

Food Insecurity and Diabetes Prevention and Control in California



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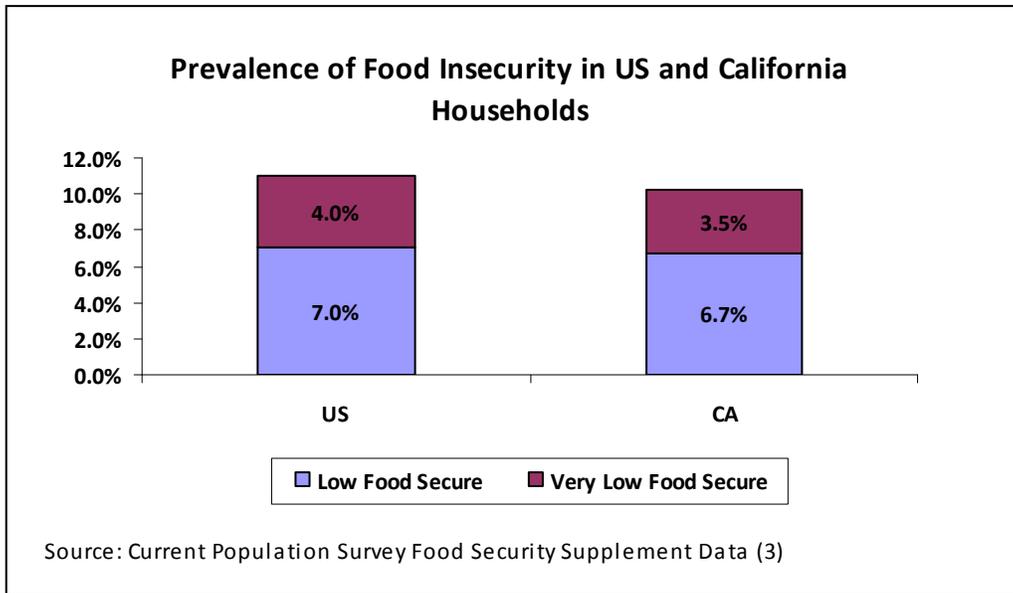
Food Insecurity and Hunger

Hunger and food insecurity are related concepts, but have distinct definitions. *Hunger* is defined as the “uneasy or painful sensation caused by a lack of food” (1).^{*} This physical sensation can occur after only a few hours without food, but often disappears with prolonged fasting. *Food insecurity* is a broader concept, one which incorporates the physical sensation of hunger as well as anxiety that food budgets are inadequate, the experience of running out of food without money to buy more, perceptions that food is inadequate in quality or quantity, adjustments to normal food use, and reduced food intake (2). These elements of food insecurity encompass important compensatory strategies used by food insecure adults to prevent the physical sensation of hunger, such as relying on a few low-cost, energy-dense foods for much of caloric intake. These low-cost, energy-dense foods are often highly processed foods which offer little nutritional value. In 1990, the Life Sciences Research Organization defined *food insecurity* as the limited or uncertain “availability of nutritionally adequate and safe foods” or “ability to acquire acceptable foods” without resorting to soup kitchens, food banks, scavenging, or other coping strategies (1).

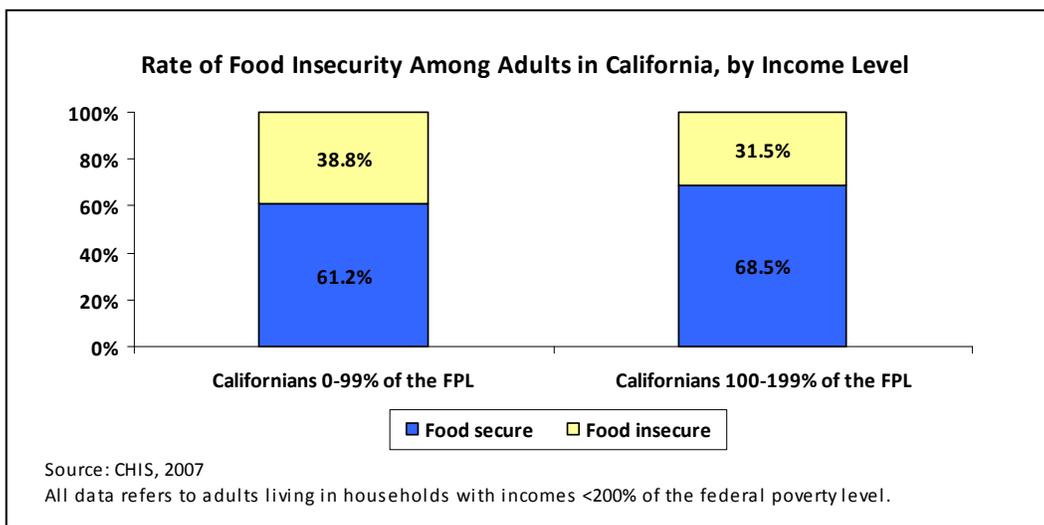
Both low and very-low food secure households are considered food insecure. In the United States, adults respond to increasingly severe levels of food insecurity in a predictable progression. Households categorized as having “low food security” often display similar compensatory behaviors, while households categorized as having “very low food security” display additional behaviors. More than 70% of low food secure households report anxiety about running out of food, the experience of running out of food, and the inability to afford balanced meals. In addition to these behaviors, most adults in very low food secure households cut the size of their meals or skip meals, eat less than they feel they should, and experience the physical sensation of hunger (3). These compensatory strategies are experienced first among adults in the household, and only affect children as household food insecurity becomes more severe.

