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Biobehavioral Factors That Shape Nutrition in Low-Income Populations:

A Narrative Review

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Abstract

Although evidence exists for an association between income level and diet quality, a causal relationship has not been established. A number of studies find that the price of nutritious food and the time cost to prepare foods are economically driven reasons for this relationship. However, in addition to economic constraints, low-income individuals and families face a number of additional challenges linked with food choice, eating behaviors, and diet-related chronic conditions that contribute to diet quality and health. Low-income individuals have a higher burden of employment and food- and housing-related insecurity that threatens the livelihood of their household. Poverty and exposure to these insecurities are hypothesized to activate biobehavioral and psychological mechanisms—endocrine, immune, and neurologic systems—that influence food choice and consumption. Examples of biobehavioral and psychological factors that influence diet are stress, poor sleep, and diminished cognitive capacity. High levels of stress, poor sleep, and cognitive overload compound the challenges of economic constraints, creating a mentality of scarcity that leads to poor diet quality.

Introduction

Low-income individuals and families face a number of challenges to acquiring enough nutritious foods for a healthy and active life. High costs for nutritious foods are hypothesized as the most compelling challenge to acquiring high diet quality. For example, a report published by the U.S. Department of Agriculture (USDA) examined how the purchase

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of fruits and vegetables varied across income levels. It was reported that monthly food spending on fruits and vegetables was about \$53 for income categories ranging from \$10,000-\$14,000 to \$50,000-\$69,999.¹ Not until family incomes increased beyond \$70,000 was there a significant increase in spending on fruits and vegetables to \$76 per month, suggesting a threshold effect. At this higher income level; however, spending on other foods, including calorically dense foods, also increased.

A review of the literature linking SES and diet quality by Darmon and Drewnowski² makes a case of not only a causal relationship but of a positive dose-response relationship between higher levels of SES linked to improved diet quality. The authors posit two primary reasons for the strong, monotonic relationship between income and diet quality.² The first is the higher cost in both food price and time to acquire and prepare food; which was highlighted in the IOM report, *Supplemental Nutrition Assistance Program: Examining the Evidence to Define Benefit Adequacy*.³ The second is the limited access to nutritious foods because of limited availability of grocery stores in low-income neighborhoods.^{2,4} Both of these mechanisms have been challenged. Using longitudinal data, economists have found that the income differences are weak when other factors are included, namely education and nutrition knowledge.⁵ Recent studies that focus on the food environment and dietary intake have been inconsistent for adults⁶ and find moderately strong relationship for children,⁷ and have highlighted the wide variation in measurement of the food environment. Food price alone does not explain poor dietary intake. Understanding barriers to the purchase and consumption of nutritious foods is important for informing a new generation of interventions targeted at improving diet quality.

The U.S. Dietary Guidelines for Americans are a set of recommendations for a healthy eating pattern associated with decreased risk for diet-related chronic diseases.⁸ Several studies have highlighted that the majority of Americans eat poorly.⁹⁻¹² For example, on a given day, only 2% of Americans reported meeting the recommendation for whole grains, 12.5% for fruits, and 13% for vegetables. Thus, suggesting that most Americans, regardless of income, eat poorly.¹³ A number of cross-sectional and longitudinal analyses have found very modest income inequalities and social disparities in dietary intake,¹⁴⁻¹⁶ and at least one study did not find income differences.¹⁷ Although reasons for consuming a poor diet may differ between upper- and lower-income Americans, at all income levels, diet quality is much lower than what might indicate a healthy diet quality. Over the life course, a persistent poor-quality diet compounded by stress can adversely impact future dietary intake, eating behaviors, and health outcomes.¹⁸

Further compounding economic constraints of acquiring a nutritious diet are the accompanying psychological and biobehavioral factors experienced by low-income individuals and households. The biobehavioral theory of health suggests a complex interplay between social and environmental exposures and human biological responses, which change and shape behavior.¹⁹ Stress and emotional responses to poverty and environmental uncertainties such as employment, food, and housing insecurities are regulated by the nervous, endocrine, and immune systems, and can influence health behaviors that play an important role in food choice, consumption, and diet-related chronic disease processes.¹⁸⁻²⁰

