PREVALENCE, PREDICTORS, AND EXPERIENCE OF FOOD INSECURITY AMONG INDIVIDUALS WITH INBORN ERRORS OF METABOLISM

By

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Chapter I: Introduction

Problem and Significance

The wide array of social, psychological and financial burdens placed on families of children with special health care needs (CSHCN) increases the risk of food insecurity in this population insecurity. Food insecurity, defined as the lack of consistent access to sufficient affordable, nutritious food, is associated with negative health, behavior and psychosocial consequences in both children and adults. Food insecurity affects approximately 13% of households in the United States and 16% of households in Oregon (1). However, little is known about the prevalence of food insecurity among individuals diagnosed with inborn errors of metabolism and their families.

Inborn errors of metabolism (IEMs) are rare disorders caused by genetic changes in enzymes involved in nutrient metabolism. IEMs are permanent, lifelong conditions that often require patients to follow a specialized, restrictive diet and supplement their diet with special medical foods and formulas. All individuals with IEMs are considered to have special health care needs. Previous research has demonstrated higher rates of food insecurity among patients with acute or chronic health concerns; one study found that individuals with chronic health conditions had a seven-fold increased odds of persistent food insecurity (defined as 3 or more consecutive months of food insecurity) (2). Given the chronic nature of IEMs and the additional expense of medical and nutrition management, often including specific medical formulas and foods, it is likely that the prevalence of food insecurity is similar to or greater than national and state averages in the IEM population. Research is needed to establish the prevalence of food insecurity among individuals diagnosed with IEMs and to explore risk predictors. This information is crucial in providing clinicians and policy makers with information on the burden of

food insecurity in the IEM population. Additionally, little is known about best practices for intervening in this population once food insecurity has been identified. While raising awareness of community resources may be impactful, it is unknown whether or not there are more effective intervention strategies. For individuals with IEMs, established community and government resources may be insufficient to meet needs.

The purpose of this study was to identify the prevalence, predictors and experience of food insecurity among patients seen in the Oregon Health & Science University (OHSU) Metabolic Clinic. The OHSU Metabolic Clinic serves patients with IEMs residing throughout Oregon and southwest Washington. The OHSU Metabolic Clinic began screening for food insecurity in February 2016 using a validated 2-question screening questionnaire (3). The screening form also includes an additional, adapted version of the 2-question questionnaire to screen for food insecurity related specifically to medical formulas and low-protein medical foods. All patients who responded to the survey were provided with a handout with a list of food resources and assistance programs. A retrospective chart review of the OHSU electronic medical record was completed to review patient responses to screening questions and to record patient characteristics that may be associated with food insecurity. Additionally, a cohort of adult patients was recruited to complete a survey exploring the relationship between IEMs and food insecurity, quality of life, and overall financial burden.

Specific Aims

Aim 1: Determine the prevalence of food insecurity among patients with inborn errors of metabolism followed in the OHSU Metabolic Clinic, and compare to local, state and national rates of food insecurity.

- Hypothesis 1: The prevalence of food insecurity among Metabolic Clinic patients will be higher than local, state and national rates.

Aim 2: Examine whether anthropometric, demographic, or diagnosis-related factors are predictors of food insecurity among patients with inborn errors of metabolism.

- Hypothesis 1: Food insecurity will be more prevalent among individuals with low socioeconomic status (estimated via receipt of public insurance), adult patients, race or ethnicity other than white, and medical teams that include a dietitian. Further, food insecurity will be more prevalent among those using formulas and low-protein medical foods to manage their metabolic condition.

Aim 3: Describe the individual experience of food insecurity among adult patients with inborn errors of metabolism by gathering data on quality of life and financial burden of disease, and compare responses to the 18-item USDA food insecurity screener with the 2-question screener used in clinic.

- Hypothesis 1: Food insecurity rates will be similar among those screened with the 2-item screener and the 18-item questionnaire.

Chapter II: Background

Food Insecurity Definitions and Prevalence

Food insecurity, defined by the US Department of Agriculture (USDA) as limited or uncertain access to adequate food, is a major public health concern in the United States (4). In 2015, 12.7% of households in the United States were food insecure, according to data from the USDA Economic Research Service (ERS) (1). The prevalence of food insecurity (FI) among Oregonians trends higher than the national average; in 2015, 16.1% of households in Oregon were food insecure (5). In Multnomah county, which includes the city of Portland, the prevalence of FI is comparable to the state prevalence (15.5% of households); FI in neighboring suburban counties is comparable to the national average (11.5% and 11.8% of households in Washington and Clackamas counties, respectively) (6).

Screening for Food Insecurity

The USDA, in partnership with the Department of Health and Human Services' National Center for Health Statistics (DHHS NCHS), developed FI screening tools in response to the National Nutrition Monitoring and Related Research Act of 1990 (7). In 1995, they released a validated 18-item FI screener called the Food Security Survey Module (FSSM) to identify FI in the United States. Data on FI were collected as part of the annual US Census Bureau's Current Population Survey beginning in 1995. In 1998, the US Economic Research Service (ERS) assumed the role of analyzing the data and developing reports. Currently, the USDA FSSM is used to collect data from current population surveys, including national surveys such as the National Health Interview Survey (NHIS) and National Health and Nutrition Examination Survey (NHANES), and is also considered the gold standard food security measurement in research (7).

Data from the FSSM were originally used to classify households as food secure, food insecure without hunger, or food insecure with hunger based on the number of affirmative responses (4). A new classification system developed in 2006 re-classified families as having high food security, marginal food security, low food security, and very low food security. A summary of these definitions is outlined in **Table 1**.

Table 1. USDA FSSM Food Security Classifications (4)

Number of affirmative responses on FSSM	**Original Food Security Classifications (FSSM 1997-2005)**	**New Food Security Classifications (FSSM 2006- Present)**
None	Food security	Food security
1-2	Food security	Marginal food security
3-5	Food insecurity without hunger	Low food security
>6	Food insecurity with hunger	Very low food security

Short-item FI screening tools have been developed from the 18-item FSSM for clinical and research purposes, including a 10-item screener for adult FI, a 6-item short form, and a self-administered form for adolescents (8). Hager et al developed a validated 2-item FI screener with 97% sensitivity and 83% specificity compared to the 18-item FSSM for low-income families with children (3). Given the 2-item screener's ease of use and sensitivity in capturing FI, the American Academy of Pediatrics has recommended that pediatricians use this tool to screen for FI as a part of routine clinical care (9).

Risk Factors for Food Insecurity

Many socioeconomic and environmental factors have been associated with a greater likelihood of being food insecure, including low socioeconomic status, low educational status, non-white race or Hispanic ethnicity, female gender, and lack of health insurance or use of

private health insurance (9-14). Income is most directly and consistently tied to risk of FI (14). Consequently, factors that are associated with poverty – race, neighborhood factors, educational status, and household characteristics – also tend to be associated with FI. Having children in the household increases the risk of FI. USDA data shows that FI among households with children is 16.6% compared to the national average of 12.7% in all households (1). Single-parent households, which tend to have a lower household income, are also at an increased risk of FI (15). Households with children that are headed by single mothers are at a much higher risk of FI; in 2015, 30.3% of households led by single mothers were food insecure (1).

Consequences of Food Insecurity

Food insecurity has been linked with a myriad of adverse outcomes for both children and caregivers. Poor mental health is one of the first and earliest consequences of FI (16). Research shows that even with marginal food security, caregivers are significantly more likely to report depression, stress and anxiety (2, 13, 16). Additionally, FI is associated with "toxic stress" that can overwhelm the household (17). Families constantly have to consider where their next meal is coming from and work to balance or stretch limited resources, leading to depression, frustration and hopelessness (17, 18). Further, there is a dose-response effect between increasing severity of FI and increased stress levels (16).

Strikingly, adverse health effects associated with FI are observed in children as well as adults. Caregivers tend to do everything in their power to shield children from the physical effects of FI by reducing the amount they eat or skipping meals to ensure that children are fed (19). Research supports the idea that caregivers seek to protect children from FI; studies have shown that child food intake is usually not reduced with household FI unless the household is experiencing very low food security (9, 16, 19). While reductions in child food intake are often observed only in households with severe FI, children experience emotional or psychological

effects even with marginal FI (16). The body of qualitative research on FI provides an especially rich understanding of a child's experience of FI. Semi-structured interviews with children reveal that children are not only aware of their parent's attempts to hide FI, but also experience profound effects of FI themselves (20). Interviews with food insecure children show that children often take actions to alleviate the problem by reducing the amount of food they eat, snacking less, or asking others for food (20, 21). Knowles et al interviewed 51 caregivers of children with at least one child less than four years of age (17). The caregivers interviewed described seeing their children mirror their emotional distress; according to one parent, "they feel your feelings". Children in FI households felt their parents' stress, anxiety and frustration with the situation, leading to poor parent-child communication and greater child sadness and aggression (17, 20). A literature review by Cook et al assessed the effects of marginal FI on the health of children and caregivers (16). They reported that the risk of depression, anxiety, aggression, inattention or hyperactivity, and poor test scores among children increased even with marginal household FI. This research suggests that children are acutely aware of and suffer the emotional consequences of FI even before there are tangible changes in food intake or quality.

In addition to effects on emotional health, FI among children has also been tied to other outcomes including poor global development in young children, reduced cognitive function, poor academic performance, and dysregulated behavior (9, 22, 23). The effects of FI on global development are especially profound in children ages three and younger (10, 16). One study found that household FI was associated with a 76% increased risk of poor development among children under three (10). Furthermore, there is a linear relationship between severity of FI and developmental risk, with researchers noting an increased risk of one or more developmental problems with even marginal FI (16). During this critical window of development in a young child's life, inadequate nutrition quality and quantity can have impactful, life-long effects on development.

As children get older, FI is linked with adverse academic outcomes including reduced cognitive function and school performance. Research has noted that FI children are more likely to have a lower IQ (24), poor learning and test scores (16), lower grades in school (9), and more missed days of school (23). The relationship between FI, cognitive function and school performance is complex. Malnutrition and nutrient deficiencies during childhood can adversely affect brain development and cognitive function (25). Hunger can also be distracting for children and make it difficult to pay attention at school. Additionally, emerging research has begun to link malnutrition with neurodevelopmental alterations and reduced IQ in middle school children (24).

In addition to difficulties with school performance and cognition, children also experience reductions in soft skills like social skills and behavior that can affect future success. A longitudinal cohort study of 4,710 children in the United States observed the effects of FI on children's social skills when children were in 1st, 3rd, and 5th grade (22). Researchers found that FI at any time period was associated with worse social skills, especially in young children, even after controlling for confounding factors including income. The effects were long-lasting: boys who were food insecure in first grade had reduced social skills and psychological stress until fifth grade, the last point of data collection. FI has also been linked with aggression, inattention, hyperactivity, and atypical or borderline behavior problems (16, 23, 24). Taken as a whole, children experiencing FI may have emotional, cognitive and behavioral effects that follow them into adulthood.

FI also affects weight status in both children and adults. By definition, uncertain access to food often reduces the nutritional value and quantity of food available to support one's full growth and health potential. As a result, FI may place individuals at a greater risk of malnutrition. However, the paradox of FI is that it has also been linked to overweight and obesity (13). Healthy foods – including fresh produce, meats, and whole grains– tend to be more expensive than fast foods or convenience foods. Families are more likely to choose inexpensive foods when money is tight; however, these foods are often calorie-rich and nutrient-poor (9).

Studies attempting to determine the effect of FI on weight status are often conflicting. Researchers from Oregon State University, for example, did not find any significant associations between FI and dietary intake or child BMI among children in rural Oregon communities (26). Conflicting research findings could mean there is no true association between FI and weight status, or alternatively could be a result of variations in study population and design.

Food insecurity has also been linked to adverse health outcomes. This relationship is likely bidirectional, as FI can put individuals at an increased risk for poor health outcomes, but pre-existing health conditions can also place a financial strain on families and increase risk of FI (27). Much research has been done to explore the relationship between FI and health. FI has been linked with a greater risk of fair or poor health (2, 12, 16, 27-29). These associations may be mediated in part by dietary choices among individuals who are food insecure and have limited food resources. Poor dietary quality increases the risk of chronic diseases including obesity, diabetes and heart disease. Choosing nutrient-poor, calorie-rich foods may also place individuals at an increased risk of micronutrient deficiencies. In addition, inadequate food places individuals at a greater risk for malnutrition, which has been independently associated with poor healing and increased infections (25).

Food Insecurity and Additional Health Care Needs

Individuals with acute or chronic health care needs may face higher rates of FI due to the increased amount of time and money spent managing their health condition. Researchers have found similar or higher rates of FI in the presence of acute disease and chronic conditions (2, 10, 12, 13). Thirteen percent of adults who presented to Boston-area emergency departments were food insecure, compared to the state's average of 9.6% (13, 14). Of those surveyed with FI, 25% reported they had gotten sick due to an inability to afford necessary medications. Of children presenting to the emergency room or who had been hospitalized within

the past year, 25-45% were food insecure (10, 12). The rate of FI in this population is much higher when compared to the national average of 12.9%. Poor health status can lead to increased health care expenditures for prescriptions, co-pays, or out-of-pocket care; missed work due to poor health; and time and transport to medical appointments (27, 30, 31). Additional expenses and reductions in work due to disease may contribute to reduced income and increased expenditures. Increased health care needs place a high burden on a household's resources and increase FI risk.

When individuals with additional health care needs have a limited income and must determine where to allocate limited resources, there is often a decision that must be made between paying for medical treatment and paying for food. In a cross-sectional study of 9,696 adults with at least one chronic disease, Berkowitz et al found that individuals with FI were four times more likely to underuse medications than those who were not food insecure, after controlling for confounding factors such as income and health status (11). The researchers described the "treat or eat" hypothesis, in which households with limited incomes often favor either food or medications when making purchasing decisions. Households that more often purchased medications were more likely to be Hispanic or Black. Adults who purchased food instead of medications were more likely to have dependent children.

In addition to choosing between medical treatments and food, it is thought that FI individuals have to make similar purchasing decisions between food and housing, utility bills, and other essential costs. In a 2010 Feeding America survey of hunger across the country, the authors found that of food insecure clients who visited Feeding America food banks, 46% of clients had to choose between household utilities or heating and food, 39% had to choose between paying for their rent or mortgage and food, 36% had to choose between transportation costs (including having a car and paying for gas) and food, and 34% had to choose between paying for food or medical care (32). Clearly, FI forces families to make crucial choices between food and other expenditures.

Children with Special Health Care Needs

Since acute or chronic disease and the presence of children in the household are both independent risk factors for FI, households with children with special health care needs (CSHCN) are likely to be at an increased risk of FI. Children with special health care needs are defined by the Maternal and Child Health Bureau (MCHB) as "those who have one or more chronic physical, developmental, behavioral, or emotional conditions and who also require health and related services of a type or amount beyond that required by children generally" (33). The MCHB surveys the prevalence of CSHCN as part of the National Survey of Children with Special Health Care Needs (NS-CSHCN). In 2009-2010, the NS-CSHCN found that 23% of households with children had at least one child with special health care needs (34). The NS-CSHCN asks about 18 health issues including developmental delays or disabilities, behavior issues, physical disabilities, and specific diagnoses such as epilepsy, cerebral palsy, or autism. Common diagnoses for CSHCN include ADD/ADHD (32.2%), asthma (30%), learning disabilities (27.2%), and speech problems (15%); 71.8% of children surveyed experienced more than one condition. Most CSHCN (91%) had one or more functional difficulties such as learning difficulties, respiratory problems, chronic pain, and psychological distress (34).

A study by Adams et al found that the odds of FI were more than two times greater for Oregon mothers of CSHCN when compared to families without CSHCN, even after controlling for confounding factors (28). Families with CSHCN may be at increased risk of FI due to increased financial and nonfinancial strains, including high utilization of the health care system, a reduction in income or hours in work due to increased caregiving, and additional stress, anxiety and depression (30, 31, 35). Parents of CSHCN spend significantly more time directly caregiving for their children or coordinating care. Caicedo et al. surveyed a cohort of medically complex or medical technology dependent CSHCN and found that parents spent, on average, 33 hours per week providing direct, hands-on care (such as feeding, bathing, administering medications or therapies) to children and 7 hours per week coordinating health care

appointments (35). This represents a significant burden on parents' time and energy that could make additional work and responsibilities difficult, if not impossible. Many parents of CSHCN reduce their hours at work or stop working entirely to care for their children, impacting the household's financial situation (31). A review of the effects of raising CSHCN on families found that parents were 1.3 – 7.9 times as likely to cut back on work or stop working to care for their child, depending on the severity of the condition (30). Parents were also more likely to cut back or stop working if they spent greater than an hour per day coordinating care, had young children, were immigrant parents, or had significant out of pocket medical costs (31). The burden of additional caregiving duties is felt most strongly in single parent households, who are already more likely to be food insecure.

