

THE GEOGRAPHY OF FARMWORKER HEALTH: A MIXED-METHOD
EXPLORATORY ANALYSIS OF CHRONIC DISEASE

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
MSFW	Migratory and Seasonal Farmworker
GPS	Global Positioning System
EH	Essential Hypertension
INS	Immigration and Naturalization Services
UFW	United Farm Workers
FLOC	Farm Labor Organizing Committee
MSAWPA	Migrant and Seasonal Agricultural Worker Protection Act
NCFH	National Center for Farmworker Health
NAFTA	North American Free Trade Agreement
NAWS	National Agriculture Workers Survey
FPL	Federal Poverty Level
C/MHC	Community and Migrant Health Center
MHA	Migrant Health Act
MHP	Migrant Health Program
WHO	World Health Organization
MS	Metabolic Syndrome
CVD	Cardiovascular disease

BMI	Body Mass Index
CAWHS	California Agricultural Workers Survey
LISA	Local Indicators of Spatial Association
ESDA	Exploratory Spatial Data Analysis
GAM	Geographic Analysis Machine
DMAP	Disease Mapping Analysis Program
GIS	Geographic Information System
E2SFCA	Enhanced Two-Step Floating Catchment
Area	
EV2SFCA	Enhanced Variable Two-Step Floating Catchment Area
HBM	Health Behavior Model
SDOH	Social Determinants of Health
SPD	Social Production of Disease
SES	Social Economic Status
GDP	Gross Domestic Product
HER	Electronic Health Record
LDS	Limited Data Set
CBRN	Community Based Research Network
ICC	Integrative Care Collaboration

HIE	Health Information Exchange
ZCTA	Zip code Tabulation Area
USPS	United States Postal Service
EPSG	European Petroleum Survey Group
MAUP	Modifiable Aerial Unit Problem
MC	Monte Carlo
STPM	Space-Time Permutation Model
LLR	Logarithm of the Likelihood Ratio
RR	Relative Risk
MSWS	Maximum Spatial Window Size
GWR	Geographic Weighted Regression
CDC	Centers for Disease Control and Prevention
ICH	Intercare Community Health
CDRC	Clinicas del Camino Real
WIC	Woman, Infants, and Children
MICOP	Mixteco/Indigena Community Organization
Project	
STI	Sexual Transmitted Infection
GDM	Gestational Diabetes Mellitus
CAUSE Economy	Central Coast Alliance for a Sustainable

ABSTRACT

Known by some as the ‘invisible’ people because of their precarious work and low social status, migratory and seasonal farmworkers (MSFW) are a critical and underappreciated component to the agriculture industry in the United States. Despite advances in knowledge of about the health needs of this population, identifying geographic regions of high-risk remains a challenging task for community health workers and farmworker advocacy organizations. Guided by the *farmworker ecosocial model of health*, this dissertation for the first time investigated the geography of farmworker health in California, Colorado, and Michigan. This study used two quantitative techniques. The first, spatial scan statistics, were used to measure geographic variations in farmworker disease clusters, while the second technique featured the delineation of healthcare service areas. Qualitative techniques featured interviews with key informants and farmworkers based on the theoretical foundation of social epidemiology. In the study areas, this dissertation found 209 total disease clusters (< 0.02) encompassing 259 zip codes, and 2,732 farmworkers (7% of the total population) living greater than 30-minutes from community and migrant health centers (C/MHC). Patient encounters at all C/MHC’s were predominantly for diabetes and evenly distributed; however, farmworkers treated for chronic disease risk factors had the highest percentage of total encounters when comparing individual clinics. Additionally, 32 interviews conducted at C/MHC’s

revealed that contextual-level barriers to healthcare are numerous in all study areas and include lack of transportation, poverty, inadequate housing, cultural practices, low educational attainment, and healthcare literacy. Farmworkers were on average young (33.9), and likely to practice *circular-migration* in Colorado and Michigan, while their counterparts in California resided in the area year-round. By better understanding, the health of farmworkers from multiple contextual and methodological perspectives, appropriate outreach, research, and policy strategies for migratory and seasonal farmworkers can be developed to best serve the unique geographic challenges highlighted in this dissertation.

CHAPTER I

INTRODUCTION

Background

On Thanksgiving Day 1960, with the release of Edward R. Murrow's documentary "Harvest of Shame," the public witnessed for the first time the "sweatshops in the fields" and the subhuman living conditions of the often invisible, underappreciated, and unknown migrant farm workers (ER. Murrow 1960). The word 'invisible' holds an active place in the life of the migrant and seasonal farmworker (MSFW). These vital workers are often called the 'invisible people,' because they are invisible to the public, invisible politically, and often stereotyped incorrectly by the very individuals who consume the fruits and vegetables that they labor over year in and year out. MSFW's are a "special population," one that requires unique designations from medical professionals and government agencies (Tedders et al. 1998). In the United States, an estimated 3 - 5 million migratory and seasonal farmworkers (MSFWs) support an agricultural industry which contributed \$1 trillion to the United States gross domestic product (GDP) in 2015 (United States Department of Agriculture 2016; Vela-Acosta et al. 2002).

Farmworkers are grouped into two categories: migratory and seasonal. The definition of each is related to the type of work, period of employment, and federal statutes that govern migrant health funds (Arcury and Quandt 2007). Migratory workers seek employment on an annual basis and frequently travel in search of work, often taking part in the harvesting of multiple crops, locally, interstate, or internationally (Arcury and Quandt 2007). Seasonal workers, whose principal employment is agriculture, remain in

an area for a longer duration (various seasons) and participate in multiple stages of harvesting and post-processing (Health Outreach Partners 2013). The definition extends to employment within the past 24 months, and because “farmworker” is an occupational category, an individual may rotate between professions; for example, as a construction worker one year and a farmworker the following year (Arcury and Quandt 2007).

Agriculture has become increasingly mechanized, with machines planting and harvesting thousands of acres of land without in some instances the added cost of human labor.

Mechanization, however, cannot in many circumstances replace human hands in the harvesting of fruits like oranges, apples, and strawberries, or vegetables like asparagus, tomatoes, and lettuce. These crops need the human intuition necessary to determine quality and selection. Improvements in agricultural technologies include a multitude of precision techniques, like drones, GPS-guided equipment, and genetically modified crops. With innovation comes increases in market opportunities and production capabilities, a phenomenon that is fueled by the hired hands of migrant workers (Ramos 2017).

MSFW’s and their families face disparate rates of illness; these workers are often exposed to dangerous pesticides, extreme weather conditions, substandard living conditions, and severe occupational injuries (Cooper et al. 2014; Reid & Schenker 2016; Ramos 2017). MSFW’s are at an increased risk of chronic health conditions, including type 2 diabetes, essential hypertension (EH), and obesity (Weigel et al. 2007; Arcury and Quandt 2007; Pabon-Nau, Cohen, Meigs, and Grant 2010). Since the 1970s, farmworker community health advocacy organizations have made considerable strides in supporting the health needs of farmworkers. Despite these significant improvements, farmworkers

continue to face some barriers to healthcare access such as language, regulatory restrictions on health services, discrimination, low levels of educational attainment, and inadequate transportation (Arcury and Quandt 2007; Ward 2007). The structural vulnerability of farmworkers is tied to their low social status, a symptom of “economic exploitation and cultural, gender/sexual, and racialized discrimination, as well as complementary processes of depreciated subjectivity formation” (Quedada, Hart, & Bourgois 2011, 339). Farmworkers are not just low-paid, hard-working individuals, they are political, economically, and socially disadvantaged, and represent the most vulnerable population group in the United States (Arcury et al. 2016; Case 2013; Padilla, Scott, and Lopez 2014).

Historical Context

Migrant labor in North America is not a recent phenomenon. The first Europeans who came to “to Plant an English nation” on Roanoke 500 years ago were followed by thousands of immigrant workers from Europe, including farmers, artisans, servants, and, slaves from Africa (Hahamovitch 2010, 14). American history “is in large part the saga of successive waves of migrant workers and the conflicts and cultures they wrought” (Hahamovitch 2010, 14). From the start of the American Republic farming was regarded as an honored occupation, not just a job, but a way of life. Thomas Jefferson, regarded as America’s most influential agrarians, wrote: “Those who labor in the earth are the chosen people of God if ever he had a chosen people, whose breasts he has made his peculiar deposit for substantial and genuine virtue. It is the focus in which he keeps alive sacred fire, which otherwise might escape from the face of the earth. Corruption of morals in the mass of cultivators is a phenomenon of which no age nor nation has furnished an

example” (Koch and Peden 1944, p. 280).