Across the United States, 11.2% of households are food insecure. These households include 36.2 million people, 12.4 million of whom are children and adolescents (3). The prevalence of food insecurity in California is 10.2% (6.7% low food security and 3.5% very low food security), or more than 3.7 million people (3). In 2005, the prevalence of food insecurity exceeded 35% among adults with incomes less than 200% of the federal poverty level in Alameda, Napa, Fresno, Kings, Merced, Tulare, and Santa Barbara counties (4).

^{*} A glossary of key terms is included in the Appendix.



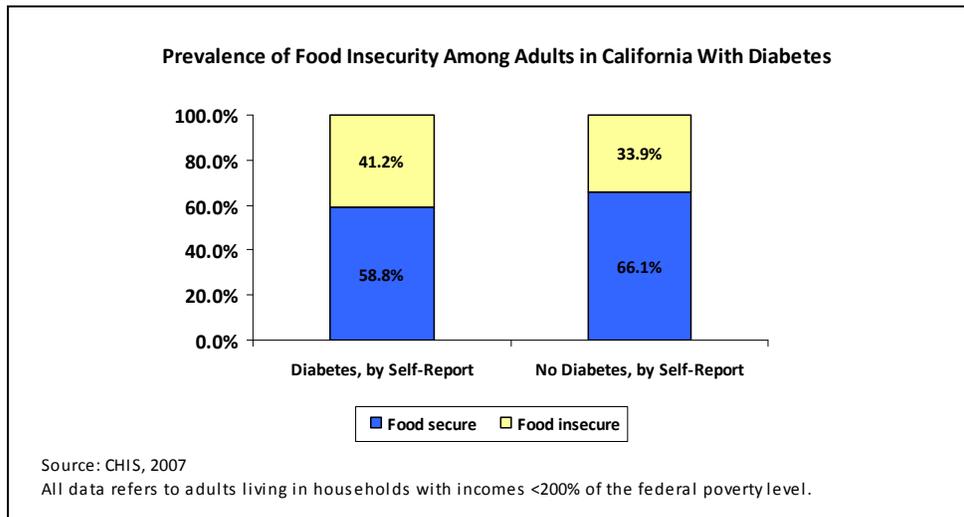
Low and very low food security are strongly related to, although not synonymous with, poverty. About 1/3 of households with incomes <130% of the federal poverty level are food insecure. However, more than half of food insecure households have incomes >130% of the federal poverty level, making them generally ineligible for Supplemental Nutrition Assistance Program (SNAP, formerly Food Stamps) benefits. Rates of food insecurity are also particularly high in African-American and Latino households (3). Other strong risk factors for food insecurity in California include old age, pregnancy, households with children (particularly single-parent households), lack of employment, and undocumented residency (5). These demographic correlations suggest that it is important to understand food insecurity as it relates to socioeconomic and racial/ethnic inequalities in health, particularly for diseases which are sensitive to dietary intake, such as diabetes.



Food Insecurity and Diabetes

Among *non-elderly* adults living in US households with incomes <300% of the federal poverty level, the rate of diabetes is about 7.1% in food secure households, 6.4% in low food secure households, and 16.6% in very low food secure households. After accounting for differences in socioeconomic status, risk of diabetes is about 2.5 times higher in very low food secure households compared to food secure households, and after additionally accounting for differences in obesity, risk of diabetes is almost 3 times higher (6). These numbers suggest that the increased risk of diabetes in very low food secure households can not be attributed solely to increased rates of poverty or obesity in these households. Average fasting blood sugar is 100 mg/dL among *non-elderly* adults living in food secure households, 101 mg/dL among those in low food secure households, and almost 107 mg/dL among those in very low food secure households, raising the possibility that food insecurity may play a role in the pathway between low socioeconomic status and increased incidence of diabetes.

Many Californians with diabetes have low or very low food security. Among all California households with incomes <200% of the federal poverty level, the food insecurity rate is 41% among those who have ever been told they had diabetes, compared to only 34% among those who had never been told they had diabetes. About 14.6% of food insecure adults in California (or 419,000 adults) self-report a diagnosis of pre-diabetes or diabetes. In contrast, only 11.1% of adults in food secure households self-report a diagnosis of pre-diabetes or diabetes. It is likely that many more food insecure Californians have diabetes than suggested by these estimates, as the inadequate access to health care commonly observed among food insecure adults often leaves diabetes unrecognized for long periods of time. The prevalence of food insecurity among Latino patients with diabetes receiving care in an adult general medicine clinic at San Francisco General Hospital was 43% (7).



Food Insecurity and Obesity

There is a well-established connection between low food security and obesity/overweight, particularly in women. This relationship has been observed in population-based surveys (8), the California Women's Health Survey (9), and among high-risk subsets of women (10). Mean body mass index (BMI) among non-elderly women in the US with incomes <300% of the federal poverty level is 29 kg/m² in food secure households, 31 kg/m² in low food secure households, and 29 kg/m² in very low food secure households (8). For an average height woman in the US, the difference in BMI between 29 and 31 kg/m² is equivalent to more than 11 pounds. For reasons that are not clear, associations between food insecurity and BMI have not been consistently observed among men or children (11, 12).

There are a number of potential explanations for the association between food insecurity and obesity. These include dietary substitutions, behavioral adaptation to episodic food scarcity (including the "thrifty gene hypothesis"), and lack of geographic access to healthy food alternatives. Each of these potential explanations has relevance for the prevention and control of diabetes.

Dietary Substitutions and Food Insecurity

The association between food insecurity and obesity is generally observed with among women low, but not very low, food security. In food secure households, adults are able to meet their daily caloric needs by spending adequate income on food. With low food security, adults appear to engage a number of compensatory strategies to use less money but still maintain their daily caloric needs. For example, reducing dietary variety and concentrating intake on a few inexpensive, calorically-dense foods will allow adults to meet, or often exceed, their daily caloric requirements while spending less money on food. This leads to what some have called the "obesity-hunger paradox." In very low food secure households, however, adults may make these same dietary substitutions, but are often unable to exceed their daily caloric requirements (13). Average BMI among very low food secure women is therefore the same as average BMI among food secure women.