Children with special health care needs often require multiple specialists to provide treatment, rehabilitation and support to aid in their growth and development. These medical teams may include pediatric specialists, surgeons, geneticists, physical therapists, occupational therapists, speech therapists, psychiatrists, dietitians, and more. Coordination of treatment is not only time consuming, but often expensive. Additional specialists or therapies may not be covered by a family's insurance, coverage may not be enough to meet the child's needs, or families may have high insurance deductibles and copayments. Although CSHCN often receive additional medical coverage or reimbursement to help with their medical expenses, research shows that for many families it is still not enough (29). Families typically pay for some of their child's care out of pocket. Attempts to quantify out of pocket costs for healthcare are highly variable due to confounding variables of disease severity, family income, and state coverage of benefits. Data from the 2006-2007 NS-CSHCN found that 61% of families were paying for some of their medical care out of pocket, and 64% of those families had out of pocket expenses greater than $250 per month (36). For families with limited incomes, any additional expense is an added stress; an extra $250 per month can represent a significant financial burden (30). Additional medical expenses may cause families to cut back on money spent on food or other

expenditures such as housing and utility bills (11). Food insecure families are more likely to experience other health-related social problems such as limited access to health care, low income security, housing difficulties, or partner violence (15). A cross-sectional survey of 46 families with CSHCN from the University of North Carolina at Chapel Hill found that 54% of those surveyed had been late on mortgage or rent payments, and 10-17% had been threatened with eviction or foreclosure (37).

In addition to reductions in income and additional medical expenses, both of which contribute to a significant financial burden, families of CSHCN are often very worried about their child's future and long-term outcomes. As a result, these families are at an increased risk of stress, anxiety and depression. Survey results from a cohort of parents with medically complex CSHCN found that parents were tired (87%), anxious (66%), felt unsupported as parents (44%), and had family functioning problems including difficulty completing daily activities or poor family relationships (45%) (35). This chronic stress, coupled with mounting financial burdens, is often paralyzing. The financial, social, and emotional burdens of caring for a child with special health care needs places these families at a much greater risk for FI.

Inborn Errors of Metabolism

Every child with an inborn error of metabolism (IEM) has special health care needs. Inborn errors of metabolism are inherited disorders in enzymes or other functional proteins that affect the normal metabolism of carbohydrate, protein or fat (38). While each individual IEM is rare, when viewed collectively, IEMs are fairly common and occur in approximately 1 per 1,000 live births worldwide (39). Many IEMs are included on state newborn screening panels, and medical and diet therapy for affected newborns is started within a few weeks of birth. Some metabolic disorders result in a rapid buildup of toxic metabolites due to an enzymatic block in the normal metabolic process. The buildup of these metabolites can lead to severe physical and

neurological disabilities and sometimes, if untreated, death. Successful management of IEMs often requires lifelong dietary therapy and medical management. In phenylketonuria (PKU), for example, the liver is unable to metabolize the amino acid phenylalanine (Phe) into tyrosine due to a genetic mutation in the enzyme phenylalanine hydroxylase (PAH). For individuals with PKU, consuming normal amounts of protein results in a toxic buildup of Phe in the blood that can lead to severe neurological impairment and disabilities (39). Dietary management of PKU requires severe restriction of dietary protein to minimize Phe intake, as well as supplementation with specially engineered medical foods that are free of the insulting amino acid, Phe (39).

While many IEMs require dietary interventions, the type and degree of dietary restriction and other interventions required varies between disorders. For some IEMs, there is not a particular metabolic substrate that must be avoided. For example, individuals with mitochondrial disorders rarely restrict a specific substrate but may require enteral or parenteral nutrition support and dietary modifications as required for gastrointestinal dysfunction or insufficient weight gain (40). For many IEMs, however, elimination of a specific metabolic substrate is necessary to prevent poor outcomes. Sometimes the dietary modification is straightforward: for individuals with galactosemia, dietary modification simply requires elimination lactose and galactose (39). For others disorders such as PKU described above, nutrition therapy is much more complex and requires the use of medical foods.

A medical food, as defined by the U.S. Food and Drug Administration (FDA) in the Orphan Drug Act (21 U.S.C. 360ee (b) (3), section 5(b)), is “a food which is formulated to be consumed or administered enterally under the supervision of a physician and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, based on recognized scientific principles, are established by medical evaluation.” (41). Medical foods are further divided into two classes: medical formulas that have been specially engineered to provide protein equivalents without the specific amino acid(s) that cannot be metabolized (i.e. Phe-free infant formulas) and low-protein medical foods (i.e. low

protein bread, spaghetti, and bars). In addition to medical formulas and low-protein medical foods, individuals with IEMs often take additional vitamin or mineral supplements to ensure adequate nutrition. Given their limited consumer market and the cost of manufacturing, medical formula and low-protein foods are very expensive. Berry et al. compared the price of low-protein medical foods to standard protein-containing versions of the same food and found that low-protein medical foods were 2-8 times more expensive than their standard counterpart (42). The prices that consumers pay may be even higher as markup of wholesale cost to consumers and pharmacies is often 200-300% (43). Medical formulas and low-protein medical foods are estimated to cost anywhere between $2,250/year for an infant to $25,000/year for a pregnant woman (44).

Insurance often helps to cover the costs of medical foods for the treatment of IEMs, but coverage varies from state to state and includes a variety of limitations. Coverage may be limited by product type (formula or low-protein foods), condition (many states only cover a few, more common IEMs), price (i.e. up to 5,000 dollars or 50% of food costs), and age (may stop at age 18) (45). Furthermore, Medicaid coverage and mandated private insurance coverage for medical foods is not guaranteed and varies from state to state (45). A 2010 survey of state NBS policies found that 61% of states guarantee medical formula and low-protein medical food coverage for some or all IEMs, and 33/50 states have state mandated coverage of medical formula and low-protein medical foods by private insurance companies (46). In Oregon, insurance coverage of medical formula and low-protein medical foods is typically provided for all patients with IEMs without cost or age restrictions for patients with public insurance. However, private insurance coverage of medical foods is variable. Regardless of insurance type, it is still unclear whether or not insurance coverage entirely eliminates financial burden. A study by Parish et al found that state policies and income requirements reduced relative and absolute income burdens, but were not associated with a decreased probability of having out-of-pocket costs (36). These findings suggest that sufficient state and insurance coverage may help to

ameliorate financial burden on families, but does not entirely solve the problem. For patients with IEMs, high out of pocket expenditures can quickly add up in the absence of adequate coverage of medical foods. A survey of caregivers of children with IEMs found that most families surveyed (84%) used at least one type of medical food and that parents paid out-of-pocket for all types of resources (42). Given that 22 of the 31 IEMs recommended on the US uniform newborn screening panel require the use of medical foods, the actual number of individuals with out-of-pocket medical costs related to their medical formula or low-protein medical foods is likely quite high (44).

Insurance coverage for low-protein medical foods tends to be much less common than coverage for medical formulas. Berry et al surveyed 305 parents of children with IEMs, mostly from the Eastern United States, on the use of medical formula and low-protein foods and adequacy of coverage (42). They found that 59% of families used low-protein medical foods, half used at least one supplement, and 50% used feeding supplies. Eighty percent of families used two or more products. Medicaid and private insurance covered some of the costs, but most families still paid out of pocket. According to their survey, 60% of families paid for low-protein medical food expenses out-of-pocket, and half of parents purchasing low-protein foods reported out-of-pocket costs greater than $100 per month. A review of medical formula and low-protein foods coverage in Europe similarly found that coverage was worse for low-protein medical foods (47).

Families receiving public health insurance may be better protected from this expense than families with private insurance. Receipt of public insurance, Supplemental Security Income (SSI), or Medicaid among CSHCN was found to be protective against out-of-pocket costs (30). Most public insurance or assistance programs require that household income be at or below 100-130% of the Federal Poverty Level (FPL) for eligibility. Some research has suggested that this places families with a median income level at an especially increased risk of high expenses (11). At incomes >130% and ≤200%, families of CSHCN or IEMs may be ineligible for most

public assistance programs, but due to increased expenditures are still likely to encounter financial hardship and FI. Studies of individuals with chronic health conditions requiring greater care and medication use have found that individuals right above Medicaid cutoffs were especially vulnerable to financial limitations that require deciding between medication and food purchasing (11, 48).

Even in states with more comprehensive medical foods coverage, this coverage often ceases when individuals turn 18 years of age (42). Pediatric populations receive greater assistance to support growth and development. Insurance changes that occur during the transition from adolescence to adulthood are associated with decreased insurance coverage of medical formula and low-protein medical foods (42). In the past, adherence to dietary restrictions for many IEMs was recommended only until individuals reached adulthood. However, recent research has suggested that going “off-diet” after the age of 18 may still be linked with adverse health outcomes (39). The relationship between adherence to diet therapy and risk of adverse health outcomes has been most extensively studied in individuals with PKU. While intellectual disability does not occur in adults with PKU who maintain good metabolic control in infancy and childhood, adults with high Phe concentrations in blood can experience an array of adverse outcomes including deficits in executive functioning, anxiety, and depression (49, 50). The current recommendation is for patients with PKU to follow a Phe-restricted diet for life (49-51). Adherence to diet therapy, including medical formula and low-protein foods, is extremely important when a female with PKU is pregnant; high PHE concentrations in the blood during pregnancy are associated with poor fetal outcomes including low birth weight, microcephaly, congenital heart defects, and intellectual disability (49). Unfortunately, pregnant women also have the highest expenses related to medical formulas and low-protein medical foods due to increased energy and nutrient needs (44).

Given the current limitations of insurance coverage, individuals with IEMs are more likely to pay out-of-pocket for their medical care during adulthood. Many adults with IEMs cite the cost

of medical treatment and foods as one of their biggest barriers to remaining on-diet, and some studies have suggested higher rates of FI among adults with IEMs (42, 51, 52). Additionally, while the financial cost of medical foods may increase the risk of FI, it is likely that any individuals with IEMs are at a higher rate of FI regardless of whether their IEM requires medical foods or formulas for treatment. Individuals with IEMs have increased health care needs – including additional clinic visits and appointments, medications and stress – that place them at a higher risk of FI (51). Additionally, some IEMs are associated with physical or intellectual disabilities that make it difficult to work, which affects income and greatly increases lifelong risk of FI (38).

To our knowledge, there is no published literature on the prevalence of FI in the IEM population. Research in similar populations such as those with chronic health conditions or CSHCN have shown higher rates of FI (2, 10, 12, 28, 29, 51). Individuals with IEM are similar to these populations in that they are also high health care utilizers and face similar psychological and financial stress. However, IEMs may further increase risk of FI due to the necessity of expensive medical foods, formulas, and supplements. Families with IEMs or CSHCN may receive additional support to help with increased expenditures; however, it is likely that this additional support is still not enough.

Intervening in Food Insecurity

Public health professionals are still determining how best to combat food insecurity in the United States. Most public health programs aim to alleviate the financial burden through food and other assistance programs, freeing up a family's resources to meet other needs. Not surprisingly, programs such as the Supplemental Nutrition Assistance Program (SNAP) or Special Supplemental Nutrition Assistance Program for Women, Infants and Children (WIC) have been shown to decrease rates of FI (11). Food assistance programs are meant to be

supplemental and, as a result, usually do not entirely meet a family's needs. Individuals experiencing FI are often aware of and utilizing more than one food assistance resource, suggesting that many of the programs are not a complete solution (2). Even among those who are eligible for food assistance programs, not all are enrolled, and many people choose not to enroll for personal reasons (i.e. personal feelings about governmental assistance, shame, social desirability). Among food insecure families whose children had been hospitalized in the last year, 19.6% of WIC eligible families and 28% of SNAP eligible families were not enrolled (12).

In the context of direct patient-provider medical care, the American Academy of Pediatrics has recommended that all pediatricians screen for FI (9). Most individuals from a wide variety of cultures and backgrounds visit the doctor at some point or another, making physician offices an optimal place for screening. Research has shown that the use of a validated 2-question screener is convenient to implement and places a low burden on practitioners and patients (3, 15, 53). Effective screening and intervention may help to identify and reduce FI when it is identified. However, most practitioners do not routinely screen for FI. A study by Hoisington et al. found that only 24% of practitioners in the Portland metropolitan area routinely asked patients about food quality, and only 12% routinely asked about food sufficiency (53). Reasons cited for not asking included lack of knowledge, discomfort discussing FI, and lack of time. Furthermore, little is known about how best to intervene once FI has been identified. Practitioners who identify patients with FI may not know about the resources available and may not have time to intervene. Furthermore, for CSHCN or those with unique medical needs or dietary restrictions, such as IEMs, traditional resources may not sufficiently reduce the burden. The purpose of this study was to identify the prevalence of FI in the IEM population and begin to identify predictors or risk factors. This knowledge will inform both the necessity of future interventions and characteristics of an appropriate intervention in this population.

Chapter III: Materials and Methods

Study Design

This study included both a retrospective chart review and a prospective, questionnaire-based study of patients with metabolic disorders who attended a clinic appointment at the OHSU Metabolic Clinic. Data for the retrospective chart review were obtained from each patient's electronic health record (EHR). In addition, patients were recruited to participate in a prospective, questionnaire-based study to describe their experiences with FI, medical expenses, and quality of life.

All protocols were approved by the Oregon Health & Science University Institutional Review Board (IRB). The retrospective study protocol was exempt from obtaining participant consent given that study variables were collected as part of routine clinical care. Potential study participants in the prospective, questionnaire-based study received information about the study protocol and were given an opportunity to provide informed consent to participate.

Setting and Study Population

Established in 1914, the Child Development and Rehabilitation Center (CDRC) at OHSU provides services to individuals with disabilities or special health care needs throughout the state. The Metabolic Clinic specifically works with those individuals who have metabolic disorders, providing individualized care using an multidisciplinary approach with a team including metabolic geneticists, a nurse practitioner, a genetic counselor, metabolic dietitians, and a medical assistant. All study participants attended a clinic appointment at the OHSU Metabolic Clinic in Portland, or were seen by the metabolic team at OHSU outreach clinics in Eugene, OR, and Medford, OR.

Inclusion and Exclusion Criteria

The primary criteria for inclusion in the retrospective study was attending a clinic appointment at the OHSU Metabolic Clinic between March 2016 and September 2016, and completing a food security screening questionnaire as part of routine clinical care. If patients visited the Metabolic Clinic more than once during this time period, information from the first clinic visit was used. If multiple siblings from the same family visited the Metabolic Clinic during this time period, data from the oldest child's chart was included. Participants who were not screened for food security status were excluded from the retrospective chart review. Individuals less than six months of age or greater than 89 years of age were excluded from the study. Cognitively impaired adults who live in medical homes were also excluded from the study.

The prospective, questionnaire-based study included adult patients 18 years of age or older who attended a clinic visit at the Metabolic Clinic and consented to be included in the study. We aimed to recruit approximately 5-10 patients for this study. Patients under the age of 18 and individuals who lack sufficient decision-making capacity were not recruited.

Data Collection and Management

All data for the retrospective chart review were obtained from the Oregon Health & Science University Hospital & Clinics EpicCare® Electronic Medical Record. Data were entered using the RedCap (Research Electronic Data Capture) data system available through the Oregon Clinical and Translational Research Institute (OCTRI). REDCap is a secure, HIPAA compliant database application that supports data capture and data export for analysis. Patients who met the inclusion criteria and were included in the retrospective chart review study were given a unique study ID. The final dataset was exported, without identifiers, to a Microsoft Excel file and imported to STATA for Windows (version 14; StataCorp LP, Texas, USA).

Data collected for the retrospective chart review were obtained as part of routine clinical care from patients and accompanying family members who attended a clinic visit at the OHSU Metabolic Clinic between March and September 2016. This appointment was a single encounter in which all demographic information, anthropometric measurements, and food security screening data were representative of the participant and household on the date of the appointment.