Jefferson’s agrarian idealism was deeply embedded in the ideals of the yeoman farmer, working his land at a scale commensurate with the labor power of the family unit (Koch 1950). Jefferson and his chief collaborator James Madison not only cherished small-scale farming but further promoted these ideas as a basis for promoting the individual's responsibility to their economic fate (Cletus & Daniel 1981). On the other hand, agriculture today has shifted from the destiny of the common man to the demands of the broader populace.

In the 21st century, agricultural production is concentrated on a small number of large farms to supply the massive demand for fruit, vegetable, and animal products. Even with tremendous social and economic strides, the United States has achieved since its inception, the use and abuse of migrant labor is a topic rarely covered. Migrant labor in the United States became increasingly crucial to agricultural production in the middle to late-19th century. For the first time, “in the hops fields of California, the beet farms of Michigan, the strawberry fields of Virginia, and the potato farms and cranberry bogs of New Jersey, farm owners relied on men, women, and children who would appear in time for the harvest and disappear thereafter” (Hahamovitch 2010, p. 14). Since the Neolithic Revolution (10,000 – 8,000 BC), agriculture has been characterized by short seasons of intensive labor (Hahamovitch 2010; Denham 2008). In the decades preceding the Civil War two transformative changes took place in the United States, the widespread use and availability of horse-drawn agricultural machinery, and the rapid rise in urbanization.

These changes forced American farmers to develop innovative planting methods to meet the rising demand for fruits and vegetables and to search for new sources of

cheap labor (Hahamovitch 2010). Historically, farmworking in the United States has changed hands demographically starting in the late 19th century (Thompson & Wiggins 2009; Shorris 1992), with large populations of Chinese, Japanese and Filipinos dominating the labor force through the early decades of the 20th century, followed by immigrants from Italy, Ireland, and Scandinavia. By 1905, Japanese immigrants made up 50% of farm labor in California. Following the Mexican Revolution (1910-1920), large numbers of Mexicans made their way to the United States to seek economic opportunities, and by the late-1920s much of these migrants had replaced the Chinese and Japanese workers (Thompson and Wiggins 2009). The passage of the New Deal (1933-1937) was another factor in the broad demographic shift in farm labor. The New Deal provided farmers with subsidies to replace low-wage workers with machinery (Rodman et al. 2015). The subsequent importation of Mexican migrant workers during the Second World War would forever alter the labor dynamics of agriculture in the United States. Wartime demand for labor in sectors outside of the agricultural industry threatened the supply of domestic labor (Burawoy 1976), which in turn prompted the governments of Mexico and the United States to sign into law an agreement that would supply Mexican laborers as agricultural workers (Burawoy 1976).

The Bracero Program (*bracero*, ‘selling the labor of one’s arms’) established on August 4, 1942, was a joint program operated under the control of the Department of the State, Department of Labor, and Immigration and Naturalization Services (INS) (Calavita 2010; Ramos 2017). The program lasted for 22 years and is regarded as the most extensive foreign worker program in U.S. history, with an estimated 5 million Braceros entering the United States (Calavita, 2010). The agreement promised adequate sanitation,

housing, and food for all Braceros and a minimum wage of 30 cents an hour (Koestler 2015). One observer stated that “contract workers returned home with exciting tales of the money that could be made in the U.S...[T]here were so many more Mexicans who wanted to come to the U.S. than were certifications of need issued by the Secretary of Labor ... [T]hat it seemed much simpler to seek employment on their own” (Hadley 1956, 344). U.S. taxpayers financed the feeding, housing, and transportation of Braceros as part of the win-the-war effort (Anderson 1976).

Along with Mexican laborers, interned Japanese Americans were used as farmworkers during the war, as were Italian and German prisoners of war (Martin 2003). For example, in the 1940s, 4,500 prisoners of war in Wisconsin worked as laborers on local farms (Sorden 1948). In many ways, the Bracero Program set up the foundation for an even larger-scale Mexican migration of the 1970s and 1980s, and traditional labor market networks between the United States and Mexico (Massey 1987). The post-World War II period was a time in which guest worker immigration was applied on a massive scale not only in the United States but also in western Europe (Bohning 1972; Krane 1979; Meissner 2004). Economic growth following the war created an immense need for unskilled laborers within a multitude of economic sectors (Bohning 1972; Krane 1979). Further economic fallout in Mexico (1970s) increased migrant movements to the United States at a rate not witnessed since the 1920s (Lacy 1988). Growing from the legacy of the Bracero Program was the creation of several labor organizations; these include the United Farm Workers (UFW) (1964) under the guiding principles of Cesar Chavez, and the Farm Labor Organizing Committee (FLOC) (Barger & Reza 1964; Ramos 2017).

On average, the U.S. imported 200,000 Braceros a year from 1948 to 1964 to work on farms in 28 states, ranging from California, South Dakota, Delaware, and Tennessee (Anderson 1976; Ngai 2004). The Bracero Program, although ending in 1964, is described as not a temporary program, but one that encouraged an even more significant and permanent migration to the United States (Hadley 1956; Hancock 1959; Samora 1971; Reichert and Massey 1980). In the 1950s, the demand for Bracero workers reached a fever pitch, with the number of visas significantly exceeding supply, thus leading to a rise in undocumented immigration. The Bracero Program was not phased out because of the influx of undocumented individuals, but due to pressure from religious and labor organizations (U.S. Immigration and Naturalization Service, 1988). Even after the demise of the program in the mid-1960s, undocumented immigration grew exponentially through the early 1980s, a period in which border apprehensions increased by over 14% (U.S. Immigration and Naturalization Service 1988).

Historically, farmworkers have been excluded from protective legislation, and migrant workers fare even worse than their seasonal counterparts. Migrant farmworkers typically are employed for a short period and earn less than farmworkers who reside in one place year-round. Seasonal workers also can draw from a more intact social network of friends and kin to improve their quality of life (Slesinger and Pfeffer 1992; Thomas 1985; Jenkins 1985). Moreover, farmworkers have not benefited from various pieces of social legislation enacted by the United States since the 1930s. For example, unemployment insurance coverage established as part of the Social Security Act (1935) initially excluded farmworkers, as did minimum-wage guarantees granted to workers under the Fair Labor Standards Act of 1938 (Slesinger and Pfeffer 1992), and it was not

until 1966 that farmworkers gained minimum-wage protection, and 1976 that they were granted unemployment insurance coverage (Slesinger and Pfeffer 1992). The United States Congress passed the Migrant and Seasonal Agricultural Worker Protection Act (MSAWPA) in 1983, and for the first time, the unique needs of farmworkers were finally recognized.

The MSAWPA to some extent protected farmworkers from low pay and unsafe working conditions; however, these protections only covered individuals employed as farm-labor contractors and not those employed by the farm owner or operator (Slesinger and Pfeffer 1992). Farms specializing in labor-intensive commodities are found throughout the United States, but the demand for migrant and seasonal workers is geographically more pronounced in parts of Florida, California, and Texas (Slesinger and Pfeffer 1992). Workers on these large-scale farms bear little resemblance to the agrarian ideals of Jefferson and are viewed merely as labor and nothing else. Farmers maximize control of their labor force by holding down wages and encouraging workers to leave the farm as soon as the harvest is completed to ensure that direct or indirect costs (housing, education, transportation) are mitigated (Slesinger and Pfeffer 1992). These farm owners further seek to influence government policy by representing the ideals of the broader agricultural sector, and in doing so, they generate sympathy for their drive to remain economically viable and free from exorbitant costs (Goldfarb 1981).

Traditionally, farmworkers have followed three traditional migration streams (Figure 1): Eastern, Midwestern, and Western. The Western stream features crops like apricots, apples, blueberries, cherries, grapes, lemons strawberries, and melons (Sarig, Thompson, & Brown 2000). Farmworkers in the Midwestern stream are involved in the

harvesting of bell peppers, cherries, corn, cucumbers, sugar beets, tomatoes, and watermelons (Sarig, Thompson, & Brown 2000). Crops in the Eastern stream include collards, Christmas trees, berries, apples, and citrus fruits (Arcury & Marin 2009). Geographic variations exist in farmworker demographics between migration streams. According to the 2014 Regional Migrant Health Profile (NCFH 2016), more than half of MSFW's in the Eastern and Midwestern streams were classified as migratory, compared to just one-third in the Western United States. However, a higher proportion of dependents was served in the Western stream, with children under 18 years of age accounting for 39% of patients regionally. The Eastern stream, in contrast, served both the lowest proportion of female patients and the smallest proportion of children at 26% (NCFH 2016). Since the early 1990s, farmworker migration patterns have been influenced by an increase in border enforcement, economic instabilities, an increase in H-2A guest worker visas, and the North American Free Trade Agreement (NAFTA) (Fan, Gabbard, Pena, and Perloff 2014; McBride & Sergie 2016).