In the US, foods with the highest energy density also tend to cost the least. Oil, shortening, butter, cookies, sugar, bread, pasta, and rice all cost far less per calorie of

"We have only one food on our plate." (17)

"Like oatmeal, you can eat that for breakfast, lunch, or dinner, and sometimes we do..." (18)

energy than fruits, vegetables, meat, and most dairy products (14).

Between 1985 and 2000, increases in the prices of fruits, vegetables, and dairy

products have far outstripped increases in the prices of sugars and sweets, fats and oils, and carbonated soft drinks (15, 16). The latter foods have thus become increasingly

cheap over the last few decades, a trend partially driven by agricultural subsidies for corn (the starting material for high-fructose corn syrup). It is thus logical that one of the first strategies used in food insecure households to stretch inadequate food budgets is to reduce dietary variety and concentrate intake on a few inexpensive foods, foods which tend to be highly-processed, rich in calories (generally in the form of high-fructose corn syrup), and poor in nutrients. Although annual per capita consumption of high-fructose corn syrup has increased from 1.5 pounds in the early 1970's to almost 63 pounds in 2000 (16), consumption of added sugars is highest among households at the lowest income levels (19). Much of these added sugar are consumed in the form of sweetened beverages.

The increased consumption of these energy-dense foods is offset by a reduced consumption of nutrient-rich foods. In an average week, US adults living in food secure households consume an average of 11 servings of fruit, 19 servings of vegetables, and 13 servings of milk/dairy, compared to the 8, 17, and 11 servings respectively in food insecure households (20). Adults in food insecure households also have lower intake of the B complex vitamins (riboflavin, niacin, B₆, and B₁₂), magnesium, iron, zinc, and calcium (20-22).

Behavioral Adaptation to Episodic Food Scarcity

Food insecurity is cyclic and episodic. For many families, the food budget is adequate during the first few weeks of the month when paychecks or SNAP (Food Stamps) benefits are distributed, but food money is often drained by the last week of the month. For other families, food budgets are adequate during most months but stretched thin by heating bills in the winter, by the loss of school-based breakfast and lunch for children during the summer months, or by periodic, unforeseen expenditures (such as health care costs related to acute illnesses). This pattern of recurrent exposure to inadequate food may result in disordered eating, in particular *binge-fast* cycles. That is, adults who are exposed to episodic food scarcity tend to overconsume during food adequacy in expectation of future food shortage. Exposure to food insecurity during childhood may be a particularly strong risk factor for such binge-eating behaviors during adulthood (23).

"... when we're down on groceries and then groceries do come in, that first day or two is, you know, it's kind of wild." (23)

"[When food became available again,] I would eat until I had such a big stomachache." (23)

"The last week of each month, it is an internal panic." (17)

Disordered eating may also be a consequence of the high levels of stress which accompany food insecurity. This is especially true in households with children, where parents fear children will be removed from the house because of neglect if they are unable to provide adequate nutrition. Chronic stress is associated with obesity,

“I was so scared that my son would be taken away.” (17)

“When I don’t have enough, I become aggressive or rude or angered with my children.” (17)

particularly the type of obesity that predisposes adults to diabetes and high cholesterol. The cyclic nature of food insecurity may therefore not only result in binge eating behaviors, but may also interact with stress pathways that promote obesity.

When food is unpredictable, it may be adaptive to accumulate fat during food plenty so that it will be available to provide energy during food scarcity. Some have even suggested that this adaptation is hard-wired into our genetic make-up (the so-called *thrifty gene* hypothesis). Throughout most of human evolution, humans have been exposed to episodic food scarcity. Hunger is an adaptive mechanism to ensure that we expend energy in order to eat as much as we can. From this evolutionary perspective, it seems logical that adults exposed to episodic food insecurity will be more likely to develop obesity. Studies in animals have shown that cyclic food restriction results in a clear preference for calorically-dense foods, food hoarding, aggression, increased body fat, decreased lean muscle mass, and quicker weight gain with refeeding (24, 25).

Our genes may also explain why food insecure adults are more likely to have diabetes (26), particularly in the food environment that predominates in the US. During starvation, sugar levels in the bloodstream fall. Muscle protein must then be broken down to create energy for the brain, a scenario beneficial to the brain but detrimental to the muscles necessary to acquire additional food. Sustained maintenance of high blood sugar levels may therefore reduce loss of muscle protein during food scarcity. If sustained over time, however, this condition may result in type 2 diabetes. Long-term studies have suggested associations between acute episodes of starvation and the development of diabetes in later life (27).

Geographic Access to Healthy Food Alternatives

The relative paucity of supermarkets in low-income neighborhoods likely exacerbates the difficulty many food insecure households face in purchasing healthy food alternatives. These so-called “food deserts” have been observed across the United States, in particular in low-income African-American neighborhoods (28, 29). A Los Angeles County study performed in 2002 demonstrated that there was one grocery store for an average of every 18,649 residents in the city, but in one low-income neighborhood there was only one grocery store for every 27,986 people (30). More than 1 million Californians do not have access to a vehicle and almost a third of them live further than one-half mile from a grocery store, creating a significant barrier to accessing fresh foods (31). Only 41% of food pantry clients in Los Angeles live within walking distance of a food store stocking fresh produce (32). Restaurants in low-income, African-American neighborhoods in Los Angeles are also less likely than those in more affluent areas to provide healthy food choices (33). Residents of low-income

neighborhoods in Los Angeles thus face compounding barriers to accessing healthy foods. These patterns are repeated, and potentially magnified, in cities across California and the rest of the United States.