Data gathered from the patient's chart included age and date of birth, sex, ethnicity, primary language spoken, state of residence, primary care provider, and insurance information. Weight, height and BMI data were collected from the chart, and percentiles and Z-scores were also collected for pediatric patients. Family characteristics collected included marital status for patients over 18. Metabolic disorder-related data collected included the patient's primary diagnosis, whether the patient was new or returning to clinic, whether or not the patient had previously been seen by a registered dietitian (RD), and whether or not the patient was receiving medical nutrition therapy (MNT). Additional data on dietary modifications and use of medical formula, low-protein medical foods, medications, and nutrition supplements were also collected. Patients' metabolic diagnoses were often grouped in order to protect patient confidentiality, given the rarity of many IEMs. Diagnostic categories and categorization of disorder-specific treatments, including the use of medical nutrition therapy, medications, supplements, and formulas was done using a Metabolic Disorder Categorization Guide developed with the metabolic dietitians at OHSU's Metabolic Clinic (**Appendix A**). To categorize diagnosis-specific treatments, standard of care dietary modifications were listed and any potential medications and nutritional supplements used for a patient's metabolic disorder were described. We defined medications as any products specifically prescribed by a physician or nurse practitioner for a patient's metabolic disorder, and nutritional supplements as any product taken by a patient for their metabolic disorder specifically but which was available over

the counter. Finally, data from the food insecurity screening form used in the Metabolic Clinic were collected from each patient's chart (**Appendix B)**.

Anthropometric Measurement Collection

All anthropometric measurements for the retrospective chart review were collected by clinic staff using standard clinic protocols. Height was measured using one of two wall-mounted stadiometers in clinic (Seca 240, Seca, Germany; or Prospective Enterprises, Portage, MI, USA). If a participant was less than two years of age or unable to stand, length was measured using a custom length board. Weight was measured using one of two electronic scales (Scale Tronix portable scale, Welch Allyn, Skaneateles Falls, NY, USA); or an industrial floor scale with a Tara Systems industrial version scale indicator (Model TR-1-NK, Tara Systems, San Diego, California, USA). Children less than two years of age were weighed with a pediatric scale (Scale Tronix Pediatric Scale 4802, Welch Allyn, Skaneateles Falls, NY, USA). For children who were unable to be weighed due to excessive movement, weight was calculated by weighing parent and child together and then subtracting for parent's weight. Weight-for-length, BMI-for-age, BMI percentile, height z-score, weight z-score, and BMI z-score were calculated automatically by the EpicCare medical record. Weight-for-length and percentile were recorded for participants less than two years of age, and BMI-for-age and percentile or BMI were recorded for participants greater than two and greater than 18, respectively. Growth charts from the World Health Organization (WHO) were used for children 0-2 years of age, and CDC growth charts were used for children greater than 2 years of age.

Metabolic Clinic Food Security Screening Protocol

Patients who visited the OHSU Metabolic Clinic received a food security questionnaire at each appointment. The questionnaire was provided by metabolic clinic staff, and patient

responses were entered into the patient's chart by the provider or medical assistant at the time of the appointment. This questionnaire includes the validated 2-item food security screener, a modified version of the food security screener asking about "medical food insecurity," or food insecurity related specifically to a patient's low-protein medical foods and medical formulas, and a question about food resources used by the family. Patients or accompanying family members from the same household responded to the following two statements by answering "often," "sometimes," or "never": "Within the past 12 months we worried whether our food would run out before we got money to buy more," and "Within the past 12 months the food we bought just didn't last and we didn't have money to get more." An "often" or "sometimes" response to either or both statements classified a household as food insecure. Participants who used medical formulas or low-protein medical foods as a component of their metabolic disorder treatment also answered a modified version of this 2-item screener, which asked specifically about the use of medical formula or low-protein medical foods. Finally, participants were asked about their use of common food resources such as WIC, SNAP (formerly food stamps), and food pantries. A "prefer not to answer" option was also available for each question (**Appendix C**). A list of food assistance programs and additional food resources was provided along with the food security screener for patients to take home, if desired (**Appendix D)**.

Prospective Questionnaire-based Study Protocol

Adult patients seen at the Metabolic Clinic were approached by a member of the study team after checking in for their appointment to assess their interest in participating in the study. Patients who provided informed consent to participate in the study were asked questions about FI and quality of life using standardized questionnaires. Food security data was collected using the 18-item USDA Adult Food Security Screening Module. Quality of life was assessed using the CDC's Healthy Days Health-Related Quality of Life questionnaire (**Appendix E)**. This

questionnaire asks participants questions about their physical and mental well-being to calculate a “Healthy Days” index, which is the number of healthy days in the last month. The questionnaire also asks specific questions about physical and mental distress, as well as limitations in activity. All patients conducted interviews in person at the time of their clinic appointment and responses were entered into RedCap. Interviews were approximately 20 minutes in length. Study participants received a $5 gift card after completing the questionnaire.

Statistical Analysis

Data analyses included descriptive statistics of the study sample, including demographic, anthropometric, food insecurity, and metabolic disorder data. Means, standard deviations, ranges, and 95% confidence intervals were calculated for continuous variables including age, weight, height and BMI. Proportions and 95% confidence intervals were calculated for all categorical variables including food security status, use of food resources, race/ethnicity, primary language, state of residence, presence and type of insurance, metabolic diagnosis, and use of medical foods, formulas, supplements and medications. Prevalence of FI in our sample was compared to most recent local, state and national rates. Given that metabolic disorders are extremely rare, diagnoses with a patient count <5 were grouped into a larger “disease category” for analysis. Subsets of data with a patient count <5 were not reported or analyzed in greater detail for the protection of patient identity and health information.

T-tests were used to compare the difference in means between individuals with and without FI and age, weight, height and BMI. Each continuous variable was analyzed to determine if variance was similar among the food secure and food insecure groups. If there was a significant difference in the variance by food security status, a t-test with unequal variance was used. Chi square tests were used to assess differences in proportions between individuals with and without FI with respect to race/ethnicity, state of residence, diagnosis or disease

category, health insurance type, marital status, gender, whether or not patient follows a modified diet for their metabolic disorder, use of medical foods and formulas, use of disease-specific medications or supplements, whether or not patient was seen regularly by RD, and whether or not patient had a primary care provider. If the sample size for any variable was small and had an expected count less than 5, Fisher's Exact Test was used instead of Chi square. If any significant differences existed among patients by food security status, odds ratios were used to estimate the effect size. We analyzed differences by food security status for eight primary variables [age, state of residence, insurance type (public vs. private), BMI-for age or weight-for-length z score (pediatric patients) or BMI (adult patients), proportion of patients receiving medical nutrition therapy, proportion of patients taking medical formula, percent taking medications, and percent prescribed low-protein medical foods] with a $P<0.01$ considered statistically significant to adjust for multiple comparisons. For all other results, a $P<0.05$ was considered statistically significant. Analyses were completed using STATA for Windows (version 14; StataCorp LP, Texas, USA).

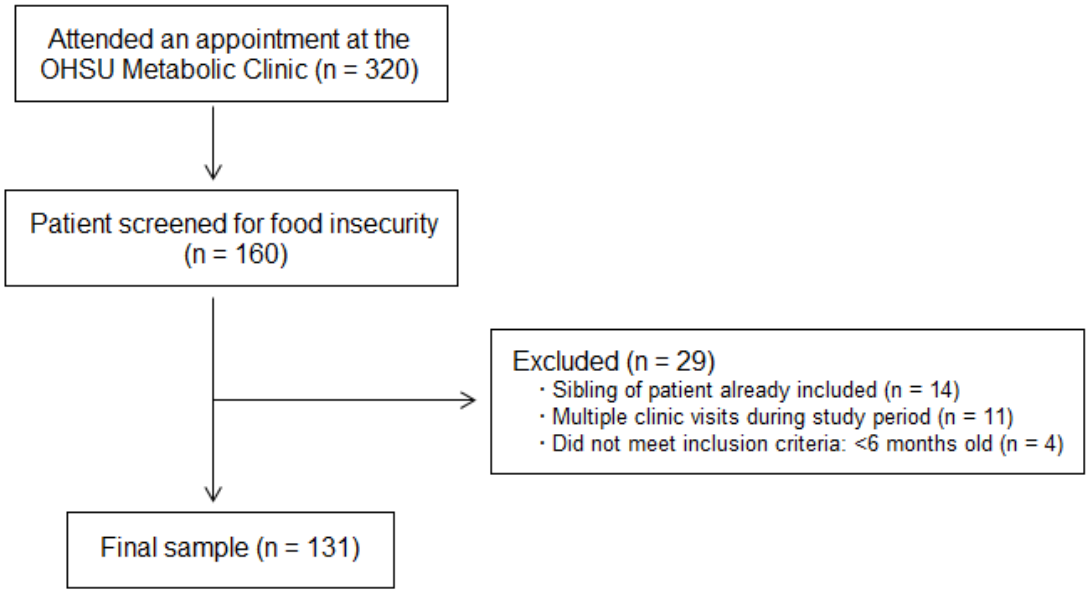
Subjects enrolled in the prospective questionnaire-based study completed the 18-item US Food Security Survey Module (FSSM) for households with children or the corresponding 10-item FSSM for households without children. The FSSM was scored according to protocol, with three or more affirmative responses indicating household FI. Rates of FI among this population were compared to the results from the 2-item screen to assess the validity of the 2-item screener in a population of patients with metabolic disorders. Quality of life questions from the CDC's Healthy Days screener were scored according to protocol and results summed and described. Answers to additional questions related to medical expenses were described.

Chapter IV: Results

Study Population Characteristics

Three hundred and twenty patients had a clinic appointment at the OHSU Metabolic Clinic during the study period of March to September 2016 (Figure 1). Of this group, 160 patients (50%) were screened for food insecurity. Some patients who were screened for food insecurity were excluded in accordance with study protocol. Reasons for exclusion included multiple clinic visits during the study period, multiple members of the same family, or age younger than six months.

Figure 1. Participant flow diagram for study inclusion.



One hundred and thirty-one patients were included in the final study cohort. Mean age of patients was 13.9 years (range: 0.5 – 59.6 years; SD: 12.4 years, **Table 2a**). The majority of patients (73%) were less than 18 years of age. There were a similar proportion of male and female patients in the study (47% male, 53% female). A majority of the patients (89%) were

non-Hispanic. Individuals could identify their ethnicity as Hispanic, non-Hispanic, or other. Only one individual stated their ethnicity as “Other”. Due to the small number of patients in this category, “Other” and “Hispanic” ethnicity groups were combined for analysis. Almost all of the participants (97%) reported English as their primary language. A majority of the patients lived in Oregon (83%), and an additional 15% lived in Washington State; only 3 patients (2%) lived in a state other than Oregon or Washington. Consequently, all states of residence other than Oregon were grouped together for analyses. For pediatric patients, weight-for-length Z-scores for children under two and BMI-for-age Z-scores for children greater than 2 years were grouped into one variable; the mean weight-for-length or BMI-for-age Z score for pediatric patients was 0.4 ±1.2. The mean BMI for adult patients was 26.3 ± 6.5 kg/m^2. About half of the patients were covered by public insurance (46%). Only one patient did not have health insurance; for statistical analysis, patients without health insurance and with private insurance were grouped together.

The most common metabolic diagnosis among the study population was PKU (44%), followed by fatty acid oxidation disorders not requiring MNT (8%) and organic acidemias requiring MNT (7%, **Table 2b**). Ninety-five patients (73%) had a diagnosis requiring MNT, with a low-protein diet being the most common dietary modification (78% of those receiving MNT). Fifty four percent of patients were prescribed medical formula, 46% were prescribed low-protein medical foods, 32% were on medications specific to their disorder, and 25% were prescribed supplements specific to their disorder.

Table 2a. Characteristics of patients screened for food insecurity at the OHSU Metabolic Clinic (*n* = 131).[1]

Characteristic	Value
Food Insecurity Data	
Food insecurity [n (%)]	26 (19.9)
Medical food insecurity[2] [n (%)]	17 (21.3)
Demographic Characteristics	
Age, years (mean ± SD)	13.9 ± 12.4
Less than 18 years [n (%)]	96 (73.3)
18 years or older [n (%)]	35 (26.7)
Gender [n (%)]	
Female	69 (52.7)
Male	62 (47.3)
Ethnicity [n (%)]	
Non-Hispanic	117 (89.3)
Primary Language Spoken [n (%)]	
English	127 (96.9)
State of residence [n (%)]	
Oregon	109 (83.2)
Washington	19 (14.5)
Other	3 (2.3)
Insurance type [n (%)]	
Non-public	71 (54.2)
Public	60 (45.8)
Marital Status[3] [n (%)]	
Single	25 (71.4)
Married	10 (28.6)
Anthropometrics	
Less than 18 years: Weight-for-length or BMI-for-age Z score[4] (mean ± SD)	0.4 ± 1.17
18 years or older: BMI (kg/m^2) (mean ± SD)	26.3 ± 6.54

[1]OHSU, Oregon Health & Science University.
[2]Medical food security screener questions only asked to participants whose diagnosis requires the use of low-protein foods or formulas: *n* = 80 responded out of 95 patients who require medical nutrition therapy.
[3]Responses only gathered from adult patients. Total *n* for marital status = 35.
[4]Two participants were missing height or length data necessary to calculate BMI. Total *n* for pediatric anthropometric variables = 94.

Table 2b. Metabolic disorder-specific patient characteristics (*n* = 131).

Characteristic	*n* (%)
Diagnosis	
PKU[1,2]	57 (43.5)
FAO disorders not requiring MNT	10 (7.6)
Organic acidemias requiring MNT	9 (6.9)
Galactosemia	7 (5.3)
Lysosomal storage disorders	7 (5.3)
Urea Cycle disorders	6 (4.6)
FAO disorders requiring MNT	6 (4.6)
Other disorders of CHO metabolism	6 (4.6)
Mitochondrial disorders	5 (3.8)
Other diagnoses or no diagnosis	18 (13.7)
Patient on MNT	95 (72.5)
Primary Dietary Modification	
Low protein	74 (56.5)
Low fat	8 (6.1)
Low galactose	7 (5.3)
Low glucose	4 (3.1)
None or other	38 (29.0)
Prescribed medical formula	71 (54.2)
Prescribed medications	42 (32.1)
Prescribed nutritional supplements	33 (25.2)
Prescribed low-protein medical foods	60 (45.8)

[1]PKU: Phenylketonuria, MNT: medical nutrition therapy, FAO: fatty acid oxidation, CHO: carbohydrate.
[2]For further information on how medical diagnoses were categorized, see Appendix A.

Aim 1: Determine the Prevalence of Food Insecurity among Patients with Inborn Errors of Metabolism Followed in the OHSU Metabolic Clinic, and Compare to Local, State and National Rates of Food Insecurity

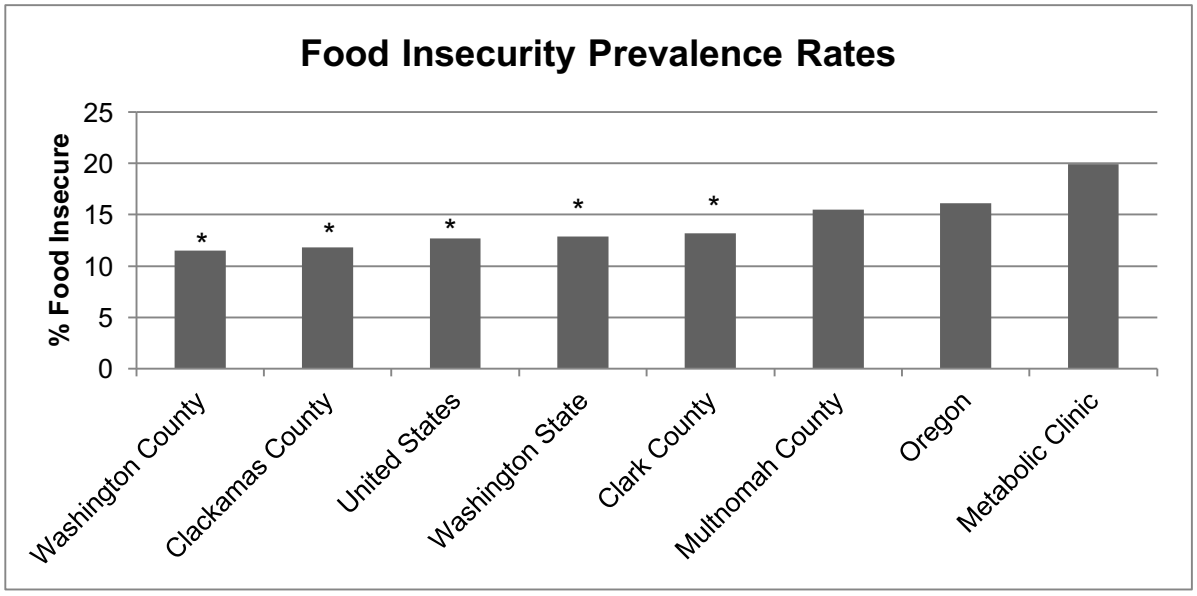
The overall prevalence of food insecurity in this study sample was 19.9% (**Table 2a**). Participants were considered food insecure if they responded affirmatively (“Sometimes”, “Always”) to either question on the validated 2-item food security screener used in clinic (Appendix C).

