure. Also, among different ethnic groups, Non-Hispanic Whites had the highest percentage (16.0%) with food insecurity and Hispanics (12.4%) had the second highest rate of food insecurity.

In addition to the basic demographic descriptive statistics, the variables that may confound and modify the effect of medical risk factors on food insecurity are presented in Table 1. Based on the bivariate analyses, individuals with CRS had lower percentage rates (3.7% versus 58.0%) of food security than those without CRS (CRS). Individuals who were never smokers were more (31.5%) food secure than those individuals who were current smokers (16.8%) or former smokers (14.0%). Finally, individuals with diabetes (6.9% versus 55.4%) and obesity (21.8% versus 40.3%) were less likely to be food secure than those without diabetes and obesity.

Table 1. Baseline characteristics of study participants[a] stratified by food security status.

Variable Demographic risk Factors	Total population (n=9,245)	Food Secure (n=5,291)	Food Insecure (n=3,954)
Female	56.9%	35.2%	21.7%
Mean age (SE)**	45.2 (0.29)	47.4 (0.40)	41.3 (0.39)
Ethnicity**			
Non-Hisp. White	54.4%	38.4%	16.0%
Non-Hisp. Black	15.9%	8.6%	7.3%
Hispanic	22.8%	10.5%	12.4%
Other	6.8%	4.7%	2.1%
Education Level**			
Some High School	38.7%	20.6%	18.2%
High School Grad	26.6%	16.6%	10.0%
Some College and beyond	34.7%	24.9%	9.8%
Medical Risk Factors			
CKD Stages[b]			
Normal to Mild $\geq$60	91.9%	55.7%	36.2%
Moderate 30–59	7.4%	5.7%	1.7%
Severe 15–29	0.6%	0.5%	0.1%
End Stage <15	0.2%	0.1%	0.1%
Diabetes	10.8%	6.9%	4.0%
Cardiorenal** Syndrome	5.2%	3.7%	1.5%
Smoking Status**			
Current Smoker	32.0%	16.8%	15.2%
Former Smoker	19.9%	14.0%	5.9%
Never Smoker	48.0%	31.5%	16.6%
Obesity Status**			
Normal Weight BMI < 25	33.8%	21.8%	12.0%
Overweight BMI = 25–29.9	31.9%	20.2%	11.8%
Obese BMI = 30–39.9	27.4%	16.3%	11.1%
Morbidly Obese BMI $\geq$ 40	6.9%	3.8%	3.0%

Note. *p < .05 **p < .001
[a]Individuals earning less than 130% of the Federal Poverty Level Guidelines.
[b]The CKD Stages were derived from categorizing the eGFR derived from Cockcroft-Gault Equation. The units are in mL/min per 1.73 m^2.

Mortality

During an average of 6.5 years of follow-up, 1,115 persons (10.1%) in the study group died. As seen in Table 2 and Figure 1, for all-cause mortality, the overall unadjusted hazard ratio (HR) for food insecurity to no food insecurity was 1.28 (95% confidence interval [CI], 1.18–1.37, p < 0.001)

Food insecurity as an effect modifier

In comparison to those individuals without CRS, the overall unadjusted HR for mortality for those individuals with CRS was 12.87 (CI 9.90-16.75, p < 0.001), as seen in Table 2 and Figure 1. Additionally, the unadjusted HR was elevated among individuals who were CRS-positive and food insecure (12.17 CI 9.39-15.78, p < 0.001) than among individuals who were CRS-positive and food secure (14.20 CI 8.24-24.49, p < 0.001). Finally, the adjusted HR remained elevated, 2.81 (CI 1.57-5.05, p < 0.001), among individuals who were CRS-positive and food insecure but closer to 1.0 (2.48 CI 1.73-3.55, p < 0.001) among individuals who were CRS-positive and food secure, after the results were controlled for medical risk factors (obesity and diabetes status) and demographic risk factor (gender, age, education level, and ethnicity).

Table 2. CRS and food insecurity HRs for mortality in multivariate regression modeling controlling for different demographic and medical risk factors.