Many low-income households make just a single monthly shopping trip to a large supermarket, usually right after receiving SNAP benefits or a paycheck. Additional shopping during the month to replace perishable items often occurs at geographically-convenient corner stores and convenience stores, where fresh fruits and vegetables are rarely stocked and, if stocked, are more expensive than in large supermarkets (34).

Food Insecurity and Diabetes Control

“The end of the month, I start getting out of food...but I have to eat something, ‘cause if I don’t eat behind my [insulin] shot, that shot will make you so sick. I just eat anything I can find during that time just to keep me from getting sick.” (18)

“Snow boots or insulin or groceries this week?” (17)

Food insecure adults with diabetes may be at increased risk of both having blood sugars that are too high (*hyperglycemia*) and blood sugars that are too low (*hypoglycemia*). Among low-income adults with diabetes in the US, only 46% of those living in food secure households had poorly controlled diabetes, compared to 63% of those living in low food secure

households and 70% of those living in very low food secure households (8). *Hemoglobin A1c* is a measure of the adequacy of blood sugar control among patients with diabetes. Most adults with diabetes are directed to achieve hemoglobin A1c values of about 7%; values greater than 9% are considered very poor. In one small study of patients receiving care in community health clinics, average hemoglobin A1c was 9.2% among food insecure patients and 7.7% among food secure patients (35). These data imply that blood sugar control among food insecure adults with diabetes is frequently very poor, which places these individuals at greater risk of diabetes complications (particularly blindness, amputations, and kidney failure).

There is additional evidence suggesting that blood sugar among food insecure adults with diabetes is frequently *too low* (hypoglycemia), a complication of diabetes treatment that significantly impairs quality of life, may affect long-term cognitive function, and can occasionally be fatal. A study from an urban, safety net hospital reported that 61% of patients with diabetes experienced at least one hypoglycemic reaction annually. Patients attributed a third of those episodes to the inability to afford food (36). In another small study, food insecure patients with diabetes were more likely than food secure patients with diabetes to report a significant hypoglycemic reaction and more likely to report their hypoglycemic reactions were due to an inability to afford food (37).

Mechanisms for Impaired Blood Sugar Control among Food Insecure Adults

There are multiple mechanisms by which food insecurity may predispose adults with diabetes to both hyperglycemia and hypoglycemia. Interventions may need to address each of these mechanisms in order to prevent diabetes complications associated with food insecurity.

Diet

A healthy diet for people with diabetes is high in vegetables, fruits, and protein (including low-fat dairy products), and low in added sugars and fats. An inability to reliably afford these foods has important implications for the ability of adults with diabetes and pre-diabetes to prevent disease complications and appropriately manage blood sugar levels. During food adequacy, binge-eating and reliance on calorically-dense foods for dietary intake makes blood sugar levels climb. High blood sugars, when maintained over time, are a risk factor for blindness, amputations, and kidney failure. During food scarcity, unreliable access to food may also reduce blood sugar to dangerous levels.

Exercise

Although patients with diabetes are urged to engage in regular physical activity, the fatigue associated with food shortages makes such activity challenging (38). For those who do exercise, inadequate dietary intake coupled with physical activity may exacerbate a tendency toward hypoglycemia if blood sugars are not carefully managed.

Health Care Costs

In the setting of severe budget constraints, individuals prioritize spending on food and health care differently. Some put off buying food so they will have enough money to buy medications or health care supplies; others put off buying medications or health care supplies so they will have enough money to buy food. Both strategies have important implications for blood sugar control. Those who put off buying medications in order to buy food may reduce the dose of their diabetes medications to make them last longer, space out dosing of medication, or run out of medications and not replace them. Food insecure adults may also be more likely than food secure adults to put off purchasing supplies for testing blood sugar levels at home. Conversely, those who put off purchasing food in order to afford their medications may be inadvertently exposing themselves to dangerously low blood sugar levels (if food is unavailable), or high blood sugar levels (if dietary intake shifts toward calorically-dense foods), or poor-quality diets with inadequate micronutrient intake. Food insecure adults also postpone needed medical care more often than food secure adults. The deferment of necessary medical care may contribute to the increased need for Emergency Room care and hospitalizations observed among food insecure adults (37).

Food Insecurity and Diabetes Co-Morbidities

Prevention of diabetes-related complications requires control of not just blood sugar, but blood pressure and cholesterol. In fact, for patients with diabetes, control of blood pressure and cholesterol is more important for preventing heart attacks and saving lives than control of blood sugar (39). Food insecure adults appear to have a 20-30% greater risk of high blood pressure than food secure adults (6). Food insecure adults report difficulty affording the low-salt food alternatives which are often recommended for patients with high blood pressure or congestive heart failure (18), instead relying on highly-processed foods for calories. The very high salt and low potassium content of these foods appear to be a significant contributor to elevated blood pressure (40). Existing studies do not show that food insecurity increases risk for elevated cholesterol. However, the difficulty affording medications among low and very low food secure adults might translate into worse control of high blood pressure, high cholesterol, and depression, each of which would be expected to increase diabetes complications. Finally, tobacco use is a strong risk factor for both food insecurity and diabetes complications (41).

Implications for Clinical Management of Pre-Diabetes and Diabetes

Health systems and clinicians should consider screening all patients with pre-diabetes or diabetes for food insecurity in settings where the prevalence of food insecurity is expected to be high (such as safety net clinics and hospitals). A single question may have test characteristics that are acceptable for use in the clinical setting: “In the past month, was there any day when you or anyone in your family went hungry because you did not have enough money for food?” Of the patients in a pediatric clinic whose caregivers were administered this question, 78% of those who responded “yes” also reported being food insecure by the 18-item Household Food Security Scale, and 84% of those who responded “no” reported being food secure using the 18-item Scale (42).