This narrative review discusses several examples of diet-related psychological and biobehavioral challenges that low-income households may face in addition to economic constraints. Living in poverty, especially extreme poverty, may have direct effects on stress, sleep, and one's cognitive capacity. However, the authors posit that uncertainty and threat to one's well-being associated with employment, food, and housing insecurities are the main mechanisms of how poverty triggers elevated levels of stress, poor sleep, and cognitive burden (Figure 1). Under conditions of uncertainty and threat, a biological response is mounted activating stress-, appetite-, and hunger-regulating hormones that signal the hypothalamus and shape eating behaviors.²¹ Together, these contribute to a mentality of scarcity,²² defined as the diminished cognitive capacity to manage challenges, which when combined with decreased purchasing power for healthy food, adversely affects dietary quality.

Approach and Findings

The authors identified a set of socioenvironmental inputs for which low-income individuals are at risk—employment, food, and housing insecurity—as well as biobehavioral responses of poor sleep, stress, and cognitive burden, which have all been found to influence dietary intake. This paper reviews the literature focusing only on research studies that assessed the relationship between a source of uncertainty or biobehavioral response and dietary intake among low-income populations. Academic journal articles were prioritized if they:

1. had a population-based focus;
2. assessed associations among low-income individuals or households; or
3. were based on a low-income sample.

Evidence of the Relationship Between Employment Insecurity and Diet

Job insecurity is defined as a “psychosocial stressor at the job level, caused by employment conditions and work organization, and reflecting a worker's perceptions of fear of job loss or instability.”²³ Job insecurity is perhaps most tangibly measured by how “precarious” one's employment conditions are; assessed with a scale to measure precariousness evaluating temporariness, disempowerment, vulnerability, wages, rights to benefits, and ability to exercise rights.²⁴ There is a preponderance of evidence from studies in the U.S., as well as countries around the world, suggesting that lower SES is linked with greater job insecurity.²³ The demands and psychosocial stress associated with insecure employment can have a deleterious effect not only on an individual's diet, but on the diet of the family as well. One qualitative study with low-wage employed parents described sacrifices and food choice coping strategies that were made in the household, and the researchers described a framework of “spill-over” between work and family.²⁵ This study describes parental behaviors of “food choice coping” to manage stress, by offering “quick meals” (e.g., macaroni and cheese, hot dogs) and using food as a treat to deal with stress. Despite multiple job stressors and lack of control, parents were reluctant to leave undesirable jobs because of their need for the income, low though it might be, and because of their hopes that these suboptimal jobs might lead to more permanent opportunities in the future. One mother described these pressures as follows: “Every day's pressure, it just wears and tears on you,

and a lot of times you do take it home...cause you're so tired, you can't do as much with your kids as you should...with me being a single mom, my kids are relying on me, and I'm relying on my job."²⁵ page 2,596

Individuals in low-income jobs that are insecure not only have greater difficulty feeding their families an optimal diet because of limited finances, but also because of limited capacity due to disproportionate job insecurity.

The relationship between employment and diet among the poor extends beyond the lower ability to purchase healthy food because of lower wages; work organization can influence eating patterns as well. Characteristics such as the length of one's workweek or the patterns of the hours that they work (e.g., "night shifts") are referred to as "work organization" factors.²⁶ Though educated, white-collar professionals tend to be working longer, regular hours in a week,²⁷ less educated workers are more likely to have irregular work hours and less flexibility with their work schedules.^{26,28} A higher percentage of low-income individuals are employed in jobs with irregular schedules, and the lowest-income earners have the most irregular work hours.²⁹ Because of an evolving "24/7" economy, two fifths of Americans work during nights, weekends, or on rotating shifts outside of a standard 9AM to 5PM workday, and this burden is disproportionately borne by the working poor, who more typically have these less desirable jobs.³⁰ A review of 21 studies regarding dietary intake among shift workers suggests that though overall total energy intake over 24 hours does not vary between day and shift workers, eating frequency, quality of the dietary intake, and energy distribution over the day is very different.³¹ Furthermore, shift workers appear to have a higher consumption of refined carbohydrates and animal fat and protein than non-shift workers, and have higher risk for metabolic disorders such as cardiovascular disease and diabetes.³¹ There are a variety of explanations to describe the lower diet quality of shift workers, including the mismatch between socially determined meal schedules of worker's friends and families and their own work-determined schedule, less optimal metabolism and digestion during the night when one is biologically "programmed" to be asleep, and availability of cheap, tasty, and energy-dense foods around the clock (e.g., in a vending machine).³¹