	Total HR (95% CI)	Food Secure HR (95% CI)	Food Insecure HR (95% CI)
Model 1 (Food insecurity)	1.28 (1.18, 1.37)**	—	—
Model 2 (CRS)	12.87 (9.90, 16.75)**	12.17 (9.39, 15.78)**	14.20 (8.24, 24.49) **
Model 3 (CRS, gender)	13.71 (10.45, 18.00)**	13.52 (10.23, 17.88)**	14.25 (8.27, 24.55)**
Model 4 (CRS, gender, age)	2.99 (2.26, 3.95)**	2.92 (2.17, 3.93)**	3.12 (1.75, 5.57)**
Model 5 (CRS, gender, age education level)	2.90 (2.17, 3.87)**	2.83 (2.06, 3.88)**	3.05 (1.71, 5.42)**
Model 6 (CRS, gender, age education level, ethnicity)	2.88 (2.15, 3.86)**	2.83 (2.07, 3.86)**	2.93 (1.62, 5.32)**
Model 7 (CRS, gender, age, education level, ethnicity, obesity)	2.78 (2.03, 3.81)**	2.67 (1.90, 3.75)**	2.93 (1.62, 5.31)**
Model 8 (CRS, gender, age, education level, ethnicity, obesity, diabetes status)	2.59 (1.90, 3.54)**	2.48 (1.73, 3.55)**	2.81 (1.57, 5.05)**

Note. ***p* < .001
[a]While Models 2–8 were used to assess for a primary association between CRS and mortality, Model 1 was used to assess for the association of food insecurity and mortality.
[b]There were some minor variations in sample sizes within each model, as there were missing responses from some participants.

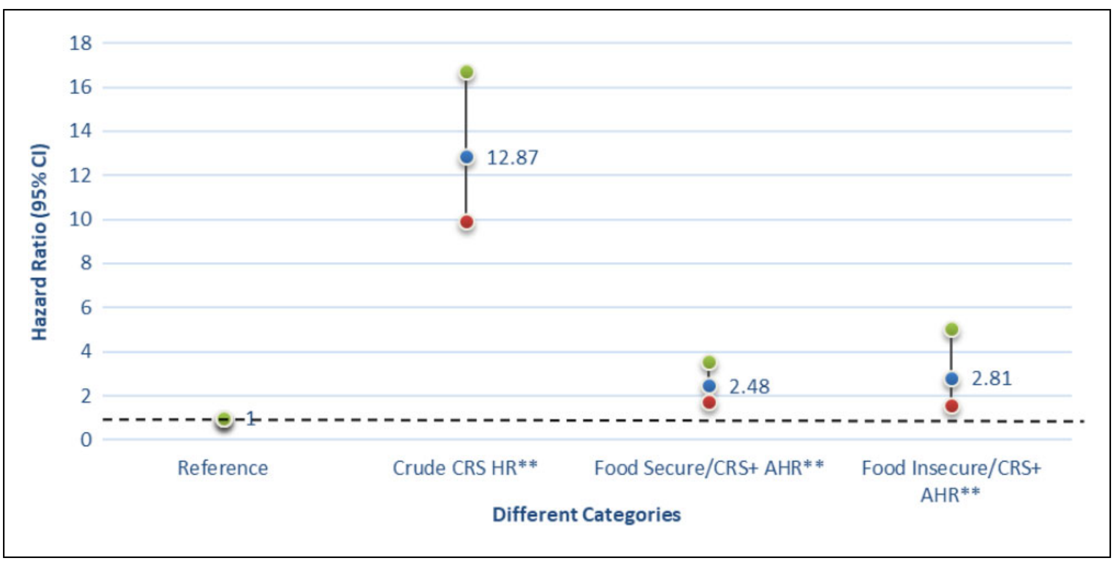

Figure 1. Unadjusted and adjusted hazard ratio (HR) of CRS as stratified by food security status. ***Note*: p < 0.001.

Discussion

This study finds new and important mortality risk profiles for individuals with food insecurity. Among adults with household incomes <130% of the FPL, food insecurity is associated with all-cause mortality. According to our findings, food insecurity is associated with 28 percent higher mortality rate than those individuals that are food secure. A number of studies have reported cross-sectionally that food insecurity is related to poor health in specific sub-populations (Chilton & Rose, 2009). This study longitudinally confirms the association of food insecurity and mortality due to poor health and adds to the overall food insecurity/mortality relationship in the literature (Gundersen et al., 2018).

These data have also provided the first opportunity to explore the longitudinal connection between specific chronic diseases like cardiorenal syndrome and food insecurity. Specifically, we found a higher hazard ratio for the food insecure group indicating the possibility of a modifying effect of food insecurity in the association between cardiorenal syndrome and all-cause mortality. Even though there were overlapping confidence intervals, the food insecurity hazard ratio was consistently higher even after controlling for confounding variables. Previous studies have demonstrated the association between chronic kidney disease and cardiovascular disease in NHANES (McCullough et al., 2008). Additionally, studies have shown that men with HIV, sexually transmitted infections, and illicit drug use are food insecure (Palar et al., 2018). Finally, studies have demonstrated the connection between food insecurity and poor mental health (Burke et al., 2017). Consequently, there is a tremendous need to address social and economic determinants of health in order to address food insecurity.