Nutrition education provided to patients with pre-diabetes or diabetes should emphasize cost-neutral strategies for dietary change. For example, reducing portion sizes may be more feasible than many dietary substitutions commonly recommended for adults with pre-diabetes or diabetes. Encouraging intake of frozen, rather than canned, fruits and vegetables is inexpensive and significantly reduces intake of salt and sugar commonly added to canned fruits and vegetables. Providing specific information about local farmers’ markets (directions, hours, etc.) may allow many to access a cheaper source of fresh fruits and vegetables than available at the grocery, corner, or convenience store.

Managing medication regimens for food insecure patients with diabetes can be challenging. Clinicians must be aware of the potential role of food insecurity as a cause of labile blood sugar levels in order to design regimens which can accommodate fluctuations in dietary intake. Clinicians should emphasize the use of insulin and oral

medication with short half-lives to reduce hypoglycemic events, such as substituting tolbutamide for longer-acting sulfonylureas. Where possible, long-acting insulin should provide coverage only for basal insulin needs to reduce the risk of hypoglycemia when meals are skipped. Nutritional insulin with a rapid onset of action and time to peak effect (such as regular and rapid-acting insulin preparations) should be prescribed before food intake, rather than three times daily. Clinicians should carefully instruct patients in how they should manage their medications if they are unable to buy food, similar to the way in which clinicians counsel patients to manage their medications if they are unable to eat because they are ill, are undergoing a medical procedure, or observing a day of fasting. Glycemic targets may need to be customized to permit some degree of hyperglycemia, with the goal of preventing hypoglycemia during food scarcity. Clinicians should pay particular attention to barriers to medication adherence in patients who are food insecure and, to the extent possible, assist patients to problem-solve financial difficulties obtaining medications (such as adhering to insurance formularies, prescribing generic alternatives, and assisting with enrollment in drug assistance programs from pharmaceutical companies).

Food insecure patients with diabetes who are eligible for benefits through SNAP, Women, Infants, and Children Program (WIC), or the California Food Assistance Program should be encouraged to enroll. Social workers or clinicians should have readily available a list of local resources for emergency food assistance. Most cities in California have programs targeted toward the frail elderly, such as Meals on Wheels programs or Congregate Dining programs, which can also offer assistance to eligible patients with diabetes.

SNAP or WIC Benefits as a Route to Decreased Food Insecurity Among California's Diabetics

SNAP, WIC, and the California Food Assistance Program have well-established and reliable infrastructures for increasing access to food across the state of California. In 2007, about 2 million people in 830,000 households across California received SNAP benefits, and almost 1.4 million people across California received WIC benefits. The average monthly SNAP benefit per person was about \$3.75 per day in 2008. This money is meant to supplement, rather than replace, the household's food budget; however, for many households this money is all that is available for food. In 2005, it was estimated that for a family of four headed by an adult working full-time at minimum wage, take home pay (minus withholding) plus the earned income tax credit plus average US SNAP benefits would bring the household's income up to only 94% of the federal poverty line (or \$18,552), leaving little money for additional food (43). In April 2009 (due to money allocated by the American Recovery and Reinvestment Act of 2009), the maximum monthly SNAP benefit for a family of four increased from \$4.90 per person per day to \$5.57 per person per day.

Extensive research conducted by the United States Department of Agriculture (USDA) shows that SNAP and WIC benefits do, as intended, increase food expenditures (44), although by somewhat less than would be expected because families divert the pre-existing food budget to meet other needs when SNAP or WIC benefits become available. However, beneficiaries do not necessarily increase dietary intake of healthy food alternatives. SNAP beneficiaries often increase intake of meats, added sugars, and added fats, without significantly changing intake of fruits, vegetables, grains, or dairy products (45). For children, nonelderly men, and the elderly, SNAP benefits do not seem to increase the likelihood of being overweight or obese, although for nonelderly women (particularly non-Hispanic Whites) SNAP enrollment may increase the likelihood of being overweight or obese (46). This association appears to be weakening as the prevalence of obesity in non-SNAP recipients increases.

There are a number of reasons to hope that the inadequacies in the US's supplemental nutrition programs may soon be eased. The categories of foods covered by WIC benefits will soon change for the first time in more than three decades. While benefits previously covered foods that were less consistent with US Dietary Guidelines (such as juice and limited quantities of fresh produce), new foods will include a variety of fresh, frozen, and canned fruits and vegetables, whole grains, tofu, fish, and low-fat dairy products. Similarly, various pilot projects will encourage SNAP beneficiaries to increase their consumption of fresh fruits and vegetables. For example, California's Healthy Purchase Pilot (AB 2384), if implemented, will allow SNAP beneficiaries in target counties to receive cash back on their Electronic Benefits Card for every dollar spent on fresh fruits and vegetables. Because every dollar spent through the SNAP Program generates \$1.67 of downstream economic activity, this program could be particularly important for California counties and California growers. Thus, supplemental nutrition benefits as currently structured may do little to assist in the prevention or management of diabetes. However, recent modifications to existing nutrition programs may encourage changes in dietary intake which may result in the prevention or improved management of diabetes. Rigorous evaluation of the health and economic effects of such programs will be important.