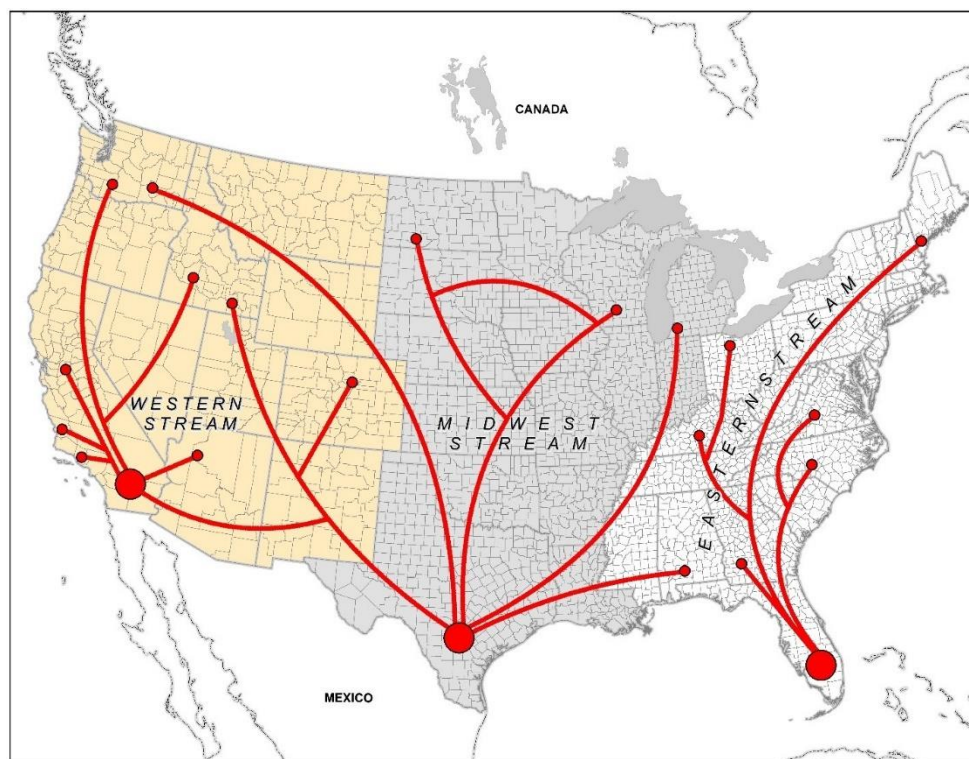


Figure 1. Traditional Farmworker Migration Streams (generalized)

Farmworker Demographics

Farmworkers are predominately adult men; approximately one in five are women, and one in twenty is under the age of eighteen (Carroll et al. 2005). Demographically, most farmworkers (58%) are married, and half (51%) have children. Whereas most (57%) farmworkers are unaccompanied by a spouse or children, 63% of those who have children are accompanied by at least some of their children (Arcury and Quandt 2007, 346). Geographic and regional differences in demographics have emerged in previous studies (Villarejo 2010; Arcury 2009). Farmworkers in the Western United States are older, less migratory, and more often settled with their families compared to the MSFW's in the Eastern U.S. Unaccompanied workers are found more often in the Eastern stream due to a higher reliance on H-2A guest workers (Farmworker Justice 2011). Carroll et al.

(2011) estimate that 48% of MSFWs do not have legal authorization to work in the United States and only 33% are legal citizens (Carroll et al. 2011).

Documentation on the legal status of farmworkers makes it challenging to identify, diagnose, and treat chronic disorders like diabetes, hypertension, and obesity. Most farmworkers (72%) are foreign-born: 68% were born in Mexico, 3% in Central America, while an estimated 1% are born elsewhere (Carroll et al. 2011). In 2011, the United States Department of Labor and the National Agriculture Workers Study (NAWS) released findings on the demographic profiles of farmworkers since 1989. In total, 68% of the 54,000 farmworkers interviewed identified as being from Mexico (Figure 2), of which 45% originated in the traditional sending states of Guanajuato, Jalisco, and Michoacán. An additional 20% of that population were from Guerrero, Oaxaca, Chiapas, Puebla, Morelos, and Veracruz states (Carroll et al. 2011).

The majority (58%) of farmworkers are classified as seasonal workers, with an additional 42% identifying as migratory (Carroll et al. 2011). The ratio of seasonal to migratory workers varies geographically. For example, in 2012, 32% of agricultural workers in California identified as transient, while in Pennsylvania during the same period, 72% of the states 3,000 workers registered as migrant (Boggess and Bogue 2016). Poverty in farmworker communities is pervasive and differs among the three streams. The Eastern stream has the highest proportion of farmworkers with incomes \leq 100% of the Federal Poverty Level (FPL) at 85%, followed by the Midwestern (76%) and Western stream (73%) (NCFH 2016). The average median income nationwide is estimated at \$6,250, compared to the average for U.S. workers at roughly \$42,000 (Larson & Plascencia, 1993; Hawkins, 2001; U.S. Bureau of Labor Statistics, 2014, Rosenbaum and

Shin, 2005). In 2012, 80.4% earned incomes at or below the FPL, and only 35% made a living wage of over 200% the FPL (Boggess and Bogue 2012, 782). From 1995 to 2009 the share of farmworkers receiving public assistance increased by more than 30% (Carroll et al. 2011).

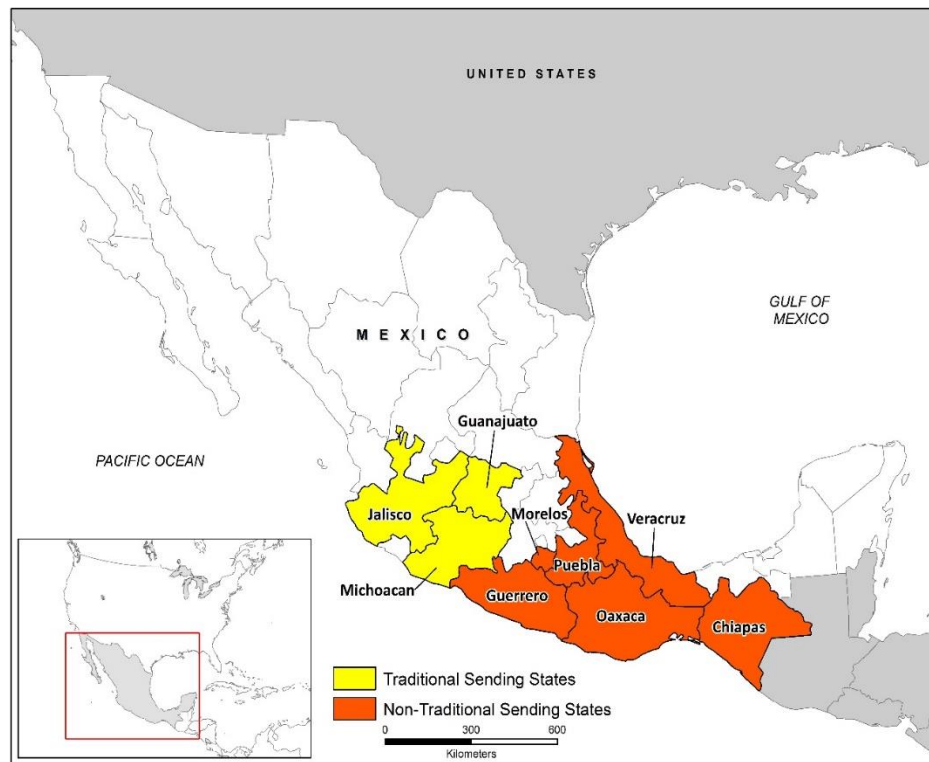


Figure 2. Traditional and non-traditional sending states

Nationwide, 33% of Hispanics earn incomes at or below the FPL, in comparison to 80.4% of farmworkers, a finding indicating that farmworkers experience a disproportionate burden of poverty compared to people of similar ethnicity (Boggess and Bogue 2012; Kaiser Family Foundation 2014). The Mexican-born share of the population peaked from 1998-2000, while from 1998 to 2009 the rate of citizenship rose by 157% (Carroll et al. 2011). In California, Mexican immigrants represent 91% of hired crop

workers, followed by U.S. natives (5%) and immigrants from Central America (4%) (Villarejo et al. 2010). The proportion of the population identifying as Indigenous Mexican or Central American peaked in 2004 and decreased by 1% from 2006 to 2010 (Carroll et al. 2011). With increased rates of citizenship, the foreign-born share of farmworkers is steadily rising since the first NAWS survey in 1989, when only 62% identified as foreign-born (United States Department of Labor 1991).