In 2015, 12.7% of people in the United States were food insecure (1). The rates were comparable for Washington State (12.9%) and higher for Oregon (16.1%). Local FI rates were 15.5% for Multnomah County, 11.8% for Clackamas county, 11.5% for Washington County, and

13.2% in Clark County (6). We calculated a 95% confidence interval for FI prevalence in our sample to estimate the true prevalence of FI among all patients with metabolic disorders; our 95% CI was 13.4% - 27.7%. We determined that there was a significant difference between FI rates if the local, state or national averages fell outside of our 95% confidence interval for food security prevalence among patients with metabolic disorders. The study population experienced significantly higher rates of FI than the national average, Washington State, and all counties in the Portland metropolitan area except for Multnomah County (**Figure 2**). The point estimate of FI in this sample was higher than the rates in Oregon State and Multnomah County, although this was not significant.

Eighty patients responded to the medical food security questions (61% of total sample; 84% of participants receiving MNT). The rate of medical food insecurity, as defined by an affirmative response to at least one question on the food insecurity screener which asks specifically about medical foods (medical formula or low-protein medical foods), was 21.3%.

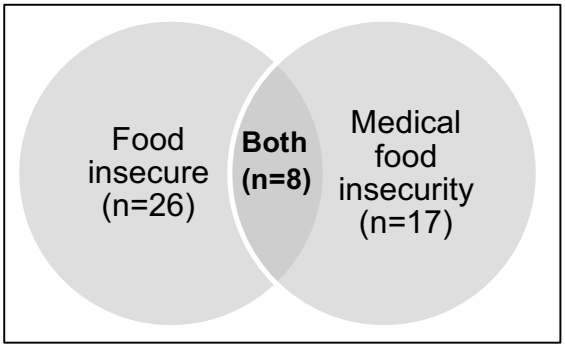
Figure 2. Comparison of sample food insecurity prevalence with local, state and national averages.



[1]* = Values with a significant difference in food insecurity rates when compared to the OHSU Metabolic Clinic. Data were considered statistically significant if the average value fell outside of the 95% confidence interval for FI prevalence in the OHSU Metabolic Clinic (95% CI: 13.4 - 27.7%)

Most individuals who experienced food insecurity or medical food insecurity reported one or the other, but not necessarily both (**Figure 3**). Of those who reported food insecurity, 19 patients (73%) had a diet that requires the use medical foods and 8 of those patients (31%) also experienced medical food insecurity. Of people who reported medical food insecurity, 47% of patients were also food insecure.

Figure 3: Overlap of food insecurity versus medical food insecurity.



Rates of medical food insecurity differed by state. In Oregon, 14.5% of patients experienced medical food insecurity, while 50% of patients who are Washington residents experience medical food insecurity. This difference was statistically significant (Pearson's Chi squared, p = 0.002). Living in Washington is associated with an almost six times increased odds of experiencing medical food insecurity (OR 5.9, 95% CI: 1.8-19.7, p = 0.004).

Use of Food Assistance Programs among Patients at the OHSU Metabolic Clinic

One hundred and twenty-three patients responded to the questions about use of food assistance programs (**Table 3**). Early versions of the food security screener used in clinic did not include a question about the use of food assistance programs, so eight patients were missing data on the use of food assistance. Twenty-nine percent of patients accessed at least one food assistance program: 23% of participants were enrolled in SNAP, 13% were enrolled in WIC, and 8% visited food banks or food pantries. Twelve percent of participants accessed two or more food resources.

Individuals who were food insecure were significantly more likely to report using any food assistance program (64% vs 20%, Pearson's chi square = 18.28, p<0.001); these findings were statistically significant for each resource analyzed (**Figure 4**). Twenty percent of

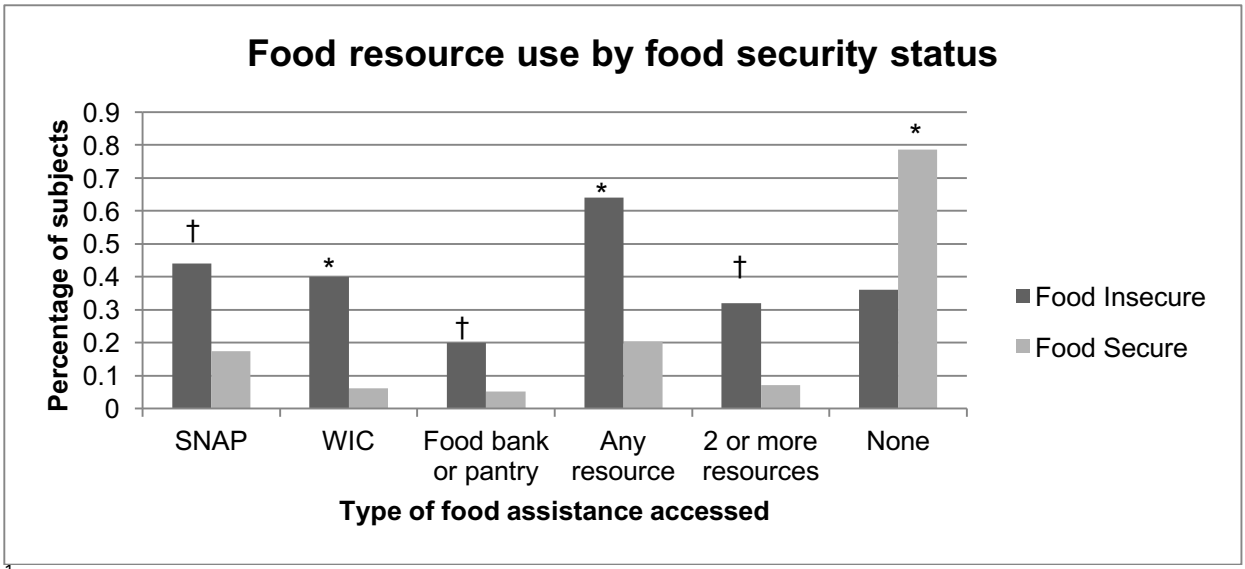
individuals who were food secure accessed food assistance programs, where SNAP was the primary resource used (17%).

Table 3. Food assistance program use among patients of the OHSU Metabolic Clinic[1].

Use food assistance programs, n (%)	Entire sample (*n* = 123)[2]	Food secure (*n* = 98)	Food insecure (*n* = 25)	p-value[3]
SNAP	28 (22.8)	17 (17.4)	11 (44)	**0.005**
WIC	16 (13.0)	6 (6.1)	10 (40)	**<0.001**
Food bank/food pantry	10 (8.1)	5 (5.1)	5 (20)	**0.029**
Using any food resource	36 (29.3)	20 (20.4)	16 (64)	**<0.001**
Using two or more resources	15 (12.2)	7 (7.1)	8 (32)	**0.002**
No resources used	86 (69.9)	77 (78.6)	9 (36)	**<0.001**

[1]OHSU = Oregon Health & Science University. SNAP: The Supplemental Nutrition Assistance Program. WIC: The Special Supplemental Nutrition Program for Women, Infants, and Children.
[2]Eight patients missing data on food assistance program use were excluded from this analysis: *n* = 123.
[3]P values represent Pearson's Chi square tests for the following variables: SNAP, WIC, any resource used, and no resources used. Fisher's exact test was used for food bank/pantry use and use of two or more resources.

Figure 4. Food resource use among patients of the OHSU Metabolic Clinic with and without food insecurity[1].



[1]Eight patients missing data on use of food assistance programs were excluded from this sub-analysis: *n* = 123. OHSU: Oregon Health & Science University. SNAP: The Supplemental Nutrition Assistance Program. WIC: The Special Supplemental Nutrition Program for Women, Infants, and Children.
[2] * = p<0.001, † = p<0.05

Aim 2: Examine whether Anthropometric, Demographic, or Diagnosis-related Factors are Predictors of Food Insecurity among Patients with Inborn Errors of Metabolism.

Eight primary characteristics were analyzed to assess differences by food security status (**Table 4**). These eight variables were age, state of residence, insurance type (public vs. private), BMI-for age or weight-for-length z score (pediatric patients) or BMI (adult patients), proportion of patients receiving medical nutrition therapy, proportion of patients taking medical formula, percent taking medications, and percent prescribed low-protein medical foods. To adjust for multiple comparisons, these characteristics were analyzed with $p < 0.01$ considered statistically significant.

These analyses revealed a trend towards a statistically significant difference in food security status by age. Individuals who were food insecure were more likely to be older (mean age = 19 years versus 12.7 years, $p = 0.08$). When age was evaluated as a categorical variable, there was also a trend towards statistical significance with a higher rate of FI among adult patients versus pediatric patients (%FI = 31% vs 16%, $p = 0.045$). Anthropometric measurements also approached – but were not – statistically significant. Children and adolescents who were food insecure had a slightly lower weight-for-length or BMI-for-age Z score (-0.04 vs. 0.5, $p = 0.11$). Adults who were food insecure had a higher BMI than food secure adults, but this difference was not statistically significant (28.9 kg/m^2 vs. 25.1 kg/m^2, $p=0.19$). There were no statistically significant differences in food security status by state of residence or insurance type. There were also no differences in food security status by metabolic treatment characteristics (use of medical nutrition therapy, medical formula, medications, or low-protein medical foods).

In secondary analyses, additional variables were evaluated by food security status, including gender, ethnicity, primary dietary modification, prescription of nutritional supplements, and whether or not the patient had been previously seen by MD/NP or an RD. These analyses are presented in **Table 5** and were not adjusted for multiple comparisons as they were

considered exploratory analyses; a $p < 0.05$ was considered statistically significant. More women than men were food insecure (65% vs. 35%), but this difference was not statistically significant. Individuals who were food insecure were also more likely to be Hispanic (23% vs 8%, Fisher's exact test, $p = 0.044$). Hispanic ethnicity was associated with a 4-fold increased odds of being food insecure (OR: 4.2, 95%CI: 1.26-13.69, $p = 0.019$). There was no significant difference in additional metabolic disorder-related characteristics such as the primary dietary modification, use of nutritional supplements, or previously being seen by an MD, NP or RD by food security status.

Table 4. Primary characteristics: population differences by food security status.

Characteristic	Food secure (n=105)	Food insecure (n=26)	p value
Age, years (mean ± SD)	12.65 ± 10.65	19.02 ± 17.24	0.082
State of residence [n (%)]			
Oregon	87 (82.86)	22 (84.62)	1
Washington or other	18 (17.14)	4 (15.38)	
Insurance type [n (%)]			
Public	47 (44.76)	13 (50)	0.631
Non-public	58 (55.24)	13 (50)	
Less than 18 years*:* Weight-for-length or BMI-for-age Z score[4] (mean ± SD)	0.49 ± 1.13	-0.04 ± 1.32	0.111
18 years or older: BMI (kg/m^2) (mean ± SD)	25.09 ± 5.18	28.93 ± 8.52	0.19
Patient on MNT [n (%)]	77 (72.38)	19 (73.08)	0.943
Prescribed medical formula [n (%)]	56 (53.33)	15 (57.69)	0.69
Prescribed medications [n (%)]	35 (33.02)	7 (26.92)	0.531
Prescribed low-protein medical foods [n (%)]	48 (45.28)	13 (50)	0.631

[1]P values represent the results of each value's statistical test: Pearson's chi square testing for gender, MNT, formula use, medication use, low protein food use; Fisher's exact test for state; t-tests with unequal variance for BMI; and t-test with equal variances for BMI-for-age or weight-for-length Z scores.
[2]MNT: Medical Nutrition Therapy

Table 5. Secondary characteristics: differences by food security status

Characteristic	Food secure (n=105)	Food insecure (n=26)	p value
Gender [n (%)]			0.147
Male	53 (50.48)	9 (34.62)	
Female	52 (49.52)	17 (65.38)	
Ethnicity [n (%)]			**0.044**
Non-Hispanic	97 (92.38)	20 (76.92)	
Hispanic or other	8 (7.62)	6 (23.08)	
Prescribed nutritional supplements	26 (24.8)	7 (26.9)	0.82
Previously seen by MD or NP[2]	97 (92.4)	26 (100)	0.356
Previously seen by RD	68 (64.8)	19 (73.1)	0.422

[1]P values represent the results of each values statistical test: t-test with unequal variance for age, Fisher's exact test for ethnicity and previously seen by MD or NP, and Pearson's chi square testing for prescription of nutritional supplements, and previously seen by RD.
[2]MD: medical doctor, NP: nurse practitioner, RD: registered dietitian.

Aim 3: Describe the Individual Experience of Food Insecurity among Adult Patients with Inborn Errors of Metabolism by Gathering Data on Quality of Life and Financial Burden of Disease, and Compare Responses to the 18-item USDA Food Insecurity Screener with the 2-question Screener Used in Clinic.

Seven patients were successfully enrolled in the prospective, questionnaire-based arm of this study. All of the participants had PKU, and all but one were female (86%, **Table 6**). The mean age of participants was 31.1 $\pm$ 11.1 (range: 18 – 48 years). Each participant responded to the 10-item USDA Food Security Survey Module for households with only adults present or the 18-item module if the household also included children. The responses to the first two questions were used to calculate the short form (or screener) food security response; this is the same protocol used for the food security screener in the OHSU Metabolic Clinic, and which has been validated by Hager et al. Responses from the full 10-item or 18-item screener were coded using USDA protocols (54). In short, 3 or more affirmative responses indicate that an individual is food insecure. Food insecurity can be further classified into low food security (3-5 affirmative responses for households without children, 3-7 for households with children) or very low food

security (greater than 5 or 7 positive responses for households without children and households with children, respectively). In this sample, each adult who screened as food secure using the 2-item screener also screened as food secure on the 10-item or 18-item questionnaire. All individuals who screened as food insecure using the two-item questionnaire were also categorized as food insecure using the 10-item or 18-item questionnaire; the additional questions helped to classify patients with FI further (low food security or very low food security). Three of the 7 patients were classified as food insecure based on their response to the screener. The individuals who were food insecure were the two youngest patients and the oldest patient in the cohort.

Participants also completed the CDC Healthy Days Health-Related Quality of Life screener (Healthy Days 14). The patient's self-reported health, the number of unhealthy days in the last month, and the number of activity-limited days are reported in Table 5. Three people self-reported their health as fair or poor; of these, 2 participants reported very low food security. Individuals who experienced FI reported a greater number of unhealthy days in the past month (19.2 vs 6.9 unhealthy days). Every individual who experienced FI reported that their physical or mental health had limited their activities in the past month, while none of the food secure individuals had their activities limited.

Participants were also asked seven additional questions about their financial expenses related to treatment for their metabolic disorder (see Table 5). Given that all patients had PKU, a low-protein diet supplemented with medical food was recommended for all patients. The questions asked about out-of-pocket expenditures for medical formula or low-protein medical foods, co-pays and medications, as well as other financial insecurities and the adequacy of their insurance coverage (Appendix D). In total, 5 of the 7 participants expressed some financial insecurity, either as FI, financial burden related to the cost of medical expenses, or worry about whether they could cover the cost of basic expenses. Three of the 7 participants reported paying out-of-pocket for any expenses related to their medical care. Of the three, two

participants paid out-of-pocket for their medical formula or low-protein medical foods (ranging from $100-$500 per month) and all three paid out-of-pocket for medications or clinic appointments (ranging from $1-$500 per month). Subject 7 reported paying $200-$500 per month on medical foods because they are not covered by her insurance. Two of the three patients who paid out-of-pocket reported that this amount is a financial burden at least some of the time, if not all of the time. Another patient, subject 3, was not currently taking medical formula or low-protein medical foods but mentioned that when she was taking her formula and attending clinic appointments regularly, the expense was a financial burden.