Results of Focused Interventions

A number of studies have investigated ways of promoting healthy eating in low-income and food insecure populations, interventions which (if effective) might be expected to improve diabetes prevention and control efforts. For example, mothers receiving WIC benefits in Los Angeles County were provided with \$10 vouchers which could be redeemed for fresh fruits and vegetables at farmers' markets or supermarkets. Voucher redemption rates were more than 90%, with very few barriers to voucher redemption reported. The most frequently purchased items included oranges, apples, bananas, peaches, grapes, tomatoes, carrots, lettuce, broccoli, and potatoes (47). Daily servings of fruits and vegetables increased by 1.4 servings per day more in the farmers' market group and 0.8 servings per day more in the supermarket group compared to the control

group (48). Based on average daily consumption, this small investment resulted in a 20-30% absolute increase in fresh fruit and vegetable consumption.

In another study, low-income, elderly recipients enrolled in Meals on Wheels were provided with biweekly fresh market baskets delivered to their homes. Participants increased their consumption of fruits and vegetables by more than a serving per day, and the number of participants eating more than 5 servings of fruits and vegetables daily increased from 22% to 39% (49). Finally, another study provided a single \$20 voucher redeemable for produce from farmers' markets to low-income women receiving other nutrition benefits. Almost 90% of intervention participants redeemed the vouchers, and voucher recipients made more visits to farmers' markets and consumed more fresh fruits and vegetables than those who did not receive vouchers (50). These studies reveal a very high demand for fresh fruits and vegetables when financial barriers are reduced.

The success of the interventions described above suggests that the infrastructure of SNAP and WIC is a viable way to reduce financial barriers to healthy dietary behaviors. However, among all Californians with household incomes <130% of the federal poverty level, only 11.3% of those with self-reported diabetes receive SNAP benefits, according to data from the 2007 California Health Interview Survey. Public health efforts must therefore extend beyond SNAP or use the infrastructure of this program to expand benefits to more people with pre-diabetes and diabetes.

Other interventions have shown that consumers are sensitive to lowering the prices of healthy food alternatives in secondary school cafeterias or at worksites (51). Recent economic models suggest that a 10% reduction in the price of fruits and vegetables at the retail level would encourage low-income households to increase fruit and vegetable consumption by 2-5% (52). While this effect on the individual level may be small, across the state of California these effects might be significant. In one study, the difference in fruit/vegetable intake among those who developed diabetes over a 20 year time period compared to those who did not was only 0.2 daily servings for men and 0.8 daily servings per women (53). Another observational study in women showed that a 3 serving-per-day increase in whole fruit consumption was associated with an 18% lower risk of diabetes, and a 1 serving-per-day increase in green, leafy vegetable consumption was associated with a 9% reduction in the risk of diabetes over an 18 year period (54).

Implications for Public Health Policy and Practice

The Diabetes Prevention Program (DPP) was a major, multicenter study which showed that weight loss through improving dietary intake and increasing physical activity levels could reduce the risk of progressing from pre-diabetes to diabetes by 58% (55). These promising results have encouraged the development of wide-scale interventions to help individuals change their diet and exercise habits and prevent the development of diabetes. Targeting diabetes prevention efforts toward low-income communities,

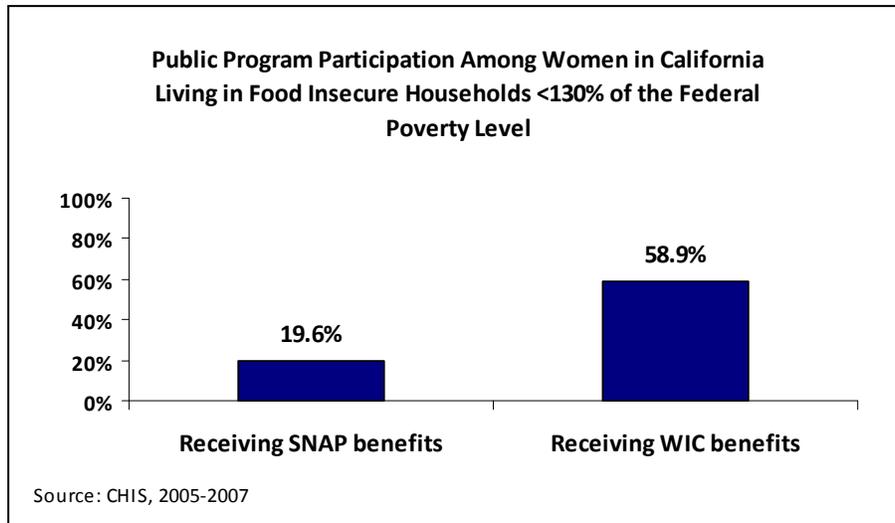
where the burden of pre-diabetes is highest, will require that these broad-scale interventions, when implemented at local, county, and state levels, also address food affordability. For example, interventions such as educational campaigns and increasing the capacity of grocery stores in low-income neighborhoods to stock fresh fruits and vegetables are likely to fail if food alternatives are not affordable. Finally, efforts to reduce tobacco use in low-income communities might both relieve inadequate food budgets and reduce diabetes complications.

Addressing Food Insecurity at the State Level

State policies, programs, and economic conditions can substantially drive a state's food insecurity rate. The most important of these conditions, in order of importance, are low average wages, high housing costs, high unemployment, residential instability, low participation in SNAP or the National School Lunch Program/Summer Food Service Programs, and a high tax burden (property, sales, and income taxes) on low-income households (56). In California, the food insecurity rate among households with children is 4.2% higher than the national average. Much of this 4.2% can be attributed to the demographic characteristics of households in the state, while only 0.2% can be attributed to unfavorable State economic policies (56).