A large number of farmworkers originate in nations where Spanish is the official language. However, a 2007 cross-sectional survey in North Carolina reported that 25% of respondents spoke an indigenous language other than Spanish (Arcury et al. 2009, 2012). Language barriers further isolate farmworkers and create tensions with residents (Ford 1988). While some farmworkers speak English fluently, others speak French Creole, or one of the several South Asian languages, although the majority (84%) speak Spanish (Davies et al. 1998; Gadon, Chierici and Rios, 2001; Carroll et al. 2005; Mehta et al. 2000). Stephen (2001, 2004) and McCauley (2001) estimate that 40% of the 174,000 farmworkers in Oregon speak indigenous languages like Mixtecos (Stephen 2001; 2004, McCauley 2001). Mixtecos are a Native American group traditionally found in Southwest Mexico in the states of Oaxaca, Puebla, and Guerrero (Farquhar et al. 2008). Outside of Mixteco, the indigenous languages of Tarasco and Triqui are common (Farquhar et al. 2008). The delivery of health services to many native speakers is complicated by the fact that these cultures do not have a written language (Villarejo 2003). Farmworkers in indigenous, pre-Columbian communities often operate in a self-governing fashion due to their differences in spoken word from the traditional Spanish speaking farmworking population (Stephen 2001).

Education attainment is another barrier to access. Villarejo et al. (2010) reported that the median number of school years completed in a survey of 654 workers ranged from 4th to 6th grade. Additionally, only two-thirds of respondents could read Spanish, a finding that according to Villarejo and his colleagues suggests that a considerable proportion of the population has low-literacy levels or is non-literate. The United States Department of Agriculture (Kandel 2008) estimates that 24% of farmworkers have from 9 to 12 years of education, with an additional 63.4% having less than nine years. The lack of education does not just affect health literacy and training, but also occupational safety (Doak, Doak, and Root 1985). Health literacy is defined as the degree to which individuals can process, obtain, and understand the information and services needed to make appropriate choices regarding their health (Institute of Medicine 2004).

Farmworker Ecosocial Model of Health

The term *ecology* refers to the interrelationship between an organism and its environment (Sallis and Owen 2015). Ecological models focus on the nature of people's transactions with their sociocultural and physical environments (Stokols 1992). The *farmworker ecosocial model of health* (Figure 3) adopted in this study will include portions of Schulz et al. (2002) and Bronfenbrenner's (2005) models. The model posits that three domains; the macrosocial, the mesosocial (community level), and the microsocial (interpersonal level) influence farmworker health and well-being through differing levels of access to information, power, and health resources (Link and Phelan 1996). *Macrosocial* factors refer to the function of population systems: for example, culture, political systems, economics, migration, and urbanization (Florey, Galea, and Wilson 2007). Combined with discrimination, migration, legal codes, language barriers,

rurality, and contextual circumstances, these factors influence the political economy of farmworker health. The identification of macrosocial determinants is the first step for health interventions strategies focusing on improving overall population health.

Mesosocial factors stratify the community level social interactions between farmworkers and the broader society in which they live and work (Johnson 2008).

Mesosocial elements include access to healthcare facilities and the description of the extensive social networks that may occur due to *macrosocial* systems like migration and the interaction with local and federal government immigration agencies (Latkin et al. 2010). Because of the social status of farmworkers, their low educational attainment, lack of transportation, fragmented community structure, geographic isolation, little access to healthcare services, and lack of political representation, their health ultimately suffers. These interactions influence the health-related or proximate behaviors of farmworkers and the population in its entirety: these include poor nutritional practices, lack of physical activity, and health literacy.

Microsocial factors operate at an interpersonal level and are the results of the accumulation of factors due to *macro* and *mesosocial* interactions. The *ecosocial model of farmworker health* will serve as the guiding principle for both phases (Phase I & II) of this mixed-methods study, as will the concepts of *space* and *place*. *Space* in the purest sense is tied to position or location and to how geographical location influences human actions and interactions. *Place* has a deeper human meaning with the human experience at particular locations (Cromley and McLafferty 2011). Interactions between factors impact health outcomes, such as the physical or social environment, cultural norms, individual attributes, and the utilization of healthcare services (Kwan 2012). The

ecosocial model of farmworker health has the potential to improve farmworker clinical information (surveillance) and decision support systems (evidence-based guidelines).

The history of ecological models in health (Table 1) has a rich conceptual tradition that spans numerous studies in the behavioral and social sciences. These models have developed from those focused-on *perceptions* of the environment (Lewin 1951) to an emphasis on the *direct effects* of the environment on human behavior (Barker 1968). A strength of ecological models in health research is that they can supply the framework for integration of other theories by placing each into the broader context that emphasizes a more comprehensive understanding of the factors that influence individual behaviors (Sallis and Owen 2015). The first part table 1 includes examples of past and contemporary ecosocial models that guide behavioral and intervention strategies some of which are used to describe health behaviors (Cohen et al. 2000; Glass & McAtee 2006; Stokols 1992; Stokols et al. 2003).

Table 1. Ecological models in health research

Author, Citation, Model	Key Concepts
Kurt Lewin (1951): Ecological Psychology	Ecological psychology is the study of the influence of the outside environment on the person.
Roger Barker (1968): Environmental Psychology	Behavior settings are the social and physical situations in which behaviors take place.
Rudolph Moos (1980): Social Ecology	Four categories of environmental factors: (1) Physical setting; (2) Organizational setting; (3) The human aggregate; (4) The social climate
Urie Bronfenbrenner (1979): Systems Theory	Three levels of environmental influences: (1) microsystem; (2) mesosystem; (3) exosystem
Daniel Stokols (2003, 1992): Social Ecology Model for Health Promotion	Four assumptions of health behaviors
Deborah Cohen et al. (2000): Structural-Ecological Model	Four categories of structural influences on human health
Thomas Glass and Matthew McAtee (2006): Ecosocial Model	Hierarchies of influence on behavior within biology and society