Food insecurity and chronic disease

Non-communicable diseases are the leading causes of death and disability in the United States (CDC, 2018). In addition, previous studies have shown the connection between food insecurity and chronic disease (Seligman et al., 2010). For instance, one study showed that individuals with multiple chronic conditions were more likely to be food insecure than those without food insecurity (Jih et al., 2018). Another study demonstrated that the prevalence of diabetes is higher among food-insecure adults than food-secure adults (Suarez et al., 2015). It is well known that diet contributes in a substantial way to the development of diseases and that dietary modification can play a role in prevention (USDHHS, 1988). A healthy and nutritionally adequate diet is important for chronic disease prevention and reduction. Some 80% of chronic conditions could be reduced by the adoption of healthy lifestyle recommendations, including diet (Bodai et al., 2018). Additionally, addressing food insecurity can lead to reduction in chronic disease related health care costs.

Food insecurity and social disparities

Social disparities are closely associated with food insecurity. It has been clearly established that insecurity due to being in an economically disadvantaged category leads to chronic stress and increased allostatic load (Khubchandani & Price, 2017). This is associated with increased catecholamine release leading to poorer health outcomes. Additionally, studies have demonstrated that even SNAP benefits are not always sufficient to address food insecurity among economically disadvantaged individuals. Furthermore, food insecurity status varies on a daily basis within the month where SNAP benefits are received (Gassman-Pines & Schenck-Fontaine, 2019). This variation is an additional contributor to allostatic load, which is related to poor health outcomes and mortality.

Food insecurity and poor diet

Food insecurity is also associated with poor diet (Steiner et al., 2018). A systematic review found food insecurity to be associated with a range of adverse nutritional quality indicators including less fruits and vegetables and lower intakes of several vitamins and minerals (Hanson & Connor, 2014). Specifically, researchers found that food insecurity was associated with 142% higher consumption of fast foods and soda among food insecure Veterans residing in California, than those individuals that are food insecure.

Limitations

Even though food insecurity is assessed by a previously validated questionnaire, the responses are susceptible to recall bias and social desirability bias as these are derived from self-reported data. For instance, review of patient records could serve as validation of self-reported data. Additionally, including longer follow-up time and disease-specific mortality may allow further exploration of the specific impact of food insecurity. Also, some of the diagnoses were derived from self-reported data leading to possible bias. Where possible, diagnoses and measures were combined with the examination portion of the study. Finally, alternative equations could have been used to calculate the presence of chronic kidney disease.

Implications for practice

Food insecurity is a condition that is largely unobservable and is connected to many medical conditions. As demonstrated through our research study, food insecurity leads to worsening clinical health and potential increased mortality. Our findings show that mortality outcomes were different in food insecure versus food secure population. Individuals who experience food insecurity also demonstrate clinical signs such as poor physical health status, poor chronic disease management, and poor cognitive function (Wong et al., 2016). Clinicians, nurses, and registered dietitians must have a high index of suspicion for food insecurity when managing chronic diseases in order to take into consideration the true impact of this condition. Regular screening may help identify individuals that are experiencing food insecurity, especially in vulnerable populations like those who are economically disadvantaged.

Recommendations for future studies

Future studies can enhance the present findings by including a longer follow-up time in order to understand the long-term impact of food insecurity. Additionally, a more diverse sample should be studied in order to investigate possible cultural and regional differences. Cultural differences in understanding of diet can further influence food insecurity. Also, researchers should study individuals' dietary behaviors and access to healthy foods in order to understand the finer nuances of how food insecurity is connected with chronic disease.

Authors' contributions

SB and TR equally conducted the literature review and contributed to the writing of the manuscript. SB conducted all statistical analyses and design of the study. SB and TR reviewed the final manuscript.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the Centers for Disease Control website https://wwwn.cdc.gov/nchs/nhanes/Default.aspx.

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) received no financial support for the research, authorship, and/or publication of this article.

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Ethical standards disclosure

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the NCHS Research Ethics Review Board and Walden University Institutional Review Board. Written informed consent was obtained from all subjects.

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