The structure of supplemental food assistance programs is directly affected by policies implemented by the State. In 2006, only 46% of eligible Californians participated in SNAP (then the Food Stamp Program), compared to a national average of 60% (57). California counties in which fewer than 30% of eligible people receive SNAP benefits include Mono, San Mateo, Napa, San Diego, San Luis Obispo, Marin, Nevada, Orange, El Dorado, and Santa Barbara counties (58). In California, homelessness and limited English proficiency may present the greatest barriers to accessing these programs (59), although bureaucratic hurdles, the fingerprinting/photo requirement, and the long-standing social stigma associated with the program are additional hurdles.

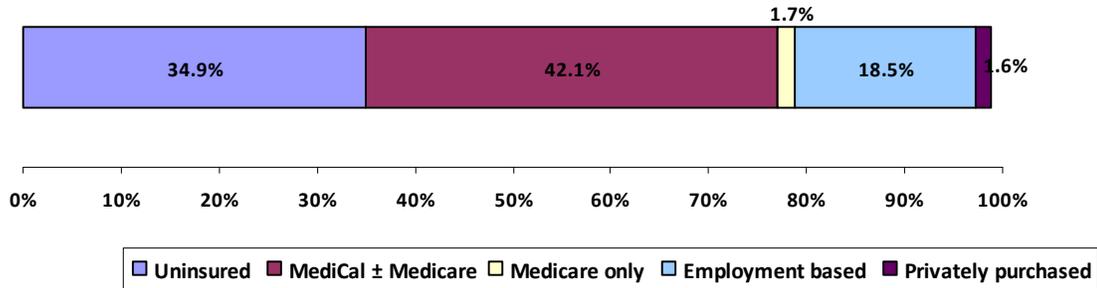
The gap between SNAP eligibility and participation in California is particularly high among the most severely food insecure (5). Fewer than 20% of food insecure women in California with household incomes <130% of the federal poverty level receive SNAP benefits, and only 58.9% receive WIC benefits (CHIS 2005-2007). Outreach efforts to engage the more than 2 million Californians who are eligible for SNAP benefits but are not enrolled should continue (60). Expanding eligibility criteria, particularly for households with children, may relieve family budgets and allow household adults to eat more balanced diets. Food insecurity rates in California are also likely to be directly related to the State's continued support of the California Food Assistance Program, which offers SNAP benefits to legal immigrants not covered by the federally-subsidized SNAP.



In conjunction with these outreach efforts, the State should strongly encourage the development of programs which facilitate shifts in dietary intake towards the consumption of healthy foods. Recent changes in the WIC program at the federal level have subsidized the purchase of fruits and vegetables. A similar program might alter consumption patterns among SNAP beneficiaries. Although there are considerable infrastructure hurdles involved with expanding the program to SNAP beneficiaries, the results may benefit California in a variety of ways, such as supporting local food growers and food vendors and encouraging the expansion of produce accessibility into low-income neighborhoods. Recent increases in SNAP benefits should also be made permanent to reduce food insecurity rates.

California produces about half of US-grown fruits, vegetables, and nuts (61). California should take full advantage of its massive agricultural system in addressing the problem of food insecurity. Enhancing infrastructure to distribute fruits and vegetables to local urban centers and sell directly to consumers at farmers' markets may benefit California's farmers financially, reduce consumer costs, enhance supply in low-income neighborhoods, improve the nutritional value and taste of fruits and vegetables (62), and serve as a model for environmental sustainability.

Health Insurance Coverage Among California's Food Insecure Adults



Source: CHIS, 2005

All data refers to adults living in households with incomes <200% of the federal poverty.

Ultimately, a broad focus on the well-being of the household unit, including health insurance, tax burden, job opportunities, and affordable housing, will more effectively address food insecurity and its health implications across the State than one narrowly focused on food affordability (63). For example, almost 35% of food insecure adults in California do not have health insurance, a condition which can quickly drain household budgets leaving little money for food, while 42% MediCal. Among California's MediCal beneficiaries, 40% of adults and 17% of children are food insecure. These issues at the root of poverty should be considered public health imperatives, insofar as these policies have a direct impact on food insecurity.

Providing State-Level Support to Interventions at the Local and County Levels

Local solutions are necessary to change the built environment so that it is more conducive to the healthy and active lifestyle achieved among participants in the Diabetes Prevention Program. The establishment and retention of full-service grocery stores and supermarkets into low-income neighborhoods across the State should be a priority, with implementation of conducive policies occurring at the local and county level. Economic incentives (such as tax credits, loans, and grants to cover investment costs necessary for refrigeration units and warehouse capacity) and zoning regulations can encourage new stores to locate in "food deserts" or improve the infrastructure at existing stores (62). Such projects should be accompanied by efforts to keep the prices of healthy food alternatives low, either by subsidies, local sourcing, or increased enrollment in the SNAP or WIC programs. For example, the *Good Neighbor Program* in San Francisco offers economic incentives such as energy-efficient retrofits, local advertising, business training, and cooperative buying to local merchants who agree to carry affordable and healthy foods. At the same time, zoning regulations to limit progressively increasing availability of cheap, nutrient-poor, energy-dense foods in low-

income neighborhoods (such as fast food restaurants and convenience stores) may further encourage shifts in dietary intake. For example, Los Angeles county recently enacted a moratorium on new fast food restaurants in the city's poorest neighborhoods (64). This moratorium is supported by data showing wide variation in the prevalence of diabetes among adults in California's poorest neighborhoods depending on the ratio of fast food restaurants to grocery stores in the neighborhood (65).

Finally, efforts to identify undiagnosed pre-diabetes and diabetes should be concentrated in neighborhoods with high rates of food insecurity, where access to health care also tends to be less reliable and the burden of disease is highest. Identification of pre-diabetes or diabetes should be coupled with reliable access to both health care and healthy foods to prevent complications from diabetes or the progression from pre-diabetes to diabetes.