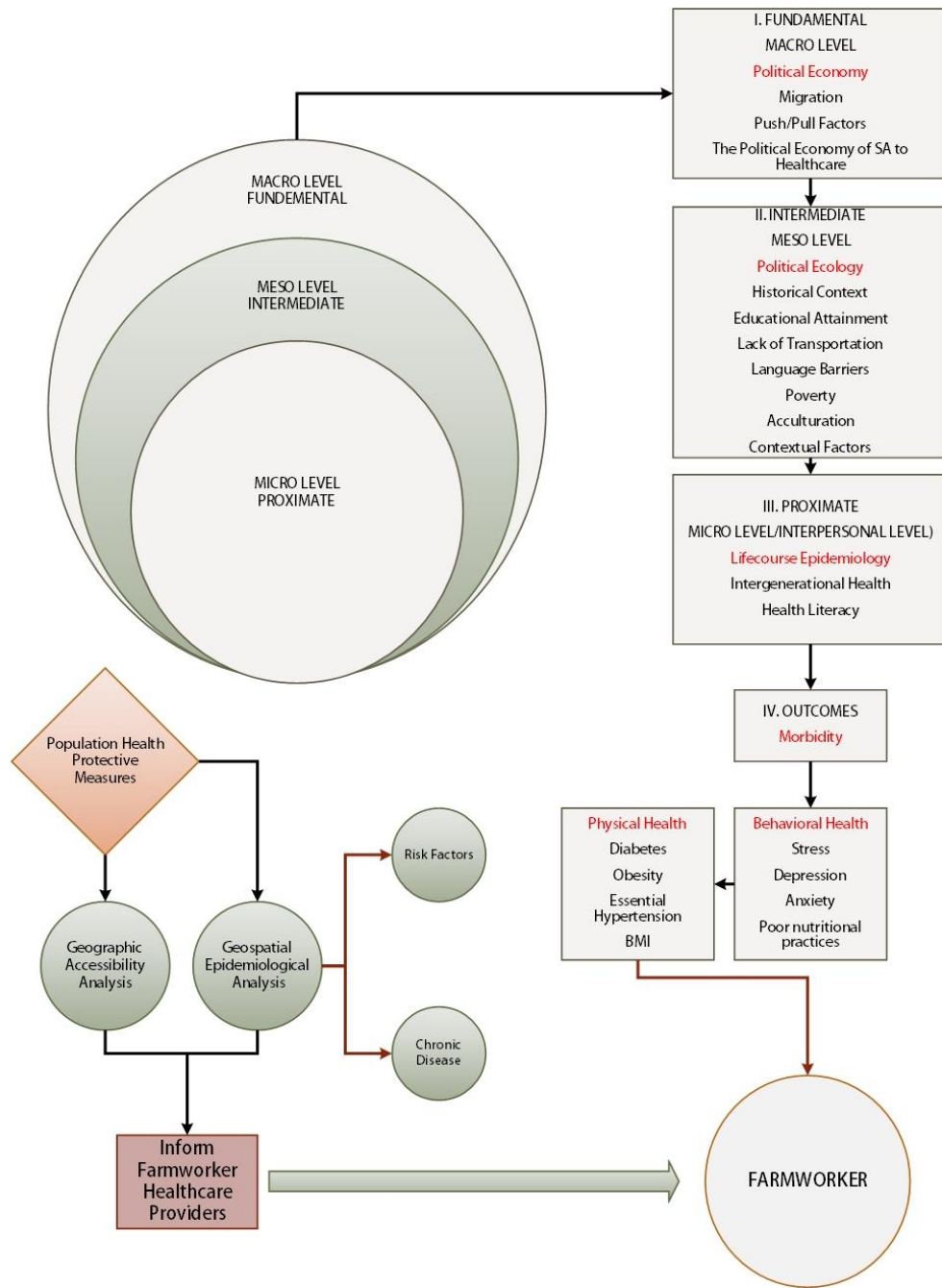


Figure 3. Farmworker ecosocial model of health

Purpose of the Study

The long-term goal of this project is to improve our understanding of the geography of farmworker health and the delivery of healthcare services. More importantly, an even more extensive gap exists in the literature as it pertains to connecting farmworker health to “place” and “space.” The specific aims of this mixed-methods research are:

1. To model the geographic distribution of chronic disease and related risk factors in Southern California, Northeastern Colorado, and Western Michigan.
2. To assess potential geographic accessibility to community and migrant health centers (C/MHCs).
3. To conduct qualitative interviews based on the principles of the farmworker *ecosocial model of health* at community and migrant health centers (C/MHC) in Southern California, Northeastern Colorado, and Western Michigan.
4. To improve the ability of healthcare service providers to better serve their patient population through the dissemination of information on the geospatial distribution of chronic disease, risk factors, and healthcare accessibility.

Objectives and Research Questions

Mixed method approaches are advantages because they provide a counter-balance to lessen the inherent limitations found in quantitative and qualitative methodologies.

Therefore, this mixed methods research aims to address the following questions:

Phase I: Quantitative

1. How does the geographic distribution of chronic disease and associated risk factors vary within each of the three study areas? (Chronic disease: Diabetes, Hypertension, Obesity) (Risk Factors: Anxiety, Stress, Depression, Tobacco use).
2. Are there any geographic variations in healthcare accessibility between study areas?

Phase II: Qualitative

1. What risk factors are associated with migratory and seasonal farmworker health and do these factors vary geographically (rural, urban, semi-urban) between study areas? How do the health needs of farmworkers and the challenges faced by key informants in treating this population differ geographically?
2. What is the demographic, occupational, social, and health characteristics of migratory and seasonal farmworkers in Southern California, Northeastern Colorado, and Western Michigan?

CHAPTER II

LITERATURE REVIEW

Farmworker Health

“Multiple factors are involved in the etiology of health problems for U.S. farmworkers, and understanding these dynamics is critical for providing care that is responsive to community preferences and priorities” (Qenani et al. 2016, 4). The health of farmworkers in the United States has a deep and complex history. The most popular federal programs, the Migrant Health Act (MHA) and the Migrant Health Program (MHP) gained prominence in 1962 under the guidance of President John F. Kennedy and were the first policies of their kind in the United States. The MHA and MHP provide farmworkers with a reliable source of affordable and comprehensive primary healthcare (NCFH 2012). The MHP was considered necessary to protect both the migrant community and the health of the public. The MHP emphasized that migratory farmworkers and their families should be able to access the same healthcare services available to all American families, with a central focus on preventive services, immunization, and health education (Villarejo 2003).

The Presidential Commission on Migratory Labor articulated the values of the MHP by stating that “to permit migratory workers to live under conditions now prevailing is to endanger not only the health of the migrants but the health of the community as well” (PCML 1951, 1). In 2014, 172 Migrant Health Centers serving 814,178 agricultural workers nationwide collected data related to health and demographics using the Uniform Data System. However, these centers are only equipped

to help <20% of the nation's farmworkers (NCFH 2016). The Uniform Data System consists of health data gathered from 1,000 health centers (166 being Migrant Health Centers) and serves as a repository for farmworker health providers. The Bureau of Primary Health Care administers the MHP and operates on a \$58.6 million budget and an average per capita healthcare bill of only \$2,800 a year.

An immigrant family will pay an estimated \$80,000 more in taxes than they will consume in services during their lifetime in the United States (Degazon 2004, p. 150; Lieber 2011). The vulnerability of farmworkers places this group at an increased risk of poor health. Aday describes vulnerable populations as “diverse groups of individuals who are at greater risk of poor physical, psychological, and social health” (Aday 2001; Ozdenerol 2017, p. 22). Political theorist Henry Shue defines any population group deprived of “basic rights” to be regarded as a vulnerable population (Shue 1996), while Bronfman and colleagues note that “while risk points to a probability and evokes an individual behavior, vulnerability is an indicator of social inequality and demands responses in the sphere of the social and political structure” (Bronfman, Levy, and Negroni 2002, 483).

2.2 Chronic Disease

The World Health Organization (WHO) “defines chronic diseases as having one or more of the following characteristics: they are permanent, leave residual disability, are caused by non-reversible pathological alteration, require special training of the patient for rehabilitation, or may be expected to require long period of supervision, observation, or care” (Britt & Britt 2001; Zwar et al. 2006, p 8). According to Connor et al. (2010), a quarter of all farmworker medical encounters at health centers were for the treatment of

chronic diseases, with diabetes and hypertension considered to be at epidemics levels in MSFW communities.

2.2.1 Diabetes and Cardiovascular Disease

Metabolic syndrome (MS) is a global health problem that increases the risk of developing type 2 diabetes, cardiovascular disease (CVD), all-cause mortality, and myocardial infarction (Mottillo, Filion, Genest and Joseph 2010; Gami et al. 2007). Migrant workers of Hispanic origin are two to five times more likely to develop type 2 diabetes mellitus than non-Hispanics (Kowalski, Hoffman, and McClure, 1992). Health behaviors are an essential precursor in predicting the future risks associated with chronic conditions like diabetes, hypertension, and obesity (Chiu et al. 2012; Setia et al. 2009; Hodge et al. 2004). The *American Diabetes Association* estimates that 9.4% of the American population (30.3 million) in 2015 had diabetes with another 1.25 million adults and children having type 1 diabetes. Diabetes was the seventh leading cause of death in the United States based on 79,000 death certificates listing diabetes as the underlying cause of death. In 2015, the total cost of diagnosing and treating diabetes was estimated at more than \$490 million (American Diabetes Association 2015).

Cardiovascular disease represents an additional health and economic burden with an estimated 600,000 Americans dying yearly from heart disease (Kochanek et al. 2011). Non-insulin-dependent diabetes (NIDDM) has increased non-uniformly, with economically disadvantaged populations taking the brunt of the economic and health burden. Prevalence rates among 793,000 agricultural workers documented at Migrant Health Centers throughout the United States in 2012 reported a combined type 1 and two diabetes prevalence rates of 7.8% (Bogges and Ochoa - Bogue 2014). In 2009, diabetes

was the fifth leading cause of death among Hispanics, with Latinos at a 66% higher risk of developing diabetes than non-Hispanics (Go et al. 2014). The prevalence of prediabetes among Mexican-Americans is estimated at 47%, with 11.4% of adult Mexican-American men currently living with diabetes (Go et al. 2014).