Evidence of the Relationship Between Housing Insecurity and Diet

Housing insecurity, also known as housing instability, has been variably defined as occurring when there are high housing costs in proportion to income, poor housing quality (including problems with electricity and heat), unstable neighborhoods, overcrowding, or homelessness,³² and also when a household makes frequent (e.g., more than two) moves in a year.³³ According to respondents in the National Survey of American Families, in 2002, an estimated 23.6% of Americans experienced difficulty paying rent.³⁴ Low-income families are more likely to be homeless, live in single room occupancy hotels, live with crowded conditions, and have unstable housing.³⁵ In 2014, more than 578,000 individuals were homeless.³⁶ Since the economic recession, added financial pressures have led many families to make alternative domestic arrangements to make ends meet, and the prevalence of "doubled-up households," defined as households including "an adult who is not the householder, spouse, or cohabitating partner of the household" increased from 22.4% in

2008 to 24.1% in 2010.³⁷ These “extra” individuals in the household can be family members (e.g., adult child moving in with parents) and non-family adults living in alternative arrangements, with or without financial compensation.

Housing insecurity among low-income individuals poses unique challenges to acquiring, storing, and preparing nutritious food for the family that are above and beyond the obvious challenge because of limited finances to pay for food. In comparison to families from high-SES backgrounds, low-income families may face unique challenges to preparing meals for all members of their household.³⁸ At the extreme end of household challenges that limit the ability to store and prepare foods, 4.4% of households in the U.S. lack a fully functioning kitchen.³⁹ However, for households that are doubled up, there is an extra demand on the capacity for food storage and preparation. The refrigerator needs to hold food for different households, and the use of the stove needs to be negotiated by two households who may not actually share meals together. Though there are theoretic advantages that can arise from pooled resources and social support, there are health consequences to consider for vulnerable families living in doubled-up arrangements.⁴⁰ One study of families who had been previously been living doubled up showed that though they were usually able to use the kitchen in the household that took them in, negotiating this use was often difficult and uncomfortable.⁴¹

Evidence of the Relationship Between Food Insecurity and Diet

Food insecurity, as defined by the U.S. Department of Agriculture, is the limited or uncertain ability to acquire enough food for an active and healthy life. During 2014, more than 48 million Americans lived in a household that experienced food insecurity.⁴² Inherent to household food insecurity is the association with anxiety, depression, and stress.^{43–45} Research on the influence of household food insecurity on mental health, such as maternal depression, suggests that the relationship is bidirectional and that interventions need to address nutrition, food security, and mental health in order to break recursive events.^{46,47}

Food insecurity-induced stress is hypothesized to influence food choice and dietary pattern by activating stress hormones and neuropeptides that favor highly palatable foods.⁴⁸ Indeed, food insecurity is associated with lower diet quality,⁴⁹ a lower intake of nutritious foods, and a greater dependence on energy-dense but nutrient-poor foods.⁵⁰ Food insecurity is also associated with dietary restraint, measured by a scale that captures dieting followed by disinhibited eating or a susceptibility to overeating⁵¹ and disordered eating measured by the Eating Attitudes Test.⁵²

Not only is food insecurity associated with higher prevalence of diet-related chronic conditions such as diabetes^{53,54} and gestational diabetes,⁵⁵ food insecurity is also associated with poor management of these conditions.^{56,57} The relationship among food insecurity, stress, and diet-related chronic disease has been characterized as a cyclic and bidirectional process whereby food insecurity and stress can lead to the development of chronic conditions. Chronic conditions, such as diabetes, then exacerbate resource constraints by adding healthcare costs, necessitating a greater need for nutritious foods, and perpetuating food insecurity.⁵⁸