Financial pressures seemed to be a common reason that individuals stopped taking their medical formulas or low-protein foods, or why they attended clinic less often. Of the three individuals who were food insecure, two of them were not currently on diet (taking medical formula or foods). Subjects 3 and 4 both cited the cost of their medical formulas, low-protein foods, and medications as the primary reason that they went off-diet. Even among individuals who were food secure, there was a common feeling of anxiety about the cost of treatment. Subject 1 expressed that her expenditures did not represent a financial burden, but they would if her partner lost his job. Subject 2, who was returning to diet when we spoke, expressed anxiety about what his insurance would cover and about the cost of medical foods. Subject 7, who was food secure, stated that the amount spent on medical expenditures was a financial burden for her and she was worried about the cost of other basic expenses.

Table 6. Prospective questionnaire study: participant demographics and responses.

ID	Age[1]	Sex	Currently taking medical foods?	FI status – short form[2]	FI status – long form	Self-rated health	# Unhealthy days per month	# Activity Limited days per month	Paid OOP in last 30 days	Monthly OOP costs for medical foods	Monthly OOP for co-pays, medication	Is the amount a financial burden?	Worry about money for basic expenses ?	Does your insurance meet your needs?
1	26-40	F	Yes	food secure	food secure	good	0	0	Yes	$100-200	$1-50	No	No	Yes
2	26-40	M	No	food secure	food secure	fair/poor	0	0	No	I don't pay OOP	I don't pay OOP	No	Some-times	Not sure
3	18-25	F	No	food insecure	VLFS (adult scale)	fair/poor	30	2	No	I don't pay OOP	I don't pay OOP	Yes	Yes	No
4	>40	F	No	food insecure	VLFS (adult scale)	good	12.5	8	Yes	I don't pay OOP	$100-200	Some-times	Yes	Yes
5	18-25	F	Yes	food secure	food secure	excellent	2.5	0	No	I don't pay OOP	I don't pay OOP	No	No	Yes
6	18-25	F	Yes	food insecure	VLFS (house-hold)	fair/poor	15	3	No	I don't pay OOP	I don't pay OOP	No	Some-times	Yes
7	26-40	F	No?	food secure	food secure	good	25	0	Yes	$200-500	$200-500	Yes	Yes	No

[1]Patient's ages are listed in ranges to protect patient confidentiality.

[2]FI: Food Insecurity, OOP: Out of Pocket.

Chapter V: Discussion

Food insecurity is a serious public health issue in the United States with impacts on both physical and emotional health; individuals with metabolic disorders may be at increased risk of food insecurity due to the financial burdens of specialty medical care. To our knowledge, this is the first study investigating the prevalence and risk factors of food insecurity among children and adults with inborn errors of metabolism. In our sample, 19.9% of participants were food insecure and 21.3% were medical food insecure (experienced food insecurity related to their medical formula or low-protein medical foods), indicating a significant burden of food insecurity in this population. Hispanic individuals had a significantly higher rate of food insecurity compared to non-Hispanic individuals, and adults (18 years of age or older) trended towards a greater risk of food insecurity compared to children. Risk of food insecurity did not differ by metabolic diagnosis, necessity of disorder-specific medical nutrition therapy, or other diagnosis-related variables. Additionally, we validated the use of the 2-item food insecurity screener from Hager et al. in a small pilot study of adults with metabolic disorders seen at the OHSU Metabolic Clinic (3).

Prevalence of Food Insecurity and Medical Food Insecurity

Overall, the prevalence of food insecurity in our population was greater than the national average. Although the point estimate for our study population was higher than the average rate of FI for the state of Oregon, the 95% confidence interval included the state average, so these findings were not considered statistically significant. The prevalence of FI among the Metabolic Clinic population may not have been significantly different from the state prevalence estimates due to high baseline food insecurity in Oregon, which has the sixth highest FI rate in the United States (1). Both the point estimate and the 95% CI interval for prevalence of food insecurity in

our population was higher than the average for Washington State. The food insecurity estimate in our clinic was not significantly different than the estimate for Multnomah County, which is Oregon's most populous county and includes the City of Portland. However, the OHSU Metabolic Clinic serves the whole state of Oregon and many patients live outside of Multnomah County, so FI prevalence in Multnomah County may not be the best comparison. There was a significantly higher average prevalence of FI among Metabolic Clinic patients compared to food insecurity rates in other counties in the Portland Metropolitan area (Clackamas, Washington and Clark Counties). However, individual demographic data on county of residence was not collected in this study, so we were unable to directly assess county-specific rates of food insecurity in our sample population. Overall, these results support our hypothesis that individuals with metabolic disorders experience high rates of food insecurity that are similar to or greater than rates in the general population.

Approximately one in five participants in our study experienced medical food insecurity, a term used in this study to represent food insecurity related specifically to the availability of medical food (both medical formula and specially modified low-protein foods). Many metabolic disorders require the use of medical foods, often for life (49). Medical food insecurity was associated with one's state of residence, with individuals in Washington experiencing significantly higher rates of medical food insecurity compared to Oregon residents. Medical food insecurity has not been formally studied in other literature and as such, we cannot compare these results to other findings.

Insurance coverage for medical foods differs by state. Oregon mandates that public insurance plans provide coverage for medical food for all individuals with a metabolic disorder regardless of diagnosis or age (45). However, many states have much less robust insurance mandates. According to a 2011 study of state insurance policies, only 61% of states had mandated public insurance coverage of medical foods for inborn errors of metabolism. Coverage has been found to vary by diagnosis and age, and some states have annual caps on

funding (42-44, 46, 47). Despite comprehensive public insurance mandates in Oregon, 1 in 7 Oregonian study participants with a metabolic disorder requiring metabolic formula or foods experienced medical food insecurity, indicating that there may be remaining gaps in insurance coverage that should be explored further. In Washington State, 50% of study participants whose diagnosis requires medical formula or low-protein medical foods experienced medical food insecurity, although rates of overall food insecurity are similar to Oregon. These high rates likely reflect lack of sufficient mandated public insurance coverage for IEM, which may be an avenue for intervention by policy makers. Poor or limited insurance coverage increases the likelihood that individuals will experience medical food insecurity, which may worsen clinical outcomes. While "medical food insecurity" is not an indicator that has been studied in other populations of individuals with IEM, the results from our study highlight the importance of looking specifically at medical food insecurity among individuals with metabolic disorders. Additional research on medical food insecurity in other states or regions of the United States may reveal the need for advocacy and policy change regarding mandated insurance coverage of medical foods (both medical formulas and specially mandated low-protein medical foods) for all metabolic disorders and across the entire lifespan.

Elevated risk of food insecurity (and high prevalence of medical food insecurity) among patients with metabolic disorders is significant and may affect treatment compliance. Individuals who are food insecure often choose foods based on price rather than nutritional composition, which can be problematic for patients with specific medical nutrition therapy goals related to their metabolic disorder. Additionally, individuals experiencing medical food insecurity may consume insufficient amounts of their metabolic formula or low-protein medical foods, which can have important consequences on disorder-specific outcomes. Food insecurity is associated with medication underuse in other low-income populations. Berkowitz et al described the "treat or eat" hypothesis, where individuals with chronic medical conditions and limited income had to choose to allocate their resources towards paying for medical care or paying for food (11). Our

pilot study seems to indicate that this choice is a common concern for individuals with metabolic disorders. Two of the three patients in our questionnaire-based study were currently “off diet” because it was too expensive. These findings are in line with those from Kemper et al who found that cost of medical formula and low-protein foods was one of the main barriers to remaining on-diet for women with metabolic disorders (52). In addition to medication underuse, FI may result in other financial insecurities such as being late on rent, mortgage or utility payments (17, 32, 37). In our pilot study, individuals who were food insecure were more likely to report worrying about paying for basic utilities. Food insecure individuals often face other financial insecurities that affect not only their health and well-being, but also their ability to successfully comply with treatment requirements related to their metabolic disorder.

Food insecure individuals are more likely to report that their health is fair or poor, and to experience greater rates of stress, anxiety and depression (3, 13, 18, 23, 55). Results from our questionnaire-based study of adults with metabolic disorders confirmed that these findings also apply to individuals with IEMs. Participants who were food insecure were more likely to report fair/poor health, activity limitations secondary to poor physical or mental health, and all expressed anxiety about having money for other basic expenses at least some of the time. These findings demonstrate that food insecurity among individuals with metabolic disorders is associated with a lower quality of life and significant financial stress, which may worsen clinical outcomes.

Use of Food Assistance Programs by Patients of the OHSU Metabolic Clinic

Twenty nine percent of people in our study utilized at least one food assistance programs such as SNAP, WIC, and food banks or pantries. Individuals who were food insecure reported much higher rates of food assistance program use than food secure participants, which is in line with previous literature suggesting that food insecure individuals are often aware of and

already utilizing community resources (2, 10). While a majority of food insecure patients are using at least one food assistance program, program-specific analyses reveal lower participation rates than state-wide averages. For example, 44% of people who were food insecure in our population utilized SNAP, while it is estimated that 73% of Oregonians who are eligible for SNAP resources are accessing these benefits (56). Low participation rates in our sample may indicate a continued need for outreach and awareness of programs. However, not all individuals who are food insecure are necessarily eligible for SNAP benefits, making it difficult to determine exactly what percentage of individuals in our sample are both eligible for and receiving SNAP benefits. Additionally, our data also reveals that many individuals who are food secure utilize food assistance programs and rely on these programs to meet their food and nutrition needs.

No Association between Insurance Type and Food Insecurity Risk

Contrary to our hypothesis, there were no statistically significant differences in food insecurity status by insurance type. Insurance type was used as a proxy for income in our study, and income has been widely associated with food insecurity risk (9, 23, 27). However, the association between income and food insecurity may be modified by other variables, such as access to government assistance resources. For example, research suggests that having public insurance may have no effect or be protective against food insecurity, while having no health insurance or private health insurance is associated with greater food insecurity risk (30). A 2012 review of financial expenditures for children with special health care needs (CSHCN) found that individuals with public insurance had lower out-of-pocket costs related to their health care (30). While eligibility guidelines vary by state, an individual who qualifies for Medicaid will generally automatically qualify for federal food assistance programs such as SNAP and WIC because eligibility requirements tend to be stricter for Medicaid. For example, individuals in Oregon are

currently eligible for Medicaid benefits if they are at or below 133% of the Federal Poverty Level (FPL), while income eligibility guidelines are ≤185% FPL for SNAP and WIC. As a result, an individual may automatically qualify for food assistance programs with proof of Medicaid benefits.

Additionally, some research has suggested that individuals who are right above the income requirements for federal assistance programs (such as Medicaid or SNAP) are at a higher risk for food insecurity, as they are not eligible to receive financial assistance but still have financial insecurities (12, 16). Previous research among caregivers of CSHCN by DeJong et al found that 33% of families were food insecure using a 1-item questionnaire, and 26% of families with CSHCN were ineligible for or denied access to nutrition assistance programs, indicating that families may have financial need but are ineligible for benefits (37). This may be the case in our sample of individuals with metabolic orders who have higher healthcare costs, which may reduce the amount they have to cover other basic needs such as housing, utilities and food. In our sample, individuals on private insurance plans reported greater use of food assistance programs than those on public insurance plans, although the difference was not statistically significant ($p=0.18$, analyses not shown). Public insurance plans have mandated coverage for some components of medical care such as medical formula and low-protein medical foods, while private plans do not necessarily have mandated coverage. A lack of mandated coverage for medical treatments or medical foods and formulas may mean than individuals with private insurance plans have higher out-of-pocket expenditures and increased financial strain that may increase their risk of food insecurity. These findings may explain the lack of a significant relationship between insurance type and food security status. Our post-hoc analyses of food assistance program use by insurance type support the idea that public insurance may reduce the risk of food insecurity, potentially by lowering out-of-pocket expenses, expanding access to medical foods (if indicated for disorder), or expanding access to food assistance programs like SNAP.

Metabolic-Disorder Specific Differences by Food Security Status

In our population there were no differences in rates of food insecurity or medical food insecurity by any metabolic disorder specific variables including metabolic diagnosis, provision of medical nutrition therapy, use of medical formulas or low-protein medical foods, or use of disorder-specific medications or nutritional supplements. These findings are contrary to our hypothesis and suggest that individuals with metabolic disorders are highly likely to experience food insecurity simply because they have a chronic condition that increases healthcare utilization, regardless of specific metabolic disorder or treatment needs. Using Oregon Pregnancy Risk Assessment Monitoring System (PRAMS) data, Adams et al. found that Oregon mothers with 2-year old children who had special health care needs were over twice as likely to be food insecure as mothers without children with special health care needs (28). Specifically, 20.7% of families with CSCHN and 9.7% of families without CSHCN were food insecure. Our study found similar rates of food insecurity among child and adult patients with metabolic disorders, although comparison data in our study was limited to national, state, and county-level food insecurity estimates. The PRAMS study defined CSHCN based on chronic use of services such as physical or occupational therapy, special diet, or specialty health care services. These criteria align with our hypothesis that utilization of any additional health care services may be enough to increase one's risk of food insecurity. Our results highlight the importance of screening all patients with metabolic disorders for food insecurity.

Demographic Differences by Food Security Status

Food insecure participants in our study were more likely to be Hispanic. These findings are in line with our hypotheses and with existing literature. In 2015, 1 in 5 Hispanic households in the United States were food insecure (1). In our sample, 6 of the 14 individuals (43%) who

identified as Hispanic were food insecure. Our sample of Hispanic individuals with metabolic disorders revealed a much higher rate of food insecurity compared to the national average, but conclusions are limited due to the small number of Hispanic participants in our sample.

In addition, adults with metabolic disorders trended towards greater rates of food insecurity than children. These findings are in line with our hypothesis and with other literature suggesting that adults are more likely to experience food insecurity, although the risk increase is often dependent on other household factors (57). Adults have higher energy and nutrient requirements requiring a greater volume of food to meet their nutritional needs. Additionally, some literature suggests that adults with metabolic disorders may experience changes to insurance coverage of metabolic formulas or foods around adulthood that may increase their risk of food insecurity (43, 52). Further, adults in households with children often attempt to shield children from the detrimental effects of food scarcity, and as a result experience greater food insecurity than children (17, 19). In addition, adults often reduce the quality or quantity of their meals in order to supply adequate meals to the children (21). Data on household characteristics were not collected in this study, so the effect of children in the household on food insecurity in our sample population is unknown.

Strengths and limitations

To our knowledge, this study is the first to assess the prevalence of food insecurity among individuals with inborn errors of metabolism. Our study had a large sample size of children and adults with metabolic disorders in Oregon and Southwest Washington. All data for the study were entered and analyzed by the same person, limiting inter-person variation. A significant limitation of the study is that only 50% of patients seen in the Metabolic Clinic during the 6-month study period were screened for food insecurity. Initiation of food insecurity screening was a new clinic protocol, and consequently there were a number of reasons why the

rate of food insecurity screening was low. Food security screeners were distributed by the clinic medical assistant and the process was not highly standardized; as a result, screening typically did not occur if the medical assistant was not present in clinic. Additionally, there appeared to be differences in rates of food insecurity screening dependent on the medical provider and whether or not the patient was seen by a RD, although this was not formally evaluated. Since only half of patients seen during the study period were screened for food insecurity and eligible for inclusion, our study population may not be a representative sample of OHSU Metabolic Clinic patients. It is unclear how the rate of food insecurity or findings of this study would differ if all patients were screened for food insecurity. Future analyses should identify differences among patients screened and not screened for food insecurity. Additionally, study variables were limited to the data collected as a part of routine clinical care and available in medical records. There are additional variables that can contribute to one's risk of food insecurity such as household characteristics (number of siblings, parental dynamics), household income, or highest level of educational attainment which cannot be pulled from participants' medical charts but may contribute to differences in food insecurity rates.