Chronic symptoms associated with diabetes are broad and include damage to the eyes, kidneys, nerves, blood vessels, and heart. Left untreated diabetes has the potential to inflict life-threatening symptoms, including blindness (retinopathy), renal disease (neuropathy), foot ulcers, amputations, cardiovascular symptoms, and gastrointestinal and genitourinary infections (genital and urinary organs) (American Diabetes Association 2012, National Eye Institute 2015). Type 1 diabetes accounts for 5 to 10% of those with the disease, while type 2 make-up 90 to 95% of all cases. Symptoms of hyperglycemia can include pronounced hunger (Polyphagia), excessive thirst (Polydipsia), increased urination (Polyuria), blurred vision, fatigue, weight loss, and susceptibility to recurring infections (American Diabetes Association 2013).

The primary consequence of uncontrolled cardiovascular disease is an increased risk of stroke, atherosclerosis, angina, hypertension, and arrhythmia (Roger et al. 2012; Chobanian et al. 2003; Goodman et al. 2013; Lieber 2008). Cerebrovascular accident (CVA) is classified into three categories: a) thrombosis, b) embolism and, c) hemorrhage (Lieber 2008, 24). The risk factors associated with CVA included an unhealthy diet, tobacco use, and physical inactivity (Lieber 2008, 24). The atherosclerotic process is a long, complicated process that involves inflammation of the arterial wall and an accumulation of lipids in the arteries (Fernstrom, Fernberg, Eliason and Hurtig-Wennlof 2017). U.S. Hispanic populations have trouble controlling their hypertension and often

face complications such as amputations, renal disease, and peripheral vascular disease (Pabon-Nau et al. 2010). Hypertension is the most common condition in all three streams nationwide and is seen at higher proportions in the Western stream, while farmworkers in the Midwestern stream have the highest prevalence of diabetes mellitus (NCFH 2016). Compared to the U.S. population, a higher percentage of male farmworkers had elevated serum counts and a higher incidence of high blood pressure than the U.S. population of both men and women. These data suggest that farmworkers are at an elevated risk for both diabetes and heart disease (Arcury and Quandt 2007).

2.2.2 Obesity and Food Insecurity

The prevalence of obesity in the United States is highest among persons of low socioeconomic status. These groups are at the highest risk for food insecurity (Townsend et al. 2001; Mokdad et al. 2001) which primarily affects rural, low-income, minority populations. Farmworkers experience incredibly high rates of food insecurity, despite being the primary contributors to the fresh fruits and vegetables available to the general public for consumption. For example, among MSFW households in Oregon, 72.7% reported chronic food insecurity, in comparison to 12.7% of all households statewide (Morton and Blanchard 2007; Richards and Smith 2006; Schafft et al. 2009; Sharkey et al. 2011; Slocum 2006; Cason et al. 2004; McClure et al. 2010; Perez-Escamilla and Putnik 2007; Reeder 2000; Weigel et al. 2007). A study of MSFWs on the U.S. – Mexico border reported that a high prevalence of food insecurity is associated with learning disorders, mental health conditions, and gastrointestinal symptoms (Weigel et al. 2007). Obesity is recognized as the second leading cause of preventable death in the United States and is known as a significant burden to economic capital (D’Alonzo, Johnson, and

Fanfan 2012). A 2013 Gallup-Healthways Well-Being Index Survey estimated that 25% of workers in the forestry, fishing, and farming sector were either obese or at elevated risk (Qenanai et al. 2016).

A recent systematic review by Lim, Song, and Song (2017) determined that the prevalence of obesity among MSFW children and adolescents to be between 31% and 73%, a finding that is similar to national studies of non-MSFW Hispanic/Latino children (43% to 61%). Obesity among the children of farmworkers is exasperated by their parent's mobile lifestyle that often places them at risk for suboptimal health (Flores et al. 2002 & McLaurin 1999). Health complications associated with being overweight or obese include an increased risk of stroke, cardiovascular disease, diabetes mellitus, osteoarthritis, obstructive sleep apnea, gallbladder disease, hyperlipidemia, and cancer (colon, rectum, breast, uterus, cervix, and prostate) (Merrill 2015). Studies of obesity among MSFWs in California reported that 80% of men and 75% of women were either overweight or obese. These findings corroborate research in Michigan, where 60% of farmworkers (n = 150) were either obese or overweight (Kowalski et al. 1999; Villarejo, 2000; Villarejo, 2003 & Villarejo et al. 2010). Dietary assessments in Michigan found low consumption of fruits and vegetables as a contributing factor, with 89% consuming less than five daily servings (Kowalski et al. 1999).

Further analysis from the same study found a mean energy intake of 1,398 kcal for women (range = 800 - 1,495) and 1,894 for men (range = 1,552 - 2,055). More than 50% of farmworkers in this study were obese, more than 33% had diabetes, and 22% had hypertension (Kowalski et al. 1999, 223). Cross-sectional analysis of 1,005 participants in twenty-nine agricultural labor camps in California discovered that the prevalence of

obesity in women and men accounted for 22% of those surveyed, with a heightened risk of chronic disease, high blood pressure (3 times increased risk), and diabetes (3-6 times increased risk) among participants (Hubert et al. 2005). In comparison to the Midwestern and Eastern streams, the Western stream has the highest proportion of obesity, asthma, depression, and mood disorders (NCFH 2016).

2.2.3 Chronic Disease Risk Factors

Stress increases the risk of type 2 diabetes among both men and women and is associated with elevated fasting blood glucose levels (Clingerman 2008; Nyberg et al. 2014). Research on Chinese immigrants in the United States reported that the stress associated with migration increases insulin resistance and the risk of developing diabetes. Similarly, the same factors are observed in Hispanic immigrant populations. Stress triggers behavioral changes in an individual's diet, leading to weight gain and poor dietary choices. Stress correlates to a reduction in vegetable consumption and an increased craving for caloric dense foods. (Bjorntorp et al. 1999; Heraclides et al. 2012; Pyykkonen et al. 2009; Rosmond 2005; Torres and Nowson 2007; Ng, D.M, and Jeffery 2003; Oliver et al. 2000; Mikolajczyk et al. 2009).

Black et al. (2003) further linked the incidence of diabetes with depression, based on a cross-sectional analysis of 2,830 Mexican American participants from California, Texas, Colorado, New Mexico, and Arizona. Black found that 47% of those diagnosed with diabetes experienced clinical signs of depression. The study concluded that diabetes and depression together could be used to predict disability, diabetic complications, and mortality from the disease (Black et al. 2003). Biological responses to life stressors further complicate existing medical conditions like diabetes and rheumatoid arthritis

(Brunner and Marmot, 2005). Psychological circumstances can contribute to long-term stress, as does social isolation, low self-esteem, insecurity, and anxiety. The accumulation of such stresses has the potential of increasing the risk of poor mental, physical health and even premature death (Wilkinson and Marmot 2003; Brunner 1997).

Earlier studies on mental health in farmworker communities in eastern North Carolina found that 38% of participants (n=125) experienced significant levels of stress, with 18.4% of these individuals having impairing levels of anxiety (Hiott et al. 2008). Other evidence suggests that acculturation stress and the lack of social support systems lead to more significant symptoms of anxiety and depression (Vega, Scutchfield, Karno and Meinhardt 1985; Hovey and Magana 2000). Anxiety causes poor health outcomes for people with diabetes (Bickett and Tapp 2016). According to Smith et al. (2013), significant and positive correlations are shared between people with diabetes and anxiety disorders (1.10-1.31) and elevated anxiety symptoms (1.02-1.93). Furthermore, population-based research by Engum (2005) concluded that symptoms of depression and anxiety were significant risk factors in the onset of type 2 diabetes independent of established risk factors for the disease.

Research has linked high systolic blood pressure, elevated total cholesterol, and smoking to hyperlipidemia, elevated body fat percentage, insulin resistance, cognitive performance (Rovio et al. 2017), and a 30-40% higher risk of developing type 2 diabetes (United States Department of Health and Human Services 2014; Fernstrom, Fernberg, Eliason and Hurtig-Wennlof 2017). Literature on the prevalence of smoking among farmworkers is limited; however, studies have previously pointed to a much higher average smoking rate (40%) in Nebraska in comparison to the statewide average of

18.5% (University of Nebraska Medical Center 2013), while in North Carolina, 38% of farmworkers in a 2003 study (Sprangler, Arcury, Quandt and Preisser 2003) were smokers. Interestingly, Sprangler and colleagues (2003) found that older farmworkers who had the highest English proficiency smoked more cigarettes per day. In the United States, cigarette smoking is responsible for 480,000 deaths per year, or 1,300 deaths every day (United States Department of Health and Human Services 2014).