Evidence of a Relationship Between Stress and Diet

Stress that causes a threat to one's well-being, compared with stress that presents a surmountable challenge, activates the hypothalamic-pituitary-adrenal axis, often causing a preference for highly palatable foods to dampen the stress response and the increased stress-related hormones shifting metabolism to favor storage of excess calories as central fat.^{48,59} The American Psychological Association national survey of stress in the U.S. has been an annual poll since 2007.⁶⁰ The 2014 survey reported that U.S. stress score was 4.9 on a 10-point Likert scale where 1 is *little or no stress* and 10 is *a great deal of stress*. Stress scores were higher among women (5.2) than men (4.5) and among individuals in low-income (<\$50,000 per year) households (5.2). The leading reason for stress was financial (64%), followed by work-related issues (60%), family responsibilities (47%), and health concerns (46%). The survey asked about eating as a response to stress. More low-income individuals with money concerns (38%) compared with low-income people without money concerns (15%) reported eating too much or eating unhealthy foods because of stress. A recent review study found that upper-income individuals were more likely to have lower stress levels, healthier eating patterns, and lower body weight.⁶¹ The opposite was found for lower-income individuals who had higher levels of stress, and who were more likely to have less-healthy dietary behaviors and higher body weight. The findings were more consistent among women than men. The nature of the relationships among level of stress, eating behaviors, and metabolism are multifactorial.⁶¹ In a study of 101 women who participated in the Special Supplemental Nutrition Assistance Program for Women, Infants, and Children, perceived stress was assessed with regard to diet quality, eating behaviors, and weight status. An analysis using structural equation modeling showed that higher levels of perceived stress had a direct association with uncontrolled eating, emotional eating, and severe obesity.⁶² In a larger sample of postpartum women who participated in the program (N=711), anxiety, depression, and perceived stress were strongly associated with emotional eating; depression was associated with dietary restraint.⁶³ Furthermore, stressful events were linked to emotional eating in qualitative study of low-income overweight/obese mothers.⁶⁴ The consistency of findings in these studies suggests that interventions aimed at improving dietary intake should consider stress and eating behaviors.

Evidence of a Relationship Between Poor Sleep and Diet

More recently, there has been increased interest in understanding the relationship between sleep quality and diet. A short period of decreased sleep duration resulted in signs of impaired glucose tolerance, decreased insulin response, and increased cortisol response, which Spiegel et al.⁶⁵ concluded demonstrate the harmful impact of short sleep on carbohydrate metabolism and endocrine function through alterations of the hypothalamic-pituitary-adrenal axis. Two important appetite-regulating hormones—leptin and ghrelin—are influenced by sleep duration and are hypothesized to play a direct role in weight gain. Leptin, created in fat (adipose) tissue, signals to the brain to suppress appetite whereas ghrelin, which is created in the stomach, signals to increase appetite. Both leptin and ghrelin travel through blood, cross the blood-brain barrier, and activate the hypothalamus. Shorter sleep duration has been associated with higher BMI levels, and also lower levels of leptin and higher levels of ghrelin, which cause hunger, increased appetite, and potentially increased caloric consumption.⁶⁶

Low-income individuals disproportionately experience poor sleep duration and face higher levels of stress, which influences food choice and eating behaviors. According to the National Sleep Foundation, adults aged 26–64 years should sleep 7–9 hours/day for optimal health.⁶⁷ Between 2007 and 2010, 37.3% of U.S. adults reported sleeping on average 6 hours.⁶⁸ Economic and ethnic disparities in sleep exist, such that low-income populations are at increased risk of poor sleep quality in comparison with those from higher-SES backgrounds.^{69–71} For instance, a cross-sectional analysis of national survey data suggests that after adjusting for age and education, individuals earning <\$20,000 annually are more likely to get 5 hours of sleep compared with individuals who earn >\$75,000 per year.⁷⁰ Furthermore, discrimination has been associated with poor sleep among African Americans.^{72,73}