Future Research

The heightened risk of food insecurity in this population may have been masked by high baseline rates of food insecurity in Oregon, or may be representative of a true lack of difference. Future research in other states or regions of the United States is warranted to add to the body of understanding on how food insecurity affects this population. Our study utilized data points that were readily available and collected as a part of routine clinical care to determine if individual factors were associated with food insecurity risk. We did not examine how food insecurity affected clinical outcomes. Further research in this population should also collect data on clinical endpoints (i.e. phenylalanine levels for individuals with PKU) to determine if food insecurity is

associated with poor metabolic control. Finally, our study population was mostly non-Hispanic white and English speaking. Future research in racially and ethnically diverse populations of individuals with IEM should address risk of food insecurity in these groups, which are traditionally believed to experience higher rates of food insecurity than non-Hispanic whites.

Conclusion

The findings from our study suggest that individuals with metabolic disorders are highly likely to experience food insecurity. There are no specific metabolic disorder specific characteristics that increase one's likelihood of being food insecure, which highlights that all individuals with metabolic disorders should be screened for food insecurity. Our study revealed that a majority of food insecure individuals are already utilizing at least one food assistance program; this population may need additional assistance or access to novel resources to reduce rates of food insecurity. Future research in other states or regions of the United States is warranted to add to the body of understanding on how food insecurity affects this population.

Our study also piloted screening for "medical food insecurity" and studied its prevalence. We saw a high overall prevalence of medical food insecurity and striking differences by state, likely related to differences in insurance coverage. These findings highlight a significant treatment barrier that is likely an issue across the United States in states whose insurance mandates for medical foods are less robust than Oregon's. Additional research is needed to validate the use of the term "medical food insecurity" and to identify prevalence in other populations of individuals with IEMs. This study and further investigations may help policy makers advocate for changes to insurance coverage of medical formula and low-protein medical foods to improve clinical outcomes.

Adults and Hispanic individuals were more likely to be food insecure, and food insecurity in our population was associated with a lower health-related quality of life and greater limitations

in activity. These results warrant further study in larger populations of racially and ethnically diverse individuals with metabolic disorders across the lifespan. Future research should also link food insecurity for individuals with IEMs to clinical outcomes, health-related quality of life, and psychological health. This study elucidates the high risk of food insecurity among individuals with metabolic disorders and highlights the need for targeted interventions to reduce food insecurity and medical food insecurity in this population.

References

1. Coleman-Jensen AG, C.; Rabbitt, R. September 6, 2016. Internet: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx 2016).
2. Hanson KL, Olson CM. Chronic health conditions and depressive symptoms strongly predict persistent food insecurity among rural low-income families. Journal of health care for the poor and underserved 2012;23(3):1174-88. doi: 10.1353/hpu.2012.0116.
3. Hager ER, Quigg AM, Black MM, Coleman SM, Heeren T, Rose-Jacobs R, Cook JT, de Cuba SA, Casey PH, Chilton M, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. Pediatrics 2010;126(1):e26-32. doi: 10.1542/peds.2009-3146.
4. 9/8/2015. Internet: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx (accessed 1/27/2016.
5. 10/28/2015. Internet: http://www.ocpp.org/2015/10/28/fs20151028-oregon-hunger-food-insecurity-rise/ (accessed 1/27/16 2016).
6. Gundersen CS, A.; Dewey, A.; Kato, M.; Engelhard, E. Internet: http://www.feedingamerica.org/hunger-in-america/our-research/map-the-meal-gap/2013/OR_AllCounties_CDs_MMG_2013.pdf (accessed 2/23/2016 2016).
7. Coleman-Jensen AG, C.; Rabbitt, R. 9/8/2015. Internet: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/history-background.aspx (accessed 3/1/2016 2016).
8. Coleman-Jensen AG, C.; Rabbitt, R. 9/8/2016. Internet: http://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools.aspx (accessed 3/1/2016 2016).
9. Promoting Food Security for All Children. Pediatrics 2015;136(5):e1431-8. doi: 10.1542/peds.2015-3301.
10. Pabalan L, Dunn R, Gregori K, Olson E, Thomas L, Willis E, Simpson P, Brousseau DC. Assessment of Food Insecurity in Children's Hospital of Wisconsin's Emergency Department. WMJ : official publication of the State Medical Society of Wisconsin 2015;114(4):148-51.
11. Berkowitz SA, Seligman HK, Choudhry NK. Treat or eat: food insecurity, cost-related medication underuse, and unmet needs. The American journal of medicine 2014;127(4):303-10.e3. doi: 10.1016/j.amjmed.2014.01.002.
12. Banach LP. Hospitalization: Are We Missing an Opportunity to Identify Food Insecurity in Children? Academic pediatrics 2016. doi: 10.1016/j.acap.2016.01.002.
13. Sullivan AF, Clark S, Pallin DJ, Camargo CA, Jr. Food security, health, and medication expenditures of emergency department patients. The Journal of emergency medicine 2010;38(4):524-8. doi: 10.1016/j.jemermed.2008.11.027.
14. Coleman-Jensen AR, R.; Gregory, C.; Singh, A. Household Food Security in the United States in 2014. In: United States Department of Agriculture ERS, ed. Washington, DC: Economic Research Report, 2015.
15. Fleegler EW, Lieu TA, Wise PH, Muret-Wagstaff S. Families' health-related social problems and missed referral opportunities. Pediatrics 2007;119(6):e1332-41. doi: 10.1542/peds.2006-1505.
16. Cook JT, Black M, Chilton M, Cutts D, Ettinger de Cuba S, Heeren TC, Rose-Jacobs R, Sandel M, Casey PH, Coleman S, et al. Are food insecurity's health impacts underestimated in the U.S. population? Marginal food security also predicts adverse health outcomes in young U.S. children and mothers. Advances in nutrition (Bethesda, Md) 2013;4(1):51-61. doi: 10.3945/an.112.003228.

17. Knowles M, Rabinowich J, Ettinger de Cuba S, Cutts DB, Chilton M. "Do You Wanna Breathe or Eat?": Parent Perspectives on Child Health Consequences of Food Insecurity, Trade-Offs, and Toxic Stress. Maternal and child health journal 2016;20(1):25-32. doi: 10.1007/s10995-015-1797-8.
18. Leung CW, Epel ES, Willett WC, Rimm EB, Laraia BA. Household food insecurity is positively associated with depression among low-income supplemental nutrition assistance program participants and income-eligible nonparticipants. The Journal of nutrition 2015;145(3):622-7. doi: 10.3945/jn.114.199414.
19. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children: a systematic review. The American journal of clinical nutrition 2014;100(2):684-92. doi: 10.3945/ajcn.114.084525.
20. Fram MS, Frongillo EA, Jones SJ, Williams RC, Burke MP, DeLoach KP, Blake CE. Children are aware of food insecurity and take responsibility for managing food resources. The Journal of nutrition 2011;141(6):1114-9. doi: 10.3945/jn.110.135988.
21. Connell CL, Lofton KL, Yadrick K, Rehner TA. Children's experiences of food insecurity can assist in understanding its effect on their well-being. The Journal of nutrition 2005;135(7):1683-90.
22. Howard LL. Transitions between food insecurity and food security predict children's social skill development during elementary school. The British journal of nutrition 2011;105(12):1852-60. doi: 10.1017/s0007114510005623.
23. Ramsey R, Giskes K, Turrell G, Gallegos D. Food insecurity among Australian children: potential determinants, health and developmental consequences. Journal of child health care : for professionals working with children in the hospital and community 2011;15(4):401-16. doi: 10.1177/1367493511423854.
24. Belsky DW, Moffitt TE, Arseneault L, Melchior M, Caspi A. Context and sequelae of food insecurity in children's development. American journal of epidemiology 2010;172(7):809-18. doi: 10.1093/aje/kwq201.
25. Beer SS, Juarez MD, Vega MW, Canada NL. Pediatric Malnutrition: Putting the New Definition and Standards Into Practice. Nutrition in clinical practice : official publication of the American Society for Parenteral and Enteral Nutrition 2015;30(5):609-24. doi: 10.1177/0884533615600423.
26. Jackson JA, Smit E, Manore MM, John D, Gunter K. The Family-Home Nutrition Environment and Dietary Intake in Rural Children. Nutrients 2015;7(12):9707-20. doi: 10.3390/nu7125495.
27. Tarasuk V, Cheng J, de Oliveira C, Dachner N, Gundersen C, Kurdyak P. Association between household food insecurity and annual health care costs. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne 2015;187(14):E429-36. doi: 10.1503/cmaj.150234.
28. Adams EJ, Hoffmann LM, Rosenberg KD, Peters D, Pennise M. Increased Food Insecurity Among Mothers of 2 Year Olds with Special Health Care Needs. Maternal and child health journal 2015;19(10):2206-14. doi: 10.1007/s10995-015-1735-9.
29. Rose-Jacobs R, Fiore JG, de Cuba SE, Black M, Cutts DB, Coleman SM, Heeren T, Chilton M, Casey P, Cook J, et al. Children with Special Health Care Needs, Supplemental Security Income, and Food Insecurity. Journal of developmental and behavioral pediatrics : JDBP 2016;37(2):140-7. doi: 10.1097/dbp.0000000000000260.
30. DeRigne L. The employment and financial effects on families raising children with special health care needs: an examination of the evidence. Journal of pediatric health care : official publication of National Association of Pediatric Nurse Associates & Practitioners 2012;26(4):283-90. doi: 10.1016/j.pedhc.2010.12.006.

31. Derigne L, Porterfield S. Employment change and the role of the medical home for married and single-mother families with children with special health care needs. Social science & medicine (1982) 2010;70(4):631-41. doi: 10.1016/j.socscimed.2009.10.054.
32. Mabli J, Cohen R, Potter F, Zhao Z. Hunger in America 2010 National Report Prepared for Feeding America. Mathematica Policy Research 2010.
33. McPherson M, Arango P, Fox H, Lauver C, McManus M, Newacheck PW, Perrin JM, Shonkoff JP, Strickland B. A new definition of children with special health care needs. Pediatrics 1998;102(1 Pt 1):137-40.
34. Initiative CaAHM. Internet: http://www.cahmi.org/wp-content/uploads/2014/06/CSHCNS-whoarecshcn_revised_07b-pdf.pdf (accessed 2/23/2016 2016).
35. Caicedo C. Families with special needs children: family health, functioning, and care burden. Journal of the American Psychiatric Nurses Association 2014;20(6):398-407. doi: 10.1177/1078390314561326.
36. Parish SL, Shattuck PT, Rose RA. Financial burden of raising CSHCN: association with state policy choices. Pediatrics 2009;124 Suppl 4:S435-42. doi: 10.1542/peds.2009-1255P.
37. DeJong NA, Wood CT, Morreale MC, Ellis C, Davis D, Fernandez J, Steiner MJ. Identifying Social Determinants of Health and Legal Needs for Children With Special Health Care Needs. Clinical pediatrics 2016;55(3):272-7. doi: 10.1177/0009922815591959.
38. Wessel AR, F. Inborn Errors of Metabolism. 5 ed. United States of America: King Printing Company, 2014.
39. Bernstein LER, F.; Helm, J.R. Nutrition Management of Inherited Metabolic Diseases: Lessons from Metabolic University. Switzerland: Springer International Publishing, 2015.
40. Koenig MK. Presentation and Diagnosis of Mitochondrial Disorders in Children. Pediatric neurology 2008;38(5):305-13. doi: 10.1016/j.pediatrneurol.2007.12.001.
41. 5/12/2016. Internet: http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/MedicalFoods/ (accessed 1/27/2016 2016).
42. Berry SA, Kenney MK, Harris KB, Singh RH, Cameron CA, Kraszewski JN, Levy-Fisch J, Shuger JF, Greene CL, Lloyd-Puryear MA, et al. Insurance coverage of medical foods for treatment of inherited metabolic disorders. Genetics in medicine : official journal of the American College of Medical Genetics 2013;15(12):978-82. doi: 10.1038/gim.2013.46.
43. Camp KM, Lloyd-Puryear MA, Huntington KL. Nutritional treatment for inborn errors of metabolism: indications, regulations, and availability of medical foods and dietary supplements using phenylketonuria as an example. Molecular genetics and metabolism 2012;107(1-2):3-9. doi: 10.1016/j.ymgme.2012.07.005.
44. Therrell BL, Jr., Lloyd-Puryear MA, Camp KM, Mann MY. Inborn errors of metabolism identified via newborn screening: Ten-year incidence data and costs of nutritional interventions for research agenda planning. Molecular genetics and metabolism 2014;113(1-2):14-26. doi: 10.1016/j.ymgme.2014.07.009.
45. America NN. Internet: http://www.medicalfood.com/Reimbursement/Coverage-by-State/ (accessed 1/27/2016 2016).
46. Weaver MA, Johnson A, Singh RH, Wilcox WR, Lloyd-Puryear MA, Watson MS. Medical foods: inborn errors of metabolism and the reimbursement dilemma. Genetics in medicine : official journal of the American College of Medical Genetics 2010;12(6):364-9. doi: 10.1097/GIM.0b013e3181deb2f0.
47. Belanger-Quintana A, Dokoupil K, Gokmen-Ozel H, Lammardo AM, MacDonald A, Motzfeldt K, Nowacka M, Robert M, van Rijn M, Ahring K. Diet in phenylketonuria: a snapshot of special dietary costs and reimbursement systems in 10 international

centers. Molecular genetics and metabolism 2012;105(3):390-4. doi: 10.1016/j.ymgme.2011.12.004.
48. Herman D, Afulani P, Coleman-Jensen A, Harrison GG. Food Insecurity and Cost-Related Medication Underuse Among Nonelderly Adults in a Nationally Representative Sample. American journal of public health 2015;105(10):e48-59. doi: 10.2105/ajph.2015.302712.
49. Singh RH, Cunningham AC, Mofidi S, Douglas TD, Frazier DM, Hook DG, Jeffers L, McCune H, Moseley KD, Ogata B, et al. Updated, web-based nutrition management guideline for PKU: An evidence and consensus based approach. Molecular genetics and metabolism 2016;118(2):72-83. doi: 10.1016/j.ymgme.2016.04.008.
50. Vockley J, Andersson HC, Antshel KM, Braverman NE, Burton BK, Frazier DM, Mitchell J, Smith WE, Thompson BH, Berry SA. Phenylalanine hydroxylase deficiency: diagnosis and management guideline. Genetics in medicine : official journal of the American College of Medical Genetics 2014;16(2):188-200. doi: 10.1038/gim.2013.157.
51. Ptomey LT, Wittenbrook W. Position of the Academy of Nutrition and Dietetics: nutrition services for individuals with intellectual and developmental disabilities and special health care needs. Journal of the Academy of Nutrition and Dietetics 2015;115(4):593-608. doi: 10.1016/j.jand.2015.02.002.
52. Kemper AR, Brewer CA, Singh RH. Perspectives on dietary adherence among women with inborn errors of metabolism. Journal of the American Dietetic Association 2010;110(2):247-52. doi: 10.1016/j.jada.2009.10.030.
53. Hoisington AT, Braverman MT, Hargunani DE, Adams EJ, Alto CL. Health care providers' attention to food insecurity in households with children. Preventive medicine 2012;55(3):219-22. doi: 10.1016/j.ypmed.2012.06.007.
54. 9/2012. Internet: https://www.ers.usda.gov/media/8271/hh2012.pdf.
55. Cook JT, Frank DA. Food security, poverty, and human development in the United States. Annals of the New York Academy of Sciences 2008;1136:193-209. doi: 10.1196/annals.1425.001.
56. . Internet: https://www.oregonhunger.org/sites/default/files/2013-14%20SNAP%20Participation%20FINAL.compressed.pdf 2017).
57. Gundersen C, Ziliak JP. Food Insecurity And Health Outcomes. Health Aff (Millwood) 2015;34(11):1830-9. doi: 10.1377/hlthaff.2015.0645.