The risk of diabetes, hypertension, and obesity is related to increases in Body Mass Index (BMI). Obesity and weight gain are associated with an increased risk of developing diabetes (Mokdad et al. 2003; Zhou 2002). In MSFW families, children are at an increased risk of developing health complications from being overweight or obese. Research on the health status of migrant farmworker children in Georgia reported a prevalence of overweight, obesity, elevated blood pressure, anemia, and stunting ranging from 13.5% to 21.8%, 24.0% to 37.4%, 4.1% to 20.2%, 10.1% to 23.9%, and 1% to 6.4% respectively (Nichols et al. 2014, p 365). The mean BMI percentile each year of the study ranged from 67.1 to 76.6, with a mean age of 7.7 years (Nichols et al. 2014). Expanding on the work of Weigel et al. (2007) (section 2.2.2), in a survey of 100 farmworkers, 19% were overweight, and 66% as obese. The mean BMI was significantly higher compared to their male counterparts ($\bar{X}=33.5\pm6.6$ vs. 28.8 ± 5.3 ; $t = 4.0$; $P = 0.0001$), as was the proportion of women with BMI that would classify them as overweight (92.9% vs. 73.7%; $X^2 = 6.0$; $P = 0.015$) or obese (73.8% vs. 40.4%; $X^2 = 10.2$; $P = 0.001$).

Finally, the role of nutritional deficiencies as a risk factor in the development of chronic disease was examined. Worldwide, 826 million people are undernourished – 792 million in the developing world and 34 million in the developed world (Katona and

Katona-Apte 2008, p 1582). In the United States, undernutrition affects an estimated 15% of ambulatory outpatients, 25 to 60% of patients receiving long-term care, and 35 to 65% of hospitalized patients (Chapman 2006). Previous research on the nutritional status of migratory and seasonal farmworkers points to diets deficient in vitamin A, iron, calcium, and vitamin C, with inadequacies most common among women (Shotland 1989). The incident of malnutrition is also higher among farmworkers than any other demographic group in the United States (Glader 1990). The correlation between physical illness, mental health, and nutritional deficiencies are well established (Horwitt 1965; Leyse-Wallace 2013; Walsh 2011). Common cognitive side effects of nutritional deficiencies include depression, anxiety, eating disorders, and attention deficit disorder (ADD) (Lakhan & Vieira 2008). Physical symptoms include an increased risk of cardiovascular events (Son & Son 2013), heart failure (Sciatti et al. 2016), type 2 diabetes (Hales & Barker 1992), and obesity (Mokhtar et al. 2001)

2.3 Healthcare Utilization and Accessibility

“Social and economic risk factors are exacerbated by poor access to healthcare” (Boggess and Bogue 2016, 779). The Kaiser Commission Report (Rosenbaum and Shin, 2005) estimated that 85% of MSFWs were uninsured, with only 42% of women from MSFW families seeking prenatal care compared to 76% of the general population nationally. Farmworkers will access healthcare services only when necessary, and this is an even wider margin among male workers, consistent with earlier studies confirming that women utilized significantly more healthcare than their male counterparts (Littlefield and Stout 1987; Slesinger and Cautley 1981). Further impeding the access to healthcare services are limited access to transportation, language barriers, and a lack of knowledge

about available services (Arcury and Quandt 2007; Krishna, Gillespie, and McBride 2010).

The California Agricultural Worker Health Survey (CAWHS) found that 31% of men had never visited a medical clinic or doctor, and only 48% had sought medical attention within the previous two years (Villarejo 2003). In a 1999 survey of California farmworkers, Villarejo et al. (2010) reported that 73% of male and 69% of female farmworkers lacked any form of insurance coverage, and 25% of men and 13% of women had never visited a clinic for medical care. Further evidence documents the fact that few farmworkers, only between 7% to 11%, have been able to obtain Medicaid, despite being qualified to do so (Villarejo 2003). Rates of insurance are lowest for unauthorized workers, followed by green card holders (Ortega et al. 2007). These rates vary by salaried farmworkers versus those paid an hourly wage, a finding likely related to healthcare cost (Hoerster et al. 2011).

Where people live matters, and this is true when speaking of farmworkers and their families. The rural nature of farm labor unintentionally places this group at a disadvantage when attempting to accessing healthcare services. Cromley and McLafferty (2002) cite accessibility to transportation as a significant problem for disadvantaged subgroups. Although farmworkers have migratory lifestyles, a majority do not own vehicles or have access to transportation services; it is estimated that only 42% own or drive a car (Carroll et al. 2005). Farmworkers in earlier studies cite poor transportation as a barrier to care (Rose and Quade 2006; Goldsmith and Sisneros 1996; Lantz et al. 1994; Perilla et al. 1998). Because of the legal ramifications of farmworker employment in the United States, obtaining a driver's license is impossible, and many are transported in vans

as work crews when arriving at new locations (Arcury and Quandt 2007).

Agricultural workers often depend on their employers for transportation to healthcare service providers, groceries, and laundry services (Arcury and Quandt 2007). Barriers that can impede progression from potential to realized access are divided into five dimensions: availability, accessibility, affordability, acceptability, and accommodation (Penchansky and Thomas 1981). Access to care is a significant problem that rural populations face. People who live far from metropolitan areas find it challenging to access specialized health services (Arcury et al. 2005). Geographic accessibility influences the use of a variety of healthcare services, including primary care (Arcury et al. 2005), hospitals (Goodman et al. 1997), cardiac revascularization (Gregory et al. 2000), and emergency rooms (Turnbull et al. 2008).

2.4 Migration, Culture, and Health

Migration is the crossing of a boundary or administrative unit for a certain minimum period, often for economic and humanitarian purposes (Nita et al. 2017). This geographic movement across artificially drawn borders and sovereign nations influences not only economic development and labor markets but also population health (Garcia et al. 2012). In receiving societies, migration stems from economic segmentation, which creates a subset of poorly paid, unstable jobs with little opportunity for advancement (Piore 1979; Portes and Bach 1985). In the sending countries, migration represents an adjustment of the inequalities that exist in the distribution of land, labor, and capital that are often found in young, developing economies (Furtado, 1976; Balan, Browning, and Jelin 1973). In the case of farmworkers, migration patterns impact health, leading many to go prolonged periods if not years without medical treatment. Farmworkers primarily

live in rural locations and are defined as “peripatetic” because of their propensity to move into and out of the United States (Poss and Pierce 2003).

Three distinct migration patterns describe the geographic movement of farmworkers: restricted circuit, point-to-point, and nomadic (Poss and Pierce 2003; Romero 2008; Donham & Thelin 2006). Point-to-Point workers travel to the same location for work year after year, while restricted circuit workers follow traditional migration streams in one geographic area (Figure 1). Two-thirds of all MSFWs are classified as nomadic or “shuttle migrants,” who travel seasonally from either inside or outside the United States (Hansen & Donohoe 2003). Shuttle migrants travel at least 75 miles to find work from a fixed geographic location (Quandt et al. 2015). Additional estimates report that at least 17% of MSFWs who work in agriculture move state to state to find employment; these families and individuals are “follow-the-crop” workers (Villarejo 2003). Furthermore, the term “circular migration” describes those people who move across the U.S. – Mexico border throughout the year with prolonged stays in both nations (Passel et al. 2009).

Circular migration is the fluid movement of people between areas, usually for employment (International Organization of Migration 2008). These repetitive patterns of population mobility present unique spatial distributions from year to year. Older farmworkers with stronger family ties to their homelands and fewer work obligations are likely to practice “circular migration” (Moreno 2015). Migration plays a substantial role in the overall health of MSFW communities. Frequent migration is commonplace among farmworkers. Such movement leads to the abandonment of established social networks which may result in dislocation, alienation, and isolation. The importance of social

networks to migration is not new. As early as the 1920s, research demonstrated that migrants tended to focus on specific districts in American cities (Zorbaugh 1929; Gamino 1930; Massey 1987). Migration only complicates the study of disease in farmworker communities and displaces individuals from their activity spaces.