Poor sleep has been hypothesized to lead to non-homeostatic eating (eating in the absence of hunger) by being more likely to eat when stimulated by sight or smell of food, and by being more likely to eat in response to negative emotions; this especially occurs with children and women.^{74,75} A review of epidemiologic studies suggests a positive correlation between short sleep duration (<6 hours) and higher total energy intake, higher fat intake (e.g., total fat and saturated fats), as well as lower fruit and vegetable intake; this is especially concerning given the fact that individuals with lower SES are more likely to have less sleep.⁷⁶ In addition to macronutrients and particular food types, short sleep duration is also shown to be negatively correlated with eating breakfast and dinner meals, based on an analysis of cross-sectional dietary recall data from the 2005–2010 National Health Examination and Nutrition Examination Survey (NHANES).⁷⁷ Other measures of sleep quality, such as sleep latency (i.e., length of time to fall asleep) and sleep disruptions (i.e., waking in the middle of the night), are associated with poor diet quality.⁷⁸ Furthermore, food insecurity is associated with poor sleep quality^{70,79} and sleep latency.⁶⁹ According to a cross-sectional analysis of data collected from the 2005–2010 NHANES, women (aged 22 years) who experienced very low food security had a shorter duration of sleep than women living with full food security. The study also found that men living with very low food security, low food security, and marginal food security took longer to fall asleep than men who were fully food secure.⁷⁹

Evidence of a Relationship Between a Mentality of Scarcity and Diet

Mullainathan and Shafir²² describe scarcity as “...more than just the displeasure of having very little. It changes how we think. It imposes itself on our minds.” This mentality of scarcity leads to a depletion of cognitive resources, which diminishes the reasoning center in the prefrontal cortex disrupting food regulation²¹ and reduces impulse control.⁸⁰ There have been a number of studies linking a depletion of cognitive resources with preferences of unhealthy foods. In the classic experiment by Shiv and Fedorikhin,⁸¹ college students were asked to memorize a seven-digit number or a two-digit number, walk into another room, and choose between a piece of chocolate cake or a serving of fruit salad. Students who memorized the seven-digit number were significantly more likely to choose the chocolate cake than students who memorized the two-digit number. Variations of this experiment have produced similar results, suggesting that impulsive eating and irrational food choices can result when cognitive resources are depleted.^{82–84}

In the presence of poverty, the mentality of scarcity is compounded.⁸⁵ Low-income individuals are more likely to face uncertainties of many necessities (e.g., housing, food, employment), each of which requires sufficient cognitive resources to manage. Furthermore, it has been well established that energy-dense, processed foods are heavily marketed and widely available in low-income neighborhoods.^{86,87} Combining the depletion of cognitive resources with marketing of unhealthy foods has been shown to exert an interactive effect on dietary intake. In an experimental study, 351 college students were randomly assigned to four groups:

1. high cognitive load and food advertising;
2. low cognitive load and food advertising;
3. high cognitive load and non-food advertising; and
4. low cognitive load and non-food advertising.⁸⁸

The participants were then allowed to eat ad libitum from an array of healthy and unhealthy snacks. Results showed that exposure to food advertising resulted in a 43% increase in unhealthy snacks consumed among students in the high cognitive load group; no effect was observed in the low cognitive load group. Resource scarcity experienced during early life is hypothesized to result in responding to a scarce resource environment as an adult by being more impulsive, taking risks, and responding to temptations. These behaviors can put individuals and households at risk of being focused on decisions based on present need (e.g., cheap, highly caloric, nutrient-poor food) and immediate gratification (e.g., cheap, highly palatable, high-fat, high-sugar food). Short-term decisions that favor high-calorie foods in the presence of uncertainty may be very rational, although not oriented to consequences of future health and well-being.⁸⁰

Thus, high levels of uncertainties, in the context of the low-income food environment, may inhibit healthy food choices among low-income individuals, even in the presence of healthy food. Combined with the influence of chronic, psychological stress and poor sleep on metabolic health,⁵⁹ this mentality of scarcity can greatly affect one's dietary intake and diet quality, contributing to increased risks of chronic conditions over the life course for low-income children and adults.^{18,19}