Appendix A: Metabolic Disorder Categorization Guide

Diagnosis Category	Possible Diagnoses	Requires MNT?	Primary Diet Modification	Medications	Supplements
amino acidopathies					
Phenylketonuria (PKU)	Phenylketonuria, PAH Deficiency, Hyperphenylalaninemia	Yes, though hyper-Phe may not	Protein	Kuvan	± Tyrosine (VERY rare)
Homocystinuria	Homocystinuria	Yes	Protein	Betaine (Cystadane)	± Cysteine, Folic acid, B6, B12
Maple syrup urine disease (MSUD)	MSUD	Yes	Protein		± Thiamin (if responsive)
organic acidemias					
Organic acidemias *requiring MNT*	PROP, MMA, IVA, GA-1	Yes	Protein	Carnitine (PROP, MMA)	B12, Riboflavin (GA-1)
Organic acidemias *not requiring MNT*	3-MCC, 3-MGA	No			
Urea Cycle Disorders					
Urea Cycle Disorders	NAGS deficiency, CPS deficiency, OTC deficiency, Citrullinemia, Argininosuccinic acidemia (ASA), Argininemia	Yes	Protein	(Buphenyl, Na benzoate, Ravicti, Ammonul, Carbaglu)	Arginine (ASS, ASL); Citrulline (OTC, CPS)
disorders of fat metabolism					
FAO disorders *requiring MNT*	VLCAD, LCHAD, CPT II	Yes	Fat	L-carnitine (sometimes)	MCT supplement
FAO disorders *not requiring MNT*	MCAD, SCAD, CPT1	No		L-carnitine (sometimes)	
Primary carnitine deficiency		No		L-carnitine	
disorders of carbohydrate metabolism					
Galactosemia	Galactosemia	Yes	Galactose		Calcium, vitamin D
Glycogen storage diseases	Any GSD except GSD II	Yes for GSD Type 1a/b, Type 3	Carbohydrate modification		Cornstarch or Glycosade
Other disorders of carbohydrate metabolism	Pyruvate DH complex deficiency, Hereditary fructose intolerance, hypoketotic hypoglycemia	Yes	carbohydrate OR fructose+ sucrose, respectively		Thiamin
mitochondrial diseases					
Mitochondrial Diseases	Kearns-Sayre Syndrome, Leigh Syndrome, MELAS, Pearson syndrome, Complex 1-5 Deficiency	No		Yes - variety	Often Co-Q10
lysosomal storage disorders					
Lysosomal storage disorders	Cystinosis; Fabry, Gaucher, Pompe, Schindler, Sandhoff, and Mucopolysaccharide Storage Diseases	No		Yes - variety	

Appendix B: Data Collection Form

Study ID: _____

Routine Care Data Collection Form-- Collect for each household screened for Food insecurity. (*Data will be obtained by chart review.)*

Date completed: _____ Completed by: _____

Date of clinic encounter: _____

2-questions Food Security Screening:
For each statement, please tell me whether the statement was "often true, sometimes true, or never true" for your household:

A. "In the past year, we worried about whether our family's food would run out before we got money to buy more."

1 ☒ *often* 2 ☒ *sometimes* 3 ☒ *never*

B. "Within the last year, the food we bought did not last and we did not have money to get more."

1 ☒ *often* 2 ☒ *sometimes* 3 ☒ *never*

If you or your child follows a low-protein diet, please answer the following questions.
Check box here if not applicable: ☒

A. "In the past year, we worried about whether our low protein medical foods would run out before we got money to buy more."

1 ☒ *often* 2 ☒ *sometimes* 3 ☒ *never*

B. "Within the last year, the low protein medical foods we bought did not last and we did not have money to get more."

1 ☒ *often* 2 ☒ *sometimes* 3 ☒ *never*

Food program use: ☒SNAP ☒WIC ☒Food bank/ Food pantry ☒Other: _____

Patient level information (Collected by chart review)

Name:_____ MRN: _____

Patient DOB: ___ / ___ /_____

Sex: M F

Ethnic group _____

Primary Language: _____

Marital Status (if ≥ 18 years of age): _____

State of residence: _____

Height: _____ Percentile: _____ Z-score: _____

Weight: _____ Percentile: _____ Z-score: _____

BMI: _____ Percentile: _____ Z-score: _____

Does patient have a primary care provider (PCP)? Yes No

Name of insurance company: _____

Metabolic Disorder Treatment-Specific Characteristics

Primary metabolic diagnosis: _____ ICD-10 code:_____

Treatment regimen

Is patient on metabolic nutrition therapy: Yes/No

If yes:

Diet modification: Galactose Glucose Protein Fat Other

Prescribed medical formula: Yes/No

Has patient ordered formula in past 3 months? Yes / No

Prescribed nutritional supplements (other than formula) specific to disorder (ex: amino acids) Yes / No

Prescribed medications specific to disorder: Yes / No

Based on disorder, are low-protein medical foods recommended? Yes / No

Has patient previously been seen in metabolic clinic by an MD/NP? Yes / No

Has patient previously been seen in metabolic clinic by a metabolic RD? Yes / No

Is a follow-up visit recommended and/or scheduled? Yes / No

Appendix C: OHSU Metabolic Clinic Food Security Screening Form

Patient
Label

For you to get the most out of your clinic visit today, please write down any questions or goals that you would like to discuss with your clinic provider.

Food insecurity is a significant problem in Oregon and Washington. We would like to know if you and your family have concerns about food access.

Please answer the following questions by (circling) your answers:

a. In the last year, we worried whether our family's food would run out before we got money to buy more.

Often Sometimes Never Prefer not to answer

b. In the last year, the food we bought did not last and we did not have money to get more.

Often Sometimes Never Prefer not to answer

If you or your child follows **a special diet managed by a metabolic RD (Joyanna or Sandy),** please answer the following questions:

a. In the last year, we worried whether our **special medical foods or formulas** would run out before we got money to buy more.

Often Sometimes Never Prefer not to answer

b. In the last year, the **special medical foods or formulas** we bought did not last and we did not have money to get more.

Often Sometimes Never Prefer not to answer

Our household currently uses these food programs:

None SNAP WIC Food Bank/Pantry Prefer not to answer

Please return this form to your clinic provider.

Appendix D: Food Resource Handout for Metabolic Clinic Patients

NOT ENOUGH FOOD FOR YOUR FAMILY? NEED HELP COOKING OR SHOPPING FOR HEALTHY FOOD ON A BUDGET?

You might qualify for **SNAP** (Supplemental Nutritional Assistance Program, formerly known as Food Stamps)

- To learn more: http://www.oregon.gov/dhs/assistance/pages/foodstamps/foodstamps.aspx
- Contact your local SNAP office at 1-800-723-3638 (Oregon) or 1-877-501-2233 (Washington) for questions about SNAP benefits in your state.

If you are pregnant or have children under five, you may qualify for **WIC** (The Special Supplemental Nutrition Program for Women, Infants, and Children)

- To learn more: https://public.health.oregon.gov/HealthyPeopleFamilies/wic/Pages/index.aspx
- Call 1-800-723-3638 (Oregon) or 1-800-841-1410 (Washington) to find your local WIC clinic

Most **farmers markets** accept SNAP & WIC vouchers. Some match or add to your SNAP dollars, so you have more money to spend!

- Visit http://www.oregonfarmersmarkets.org/market-finder to find a market taking SNAP/WIC
- For a list of matching programs, visit www.bit.ly/matchprogram or ask your clinic provider.

There may be a **food pantry** in your neighborhood where you can get a free box of food.

- Go to http://www.foodpantries.org/st/oregon to find one near you.

During the summer, kids can get **free meals**!

- Find a location near you at http://www.summerfoodoregon.org/

Take free **gardening classes** and learn to grow a portion of your own food.

- www.oregonfoodbank.org/takeaclass or call 503-282-0555 and ask about "Seed to Supper."

Learn to **cook healthy food** and shop on a budget- no stove or oven required!

- www.oregonfoodbank.org/takeaclass or call (503)-282-0555

For more nutrition information & **low-cost healthy recipes** visit:

- https://www.foodhero.org/

For more information about food assistance, nutrition programs or other resources, contact **211info**. 211info can provide free, confidential, one-on-one help connecting to resources.

- http://211info.org
- Text your zip code to 898211
- Dial 2-1-1
- Send an email to help@211info.org

Appendix E: Prospective Study Participant Questionnaire

Name: _____

Date: _____

The following questions are designed to help us learn more about the financial challenges and quality of life for people with metabolic disorders. This survey should take approximately 30 minutes. Please answer all questions to the best of your ability. If at any time you feel uncomfortable responding, you may say "I'd prefer not to answer."

USDA Food Security Screener Module

If you've noticed, we've been asking some questions about food security in Clinic. These questions may sound similar! These questions are about the food eaten in your household in the last 12 months. Please choose the answer that best represents you.

1. The first statement is "(I/We) worried whether (my/our) food would run out before (I/we) got money to buy more." Was that often true, sometimes true, or never true for (you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

2. "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

3. "(I/we) couldn't afford to eat balanced meals." Was that often, sometimes, or never true for you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

4. In the last 12 months, since last (name of current month), did (you/you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food? *
[ ] Yes
[ ] No (Skip AD1a)
[ ] DK (Skip AD1a)

5. [IF YES ABOVE, ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

6. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?
[ ] Almost every month
[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK
[ ] Yes
[ ] No
[ ] DK

7. In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?
[ ] Yes
[ ] No
[ ] DK

8. In the last 12 months, did you lose weight because there wasn't enough money for food?
[ ] Yes
[ ] No
[ ] DK

9. In the last 12 months, did (you/you or other adults in your household) ever not eat for a whole day because there wasn't enough money for food?
[ ] Yes
[ ] No (Skip AD5a)
[ ] DK (Skip AD5a)

10. [IF YES ABOVE, ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
[ ] Almost every month
[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK

Are there children living in your household?
If yes: answer remaining questions.
If no: this portion of survey is completed.

Child-Referenced Questions: Questions 11-18
11. “(I/we) relied on only a few kinds of low-cost food to feed (my/our) child/the children) because (I was/we were) running out of money to buy food.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

12. “(I/We) couldn’t feed (my/our) child/the children) a balanced meal, because (I/we) couldn’t afford that.” Was that often, sometimes, or never true for (you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

13. "(My/Our child was/The children were) not eating enough because (I/we) just couldn't afford enough food." Was that often, sometimes, or never true for (you/your household) in the last 12 months?
[ ] Often true
[ ] Sometimes true
[ ] Never true
[ ] DK or Refused

14. In the last 12 months, since (current month) of last year, did you ever cut the size of (your child's/any of the children's) meals because there wasn't enough money for food?
[ ] Yes
[ ] No
[ ] DK

15. In the last 12 months, did (CHILD’S NAME/any of the children) ever skip meals because there wasn't enough money for food?
[ ] Yes
[ ] No (Skip CH5a)
[ ] DK (Skip CH5a)

16. [IF YES ABOVE ASK] How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?
[ ] Almost every month

[ ] Some months but not every month
[ ] Only 1 or 2 months
[ ] DK

17. In the last 12 months, (was your child/were the children) ever hungry but you just couldn't afford more food?
[ ] Yes
[ ] No
[ ] DK

18. In the last 12 months, did (your child/any of the children) ever not eat for a whole day because there wasn't enough money for food?
[ ] Yes
[ ] No
[ ] DK

Thank you for participating! Now, I'm going to ask you a few questions about your health and well-being in the past 30 days. Please answer to the best of your ability. If you aren't sure, it's okay to say "I don't know".

CDC HR-QOL Healthy Days 14
Healthy Days Core Module

1. Would you say that in general your health is
    a. Excellent
    b. Very good
    c. Good
    d. Fair
    e. Poor
    f. (Don't know/not sure)
    g. (Refused)

2. Now thinking about your physical health, which includes physical illness and injury, how many days during the past 30 days was your physical health not good?
    a. Number of days:_____
    b. None
    c. Don't know/not sure
    d. Refused

3. Now thinking about your mental health, which includes stress, depression, and problems with emotions. For how many days during the past 30 days was your mental health not good?

a. Number of days: _____
b. None
c. Don't know/not sure
d. Refused

(*if response to Q2 and Q3 is none, skip Q4)*

4. During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work or recreation?
    a. Number of days: _____
    b. None
    c. Don't know/not sure
    d. Refused

Activity Limitations Module

5. Are you LIMITED in any way in any activities because of any impairment or health problem?
    a. Yes
    b. No
    c. Don't know/not sure
    d. Refused

    (*if any response except yes, go to healthy days symptoms module)*

6. What is the MAJOR impairment or health problem that limits your activities? Check all that apply.
    a. Metabolic disorder
    b. Arthritis/rheumatism
    c. Back or neck problem
    d. Fractures, bone/joint injury
    e. Walking problem
    f. Lung/breathing problem
    g. Hearing problem
    h. Eye/vision problem
    i. Heart problem
    j. Stroke problem
    k. Hypertension/ high blood pressure
    l. Diabetes
    m. Cancer
    n. Depression/anxiety/emotional problem
    o. Other impairment/problem
    p. Don't know/ not sure
    q. Refused

7. For how long have your activities been limited because of your major impairment or health problem?

   a. _____
   b. Don't know/not sure
   c. Refused

8. Because of any impairment or health problem, do you need the help of other persons with your PERSONAL CARE needs such as eating, bathing, dressing, or getting around the house?
   a. Yes
   b. No
   c. Don't know/not sure
   d. Refused

9. Because of any impairment or health problem, do you need the help of other persons in handling your ROUTINE needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?
   a. Yes
   b. No
   c. Don't know/ not sure
   d. Refused

Healthy Days Symptoms Module

10. During the past 30 days, for about how many days did PAIN make it hard for you to do your usual activities, such as self-care, work or recreation?
    a. Number of days: _____
    b. None
    c. Don't know/not sure
    d. Refused

11. During the past 30 days, for about how many days have you felt SAD, BLUE, or DEPRESSED?
    a. Number of days: _____
    b. None
    c. Don't know/not sure
    d. Refused

12. During the past 30 days, for about how many days have you felt WORRIED, TENSE, or ANXIOUS?
    a. Number of days: _____
    b. None
    c. Don't know/not sure
    d. Refused

13. During the past 30 days, for about how many days have you felt you did NOT get ENOUGH REST or SLEEP?

a. Number of days: _____
b. None
c. Don't know/not sure
d. Refused

14. During the past 30 days, for about how many days have you felt VERY HEALTHY AND FULL OF ENERGY?
    a. Number of days: _____
    b. None
    c. Don't know/not sure
    d. Refused

Thank you again for your participation. There are only a few questions left! These next few questions are here to help us learn more about financial challenges facing people with metabolic disorders. Please answer to the best of your ability. If you do not feel comfortable responding, you can say, "I prefer not to answer".

Financial Questions

1. During the past month, have you had to use your own money (i.e. pay out of pocket) to pay for any expenses to care for yourself with regards to your metabolic disorder?
    a. Yes
    b. No
    c. Prefer not to answer

2. About how much money per month do you spend out-of-pocket to pay for medical formula or low protein medical foods?
    a. $1 - $50
    b. $50 - $100
    c. $100 - $200
    d. $200 - $500
    e. More than $500
    f. I don't pay out-of-pocket for medical formula or low protein medical foods
    g. Prefer not to answer

3. About how much money per month do you spend out-of-pocket to pay for clinic appointments, co-pays, medications, or other expenses related to your metabolic disorder?
    a. $1 - $50
    b. $50 - $100
    c. $100 - $200
    d. $200 - $500
    e. More than $500

   f. I don't pay out of pocket for medical expenses
   g. Prefer not to answer

4. Does the amount of money you spend per month on healthcare-related costs represent a financial burden for you?
   a. Yes
   b. No
   c. Sometimes, but not always
   d. Prefer not to answer

5. Do you ever worry that you don't have enough money to cover all of your basic expenses (food, housing, medical care, utilities, childcare if applicable)?
   a. Yes
   b. No
   c. Sometimes, but not always
   d. Prefer not to answer

6. Do you feel that your insurance coverage covers the financial costs associated with your healthcare?
   a. Yes
   b. No
   c. Sometimes, but not always
   d. Prefer not to answer

7. Is there anything else that you would like me to know?

Appendix F: Evidence Table

Author	Year	Journal/ Website	Type	Population	Outcomes Measured	Major Findings
Adams EJ	2015	Matern Child Health J	Longitudinal Cohort	n = 1661 mothers in OR	FI with 1-iten screener, CSHCN yes/no	11.6% of mothers had CSHCN. Having a child with SHCN doubled odds of being FI, even after controlling for baseline FI.
Banach LP	2016	Acad Pediatr	Cross-sectional	n = 706 children from NHANES 2007-2012 who had been hospitalized in last year	FI with 18-item FSSM	25.3% of children were from FI households. Higher rates of FI in girls, minority households, older children, recently hospitalized, uninsured. 27% of kids eligible for WIC (19.6% FI) not on it; and 31% of SNAP eligible (28% FI) not on it
Beer SS	2015	Nutr Clin Pract	Review	Pediatric population in US	-	Consequences of pediatric malnutrition include decreases in physical strength, poor healing, decreased immune function, developmental delay. In early life, malnutrition can stunt brain development leading to cognitive delays.
Belanger-Quintana A	2012	Mol Genet Metab	Cross-sectional	n = 10 PKU professionals across europe	financial purden of PKU	Mean annual cost of Phe-free foods was 4273-24590 euro. Mean cost rose with age. All countries provided coverage for formula but low-protein foods was less reimbursed.
Belsky DW	2010	Am J Epidemiol	Longitudinal Cohort	n = 2125 children from 1063 families in UK e-risk cohort, followed at 5, 7, 10, 12 years	FI with 7-item screener, child IQ, behavior and emotional problems, maternal personality	9.7% FI. Children in FI households had mothers with higher behavioral/emotional problems, lower IQ, high risk personality. Emotional problems in children still associated with FI after adjusting for all other household features - last into adulthood.
Berkowitz SA	2014	Am J Med	Cross-sectional	n = 9696 adults from NHIS 2011 with >/= 1 of 8 chronic diseases	FI with 10-item screener, medication underuse, clinical variables	Medication underuse more common among FI individuals (55.5 vs 16% - 4x greater odds). Medication underuse a/w income 100-200% FPL, minorities, lack of medical home, no insurange, greater comorbidities. Adults who (eat> treat) more likely to have dependent children. Adults (treat > eat) more likely to be Hispanic or Black.