Conclusions

Food insecurity in California substantially impedes progress in diabetes prevention and control efforts and contributes to widening socioeconomic and ethnic disparities in diabetes incidence. Food insecurity, a phenomenon that affects the entire household, is also an important contributor to the heightened risk of diabetes among California's children. Strategies at the State, county, and local level can help reduce the burden of food insecurity across California. Such strategies will likely translate into decreased progression from pre-diabetes to diabetes and decreased diabetes complications in the low-income communities disproportionately burdened by the disease.

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APPENDIX

Glossary of Key Terms

Body mass index (BMI)	Body mass index is a measure of body fat that incorporates both height and weight. It is applicable to both adult men and women. A BMI <18.5 kg/m ² is considered underweight; 18.5-24.9 normal weight; 25-29.9 overweight; and ≥30 obese. A BMI calculator is available at www.nhlbisupport.com/bmi/ .
California Health Interview Survey (CHIS)	CHIS is a random-dial telephone survey conducted every two years in California. Because it is population-based, the data can be used to extrapolate to the entire non-institutionalized population of California. CHIS 2005 and CHIS 2007 each surveyed more than 45,000 households. More information about the survey is available at www.chis.ucla.edu .
Diabetes	Diabetes is a disease in which the body does not make enough insulin, allowing sugar to build up in the blood instead of going into the cells. It is diagnosed by repeated fasting blood sugar levels ≥126mg/dl. Diabetes increases risk of heart attacks, strokes, kidney failure, blindness, and amputations. Almost 24 million children and adults in the US have diabetes.
Food security	<p>According to the Life Sciences Research Organization, food security is defined as “access by all people at all times to enough food for an active, healthy life and includes at a minimum: a) the ready availability of nutritionally adequate and safe foods, and b) the assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies)” (1).</p> <p>The United States Department of Agriculture currently recommends that food security be divided into four categories: high food security, marginal food security, low food security, and very low food security. “High” and “marginal” food security households are commonly referred to as “food secure,” while “low” and “very low” food secure households are commonly referred to as “food insecure.”</p>
Food insecurity	According to the Life Sciences Research Organization, food insecurity exists “whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable foods in socially acceptable ways is limited or uncertain” (1). Obtaining food using emergency food supplies, scavenging, stealing, or other

coping strategies are considered not “socially acceptable ways.” “Low food secure” and “very low food secure” households are considered food insecure.

Federal poverty level

The federal poverty level (more correctly the “poverty threshold”) is a number updated each year by the Census Bureau to reflect the household income at which a family is considered to be in poverty. The federal poverty level increases as the number of individuals in the household increases. A common way to determine degree of poverty is to express household income as a percentage of the federal poverty level.

The California Health Interview Survey, used for much of the data in this report, assesses food insecurity only in households with incomes <200% of the federal poverty level. The data from the California Health Interview Survey therefore applies only to this population. Supplemental Nutrition Assistance Program (SNAP) benefits are generally only available to individuals with incomes <130% of the federal poverty level and WIC benefits to individuals with incomes <185% of the federal poverty level (among other eligibility criteria).

Hemoglobin A1c (HbA1c)

HbA1c is a laboratory test which reflects one’s average blood sugar over the previous 3 months. The goal for most patients with diabetes is to achieve a HbA1c of about 7%, which correlates with blood sugars generally ranging from 120-190 mg/dl over the previous 3 months.

Hyperglycemia

Hyperglycemia refers to blood sugar that is too high and is associated with diabetes complications, including heart attacks, strokes, kidney failure, blindness, and amputations. In most cases, a fasting blood sugar level >140 mg/dl is considered “hyperglycemia”.

Hypoglycemia

Hypoglycemia refers to blood sugar that is too low and is associated with poor quality of life, seizures, and potentially death. Repeated episodes of hypoglycemia may result in cognitive impairment. Blood sugar <70 mg/dl is hypoglycemia.

Hunger

As defined by the Life Sciences Research Organization, hunger is an “uneasy or painful sensation caused by a lack of food.” It is a “potential, although not necessary, consequence of food insecurity” (1).

Pre-diabetes A condition in which blood sugar levels are higher than normal, but not high enough to be diagnosed as diabetes. Repeated fasting blood sugar between 100 and 125mg/dl is considered pre-diabetes. Some long-term complications associated with diabetes may begin while patients still have pre-diabetes. The rate of progression from newly-diagnosed pre-diabetes to diabetes is more than 5% per year, and a very high percentage of individuals diagnosed with pre-diabetes will ultimately develop diabetes (66).

Supplemental Nutrition Assistance Program (SNAP) SNAP (formerly the Food Stamp Program) is a federal program that assists low-income Americans to purchase food. Benefits are administered through the United States Department of Agriculture, but distributed by the individual states. Eligibility criteria for SNAP benefits in California include a gross household income less than 130% of the federal poverty level and being a US citizen or legal immigrant to the US >5 years (other legal immigrants who do not meet SNAP eligibility criteria may be covered under the California Food Assistance Program). Able-bodied adults ages 18-49 years without dependents may only receive benefits for 3 months out of any 36 month period unless they are employed (or doing an approved work activity) at least 20 hours weekly. All adult applicants must be photographed and fingerprinted. SNAP benefits are distributed using a specialized debit-card system known as the Electronic Benefit Transfer (EBT).

Women, Infant, and Children Program (WIC) WIC is a federally-funded nutrition and health program administered by individual states. Its components include vouchers for buying foods from WIC-authorized vendors, nutrition education, and referrals to health care and other community services. In contrast to SNAP benefits, WIC benefits are only available to pregnant and post-partum women and children under the age of 5 years with household incomes <185% of the federal poverty level. All immigrants, regardless of immigration status, are eligible.

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