Discussion

Darmon and Drewnowski^{2,4} make a case for a causal relationship between income and diet quality; however, several studies refute this link as a number of socioeconomic, health, and biobehavioral factors are also associated in shaping eating behavior and diet quality.^{5,21} Although the relationship between SES and diet quality may be partially explained by the high cost of nutritious foods and potential inaccessibility of fresh whole foods in some neighborhoods, there are other compelling factors that compound economic constraints and influence food choice among low-income individuals and households. Chief among these factors are the burdens of uncertainty with employment, housing, and food. These uncertainties can threaten one's well-being and livelihood, lead to an overwhelming psychological and cognitive burden, influence biobehavioral pathways (e.g., psychological

distress, short sleep duration), and create a mentality of scarcity that predisposes one to poor diet quality and subsequently cardiometabolic diseases.^{18,89,90} Therefore, increasing income alone will not necessarily lead to improved diet quality.

Using the proposed conceptual framework, a focus on employment opportunities, housing stability, and food security will assist families with procuring and consuming a nutritious diet in at least three ways. First, stable income, housing, and food will assist individuals by having more purchasing power to be able to afford nutritious foods. Second, stability will decrease stress and improve sleep, which in turn will improve dietary behaviors and diet quality. Third, stability may help to decrease cognitive burden of navigating a poor food environment and lead to improved diet quality.

Future policy and population-level interventions need to be more comprehensive and have a systems-level approach to addressing poverty-related barriers to health eating, which includes providing secure safety-net programs that address employment, housing, and food security as well as providing resources to address mental health.

Conclusions

Low-income individuals and households experience unique challenges to healthy eating and the current review confirms the need for interventions that acknowledge the multiple ways in which poverty influences dietary behaviors. Although cost of food is often cited as a major barrier to purchasing and consuming nutritious foods, this review provides a unique lens to understand how poverty, when exacerbated by uncertainty (i.e., food, employment, and housing insecurities), might trigger a biobehavioral response that alters neuroendocrine function and carbohydrate metabolism, which then leads to poor diet quality. The conceptual framework in this review could be used to inform the design of future interventions that aim to improve eating behaviors among low-income populations.

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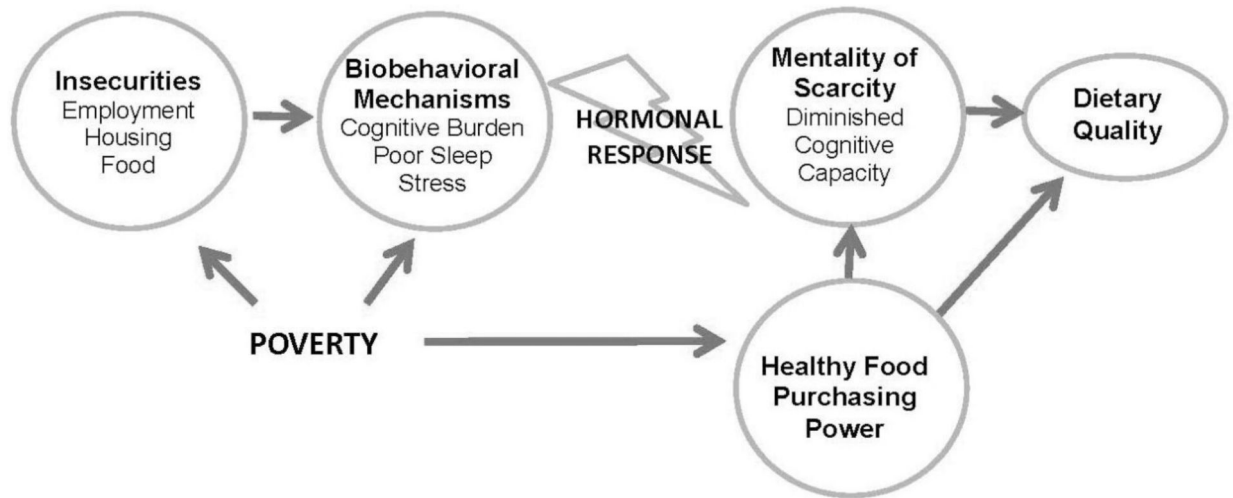


Figure 1. Conceptual Framework: how poverty creates environment of scarcity leading to poor dietary quality.