Author	Year	Journal/ Website	Type	Population	Outcomes Measured	Major Findings
Berry SA	2013	Genetics in Medicine	Survey	n = 3-5 parents of children <18 with IEM in Eastern US	Use of medical foods/formula and insurance coverage	84% of families used medical foods (59% low pro foods, 50% one or more supplements, 50% using feeding supplies. 80% used two or more types of products). Medicaid coverage of medical foods was 40%, supplements 35% and feeding supplies 31%. private insurance coverage of med foods was 30% and supplements 32%. Parents paid out of pocket for all types of resources, but mosts for low pro medical foods and feeding supplies - 60% of low pro food expenses are out of pocket. 48% of parents purchasing low pro foods paid >100$/mo. Low-pro foods cost 2-8x more than standard counterparts
Caicedo C	2014	J Am Psychiatric Nurses Assoc	Cross-sectional	n = 84 caregivers of medically complex CSHCN	Disorder data, care needs, behavioral effects, time burden	Most common disorders included seizure, CP, asthma, other breathing disorders. Most ppts were Hispanic, made <39000/yr, received additional public aid. 1/2 needed OT/PT, home health weekly. Parental effects include exhaustion, anxiety (66%), helplessness (44%), unsupported (44%), family functioning problems. 33% stopped working. Avg 33 hours/wk spent caregiving. Avg caree coordination was 7 hours/wk. OOP costs ranged from 0-5719 per month, average 350/month.
Camp KM	2012	Mol Genetics and Metab	Review	-	-	Most states provide some coverage but not all, may end at 18. Low-protein foods less widely covered. Wholesale costs of medical foods range from 1258 - 8522 annually, with consumer markup 200-300%.

Author	Year	Journal/ Website	Type	Population	Outcomes Measured	Major Findings
Coleman-Jensen AR	2014	USDA ERS	Webpage	United States	FI with 18-item FSSM	14.0% of households are FI, 19.2% of households with children are FI, 9.4% of children are FI. Most common for single mother household, black, low income. Rates of FI in Oregon are higher than nat'l average at 16.1%.
Connell CL	2005	J Nutr	Qualatative interviews	n = 32 "likely FI" children 11-16 in MS	FI with pilot child FI screener, semi-structured interviews r/t children's experience with FI, causes and outcomes of FI	Children had altered behaviors (24/32 ate less or less desirable food, 7/32 ate more or fast food when available), emotional response (shame, fear), social behaviors (eating with others or sharing). Parents had altered behaviors around eating (eating less so children could have more), emotional response (10/32 parents try to hide) and social behaviors (encourage children to eat with others, borrow food or money)
Cook JT	2013	Advances in Nutr	Review	FI in the United States	-	Mild FI in children associated with poor learning and test scores, agression, depression/anxiety, inattention/hyperactivity, maternal depressive episodes, anxiety. Validated 2-item screener picks up marginal FI. Marginal FI associated with poor caregiver health and depression, >1 developmental concerns, poor/fair child health, and hospitalizations.
Council on Community Pediatrics	2015	Pediatrics	Policy Statement	-	-	Summary of effects that FI have on children incling poor health, nutrition deficiencies, obesity, lower cognitive indicators, emotional distress, dysregulated behavior, depression/anxiety, doing worse in school, suicidal ideation. Related poor childhood outcomes to poor life-long outcomes. Recommend routine screening for FI.

Author	Year	Journal/ Website	Type	Population	Outcomes Measured	Major Findings
DeJong NA	2015	Clin Pediatr	Cross-sectional	n = 46 families of CSHCN in NC	CSHCN yes/no, health-related social problems, use of food resource programs	83% had CSHCN. 54% late on rent/mortgage, 21% receiving housing assistance, 10% threatened with eviction, 17% threated with foreclosure. 26% of families were ineligible/denied nutrition assistance. Only 30% had discussed with PCP.
DeRigne L	2012	J Pediatr Health Care	Review	-	Financial expenses of families with CSHCN	Greater OOP costs with autism, lower costs with public insurance, Medicaid. Families with low income perceived OOP costs as financial burden if >250/mo. Families with CSHCN 1.3 - 7.9x more likely to cut back on work. Non-English speaking HHs almost twice as likely to stop working.
DeRigne L	2010	Social Sci Med	Cross-sectional	n = 23380 married and n = 8814 single mothers in 2005-6 NS-CSHCN	Use of resources, time spent per week related to care	Parents more likely to cut back/stop working if single, with increasing severity of condition, if spending >1hr/wk coordinating services, child in preschool, unmet respite needs. Service use difficulties lead to 22% of married parents reducing work hours, more than 1/4 quitting job.
Fleegler EW	2007	Pediatrics	Cross-sectional	n = 205 parents of children <6 yo in Boston area	FI with 8-item scale from CCHIP, health-related social problems survey, opinions about screening/ referrals	Most families have multiple HRSPs - higher with minorities, single parents, %FPL. 39% FI and 11% with child-level FI. 54% on WIC, 40% on SNAP. While 34% of families needed referrals, only 17% were screened, 35% of those with need received referrals, 67% of those receiving referrals were contacted, 94% found the resources helpful. 88% of parents are welcome to screening questions.

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Fram MS	2011	J Nutr	Qualatative interviews	n = 26 families in SC	FI with 6-item HH screner, semi-structured interviews on experience of FI	16 families experienced LFS/ VLFS in last year and 8/10 FS families reported some type of FI behavior (limited choice, cheap foods). Children responded to FI in two ways - awareness (of how family is managing resources, emotional awareness as sadness/anger, and physical awareness as hunger) and responsibility (self-guided reduction in intake and snacking, asks for food from others).
Gundersen CS	2013	Feeding America	Webpage	Feeding America 2013 data on FI in United States	-	Statewide FI was 15.8%. FI in Portland metro area: 15.9% in Multnomah co, 12.4% in Washington co, 12.6% in Clackamas co. Rates of FI across the state varied from 9.9% in Hood River to 18.6 in Harney. Also has data by congressional district, with district 1 (PDX and north coast) at 13.5%, district 3 (Gresham area) at 16.9%; highest prevalence in district 4 (southern coast/I-5 corridor including Corvallis, Eugene) with 17.9%.
Hager ER	2010	Pediatrics	Pilot Study	n = 30098 families with children 0-3 yo from 7 urban healthcare centers in US	FI with 18-item FSSM, child health, hospitalizations, developmental risk	23% of families were FI. Questions 1 and 2 from the FSSM can be used as a 2-item screen. Found to be 97% sensitive and 83% specific. FI associated with higher odds of fair/poor health (OR 1.53), hospitalizations (OR 1.17), and developmental risk (OR 1.60).
Hanson KL	2012	J Health Care Poor Underserved	Longitudinal Cohort	n = 225 rural families with children in US, < 200% FPL	FI with 18-item FSSM	1/2 patients FI. 1/3 of FI had chronic health conditions. High risk of depression. High knowledge of community resources. 35% of ppts were persistently FI. Chronic health conditions increased odds of intermittent FI (OR 2.73) and persistent FI (OR 70.1)

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Hanson KL	2014	Am J Clin Nutr	Systematic Review	Adults or children in the US	FI with various screens, dietary quality	FI is associated with poor dietary quality in adults: lower intake of fruits/veg, dairy, vitamins A and B6, Ca, Mg, Zn. FI in children associated only with lower fruit consumption. Suggests that parents attempt to shield children from FI-related changes in diet quality.
Herman D	2015	Am J Pub Health	Cross-sectional	n = 44574 adults 18-64 yo recruited from NHIS	FI with 10-item screener, medication underuse, physical and mental health status	26% engaged in at least 1 medication underuse behavior. Dose-response relationship between FI and medication underuse. 30% of individuals with VLFS reported skipping medications for financial reasons. Highest among single parents, lack of health insurance, chronic conditions.
Hoisington AT	2012	Prev Med	Cross-sectional	n = 186 pediatric physicians and nurse practitioners in the Portland metro area	prevalence of asking about FI, what cued them to ask, barriers and comfortability to asking about FI	8.1% of ppts considered themselves knowledgable about FI. 24.3% asked most of the time/ always about HH food quality, only 12.7% asked routinely about food insufficiency. Common barriers to asking include lack of knowledge of FI, discomfort discussing, limited time. 89% would use a screener if available.
Howard LL	2011	British J Nutr	Longitudinal Cohort	n = 4710 children from Early Childhood longitudinal study with data at grades 1, 3, 5.	FI with 18-item FSSM, social skills	9-11% experience FI at any one time, only 3% persistently FI. FI significantly related to poor social skills. FI at 1st to 3rd grade associated with decline in social skills for boys. FI predicts skills around self-control, task persistence, attentiveness.
Jackson JA	2015	Nutrients	Cross-sectional	n = 95 low-income families with elementary school children in rural OR	FI with 2-item screener, child food intake using FFQ, family and nutrition home factors	No significant associations between FI and dietary intake or FI and BMI.
Kemper AR	2010	J Am Diet Assoc	Qualatative interviews	n = 19 women from IEM summer camp, 12-52 yo	Financial experience	1 of 3 major barriers to staying on diet was insurance coverage of medical foods.

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Knowles M	2016	Matern and Child Health J	Qualatative interviews	n = 51 parents with at least 1 child <4 yo recruited from Childrens Health Watch study	FI with 18-item FSSM, semi-structured interviews r/t coping strategies, health, healthcare access, housing, employment	96% women, ~85% minority. Parents made trade-offs between bills and foods, experienced mental health concerns (depression, anxiety, feer, worry, trying and failing to hide FI from kids), and cited effects on children ("they feel your feelings": stress, anxiety, frustration/agression, poor parent-child communication, child agression and sadness)
Leung CW	2015	J Nutr	Cross-sectional	n = 3518 low-income families from NHANES 2005-2010	FI with 18-item FSSM, depression with 9-item questionnaire, SNAP participation	16.1% marginal FI, 23.5% LFS, 13.8% VLFS. 9.3% depressed. Most common symptoms: tired, sleeping too much or not enough, feeling down/depressed/ hopeless. Dose-response relationship between each depressive symptom and severity of FI. Odds of depression in VLFS households 3.42 higher than food secure HHs.
Mabli J	2010	Mathematica Policy Research	Program Report	>62000 interviews and >37000 questionnaires from individuals visiting Feeding America programs in 2009	Emergency food assistance use, use of other resources, employment, income, health.	75% of families receiving emergency food assistance are FI. Clients are forced to choose between food and utility costs (46%), rent or mortgage (39%), medicine or medicinal care (34%), transportation(35%), or a vehicle and gas (36%). 41% are receiving SNAP and 51% of families with children 0-3 receive WIC. 29% of households have at least 1 member in poor health.
McPherson M	1998	Pediatrics	Editorial	-	-	Definition of CSHCN: "Those who have one or more chronic physical, developmental, behavioral, or emotional conditions and who. also require health and related services of a type or amount beyond that required by children generally"

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Pabalan L	2015	Wisconsin Medical Journal	Cross-sectional	n = 389 caregivers of children seen at Children's Hospital of WI ED	FI with 2-item screener	45.6% of participants identified as FI. Higher rates of FI for minorities. 82% of people utilized at least 1 food resource. Highlighted role of medical facilities to screen for FI.
Parish SL	2009	Pediatrics	Cross-sectional	n = 17039 low-income (<200% FPL) parents from NS-CSHCN 2006/07	OOP health care expenditures	61% of families had OOP costs. 64% had costs greater than 250/month. In OR, 63.7% of families had any burden, 26.9% had absolute costs >500/mo, 21.5% had burden >3% of income.
Ptomey LT	2015	J Acad Nutr Diet	Position Paper	-	-	IDD makes up 15% of Medicaid enrolees and 41% of expenditures. Cites higher rates of FI in adults with IDD.
Ramsey R	2011	J Child health care	Cross-sectional	n = 187 low-income families with children 3-17 yo in Australia	FI with 16-item screener, family factors, health outcomes, behavioral outcomes	Lowest income bracket 16x as likely to be FI as highest bracket. Children in FI households more likely to experience poor/fair health. 3-5x as likely to miss school, 2.5x as likely to experience behavioral difficulties
Rose-Jacobs R	2016	J Dev Behav Pediatr	Cross-sectional	n = 6724 households, recruited at urban medical centers in MD, MN, AR, MN, PA	FI with 18-item FSSM, CSHCN yes/no	14.8% of households had CSHCN. Having SHCN increased odds of household FI by 22-24%, child-level FI by 35-36%. CSHCN receiving SSI increased risk of FI by 42-51% (more likely severe cases). Suggests SSI, SNAP may not be enough to meet family's needs

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Singh RH	2016	Mol Genet Metab	Guideline	Individuals with PKU	-	Outlines updated PKU treatment guidelines including goals for nutrient intakes, blood Phe levels, nutrient interventions, long-term monitoring, and during pregnancy and lactation. Recommends following Phe-restricted diet for life to prevent cognitive deficits, anxiety, depression.
Sullivan AF	2010	J Emerg Med	Cross-sectional	n = 520 patients at 4 Boston-area EDs	FI with 18-item FSSM	13% of patients were food insecure. Greater rate of FI among young, non-white women, low SES, low education, no health insurance. Associated with greater stress, depression, drug/alcohol abuse. 27% of FI pts reported getting sick 2/2 unable to afford meds; 24% said they would forego medications if money was tight. Marginal FI found to increase odds of poor outcomes.
Tarasuk V	2015	CMAJ	Cross-sectional	n = 67033 adults in Canada ages 18-64	FI with Canadian 18-item FSSM, total costs of healthcare	12.2% participants FI (compared to 12.7% in Canada) -more common with lower income, education, female gender. FI ppts more likely to pay more for emergency medical services, inpatient or home care. Linear relationship of healthcare costs to FI: costs 16, 32, 76% higher in marginal, moderate and severely FI households.
Therrell BL Jr	2014	Mol Genet Metab	Longitudinal Survey	NBS data from 2001-2010	Incidence of IEMs, coverage	Medical foods: paid for partly by NBS feed, some insurance coverage. Additional costs of medical foods range from 2250 (infant) to 25000 (pregnant woman) per year. Coverage worse for low-protein medical foods. 22/31 disorders on NBS require medical foods or formula.
Vockley J	2014	Genet Med	Guideline	Individuals with PKU		Guidelines for care of individuals with PKU from the ACMG. Outlines role of staying on diet for life.

Author	Year	Journal/ Website	Type	Population	Outcomes Measured	Major Findings
Weaver MA	2010	Genet Med	Survey	State NBS policies	IEM coverage	61% of states guaranteed insurance coverage for all or some IEM. Private insurance mandates exist in 33/50 states.