Culture is shown to influence one's health by shaping personal behavior, mediating communication between healthcare providers and patients, and by further affecting the choice and process of resource allocation (Helman 1990; Hill, Firenberry & Stein 1990). Culture is the norms and social behaviors found in human societies. Three universal conceptual principles of culture are evoked in universals, material, and social organization (Macionis and Gerber 2011). When studying the health of farmworkers who are predominately Latino, it is necessary to consider cultural characteristics and the broader relationship to health: "the culture, experience, and beliefs of agricultural workers affect their willingness to accept and or use the health information they receive" (Arcury, Estrada, and Quandt 2010, 239).

One belief among some Latino workers is that health or illness is outside the control of the individual, either because of God's will or because of supernatural forces (Arcury, Estrada, and Quandt 2010). Humoral medicine is a widely held health belief in Mexico and Latin America (Weller 2008). Within humoral medicine, different materials and substances have different "humors" that are classified as "hot" or "cold." For example, hand washing and showering immediately after work are postponed because by placing the hot body in water, illness could result. Water in this instance is metaphorically considered to be "cold" (Arcury, Estrada, and Quandt 2010). Lay-defined illnesses are commonplace among farmworkers in the eastern United States; these

include *susto*, *nervios*, *empacho*, and *mal de ojo* (Weller et al. 2008), none of which are recognized by Western biomedicine (Arcury, Estrada, and Quandt 2010). Weller and colleagues (2008), through interviews with participants in Guadalajara, Mexico, describes folk illnesses like *susto* and *nervios* as having an association with psychological stress and depressive symptoms among respondents. Latino farmworkers further partake in home remedies to prevent disease; these include herbs, chlorine bleach, milk, and medicine purchased at local Latino stores serving the community (*tiendas*) (Poss, Pierce, and Prieto 2005; Mainous, Diaz, and Carnemolla 2008).

A growing amount of evidence points to the possibility that the health outcomes of Latino(a) immigrants worsen with time in the United States and across generations: this is known as the “Latino health paradox” (Quesada, Hart, and Bourgois 2011; Burnam et al., 1987; Ebin et al., 2001; Guendelman, 1998; Hummer et al., 1999a, b; Landale et al., 1999; Rumbaut and Weeks, 1989). The term health or epidemiologic paradox typically refers to a “pattern of morbidity and/or mortality for a particular group (e.g., Latinos, immigrants) that is at odds with what would be expected given its socioeconomic profile” (Acevedo-Garcia & Bates 2008, 103). Frequently mentioned in the literature on farmworker health is acculturation. Acculturation “is one of several forms of culture contact, and has a couple of closely related terms, including assimilation and amalgamation. Although all three of these words refer to changes due to contact between distinct cultures, there are notable differences between them. Acculturation is often tied to political conquest or expansion and is applied to the process of change in beliefs or traditional practices that occurs when the cultural system of one group displaces that of another. Assimilation refers to the process through which individuals

and groups of differing heritages acquire the basic habits, attitudes, and mode of life of an embracing culture. Amalgamation refers to a blending of cultures, rather than one group eliminating another (acculturation) or one group mixing itself into another (assimilation)” (Merriam-Webster 2018).

The adverse health consequences of acculturation among Latinos are associated with increased rates of cancer, infant mortality, mental health conditions, smoking, and alcohol use, and obesity (Clark and Hofsess 1998; Vega and Amaro 1994; Lara et al. 2005; Abraido, Chao, and Florez 2005). Research on acculturation in farmworker communities has pointed to decreased health and a correlation between health outcomes, long-term health behaviors, and the amount of time one spends in the United States. A 1999 study by Alderete et al. in rural California among 1,001 Mexican migrant farmworkers showed elevated levels of stress due to both work discrimination and acculturation. Acculturation may be a risk factor for hypertension based on the length of time one spends in the United States (Yi et al. 2014; Moran et al. 2007). Farmworker behaviors over time evolve to mimic those of the U.S.- born population, a process referred to as “Americanization,” a biological metamorphosis that decreases long-term health (Kosteniuk & Dickinson 2003; Scribner and Dwyer 1989; Scribner 1996). Increasing naturalization into ‘American’ culture, abandonment of shared cultural beliefs, and long-term family separation contributes to uneven health outcomes in farmworker communities, and the association between diabetes, cardiovascular disease, obesity, and diet are well established (R. Merrill 2015).

2.5 Mixed Research Methods for Health Research

In the realm of applied studies, the linking of quantitative and qualitative methods in health research, social sciences, education, and psychology is advocated (O’Cathain 2009; Carey 1993). The maintenance of health and treating those inflicted with illness are universal challenges. Health professionals have long integrated insight from multiple dimensions of social science research to further their understanding of human health (Carey 1993; Chowdhury, Helman, and Greenhalgh 2000; Morse 1991). In applied geographic research, it is essential for geographers to incorporate a wide variety of methods, social groups, and research philosophies (Elwood 2006; Johnson et al. 2004). The most popular and well-known applications in mixed-methods research are the incorporation of geospatial technologies and qualitative methods. In recent decades, the vast availability of quantitative and qualitative data sources has propelled the increasing integration of mixed methods studies. Thus there is a broad consensus that mixing different data types can only strengthen a study (Greene & Caracelli 1997; Creswell, Clark, Gutmann and Hanson 2003).

Since the 1960s, an increasing number of disciplines have praised mixed method approaches (Creswell & Plano Clark 2007; Johnson, Onwuegbuzie, & Turner 2005), a movement referred to by Johnson et al. (2005) as the *mixing movement* or the *current synthesis stage*. Mixed-methods are an umbrella term for multifaceted procedures that synthesize, combine, or triangulate methods (Creswell, Plano Clark, Gutmann, and Hanson 2003; Tashakkori & Teddlie 2003). Mixed-methods designs include both quantitative and qualitative methods in parallel, sequential, and transformative form (Creswell 2003; Miller & Fredericks 2006). Qualitative methods help us understand the

underlying behaviors, attitudes, perceptions, and culture in a way that cannot be recognized by quantitative methods alone; qualitative methods are particularly important in understanding questions of *how* and *why* (Ulin, Robinson, and Tolley 2005).

Qualitative research in this study focuses on the relations “between personal and social meanings, individual and cultural practices, and the material environment or context” (Tolley et al. 2016, p. 7). Questions of how and why are important and are even more crucial in our understanding of multi-causal public health problems at domestic and international scales (Ulin, Robinson, and Tolley 2005).

The qualitative researcher’s goal is to attain an insider’s view of the group under investigation. In the case of public health research, this perspective gives us an intimate look at how people both perceive and react to health problems, and which intervention strategies will be the most successful (Ulin, Robinson, and Tolley 2005). “Qualitative researchers seek answers to their questions in the real world. They gather what they see, hear, and read from people and places and from events and activities... their purpose is to learn about some aspect of the social world and to generate new understandings that can be used by that social world” (Rossman, Rallis, Phlegar & Abeille 1998, 5). Dwyer and Lamb (2001, 2) describe qualitative methodologies as a way to “seek subjective understanding of social reality rather than a statistical description of generalizable predictions”; additionally, Fotheringham (2006, 238) argues that qualitative research “probes questions that relate to a deeper understanding of the way spaces are produced and maintained.”

The spaces and social constructs occupied by the farmworkers are a human experience that cannot be adequately interpreted with geospatial technologies alone. The

definition of mixed methods research varies considerably in the literature. Writers have referred to it as multitrait-multimethod research (Scherpenzeel and Saris 2017), integrating qualitative and quantitative approaches (Brannen 2017), methodological triangulation (Hussein 2015), multimethodological research (Ahamat and Chong 2015), and mixed methods research (Creswell and Creswell 2017). Creswell and Creswell (2017) describe mixed methods research designs as involving both qualitative and quantitative methods of data collection and analysis.

In more elaborate terms, the priority each form receives from the researcher, the order in which each fall in the research process, and the “mixing” of the data in the analysis, data collection and interpretation phase, is another explanation of mixed method design. Combining these features into a single definition suggests that “a mixed methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research” (Creswell, Clark, Gutmann and Hanson 2003, 165). Six major design types are recognized in mixed methods research. These include sequential explanatory, exploratory, transformative; and concurrent triangulation, nested and transformative designs (Creswell, Clark, Gutmann and Hanson 2003, 179).

2.6 Geospatial Analysis and Health Research

The use of maps as a device for the communication of health data has existed for nearly 200 years. As early as 1796, physician Valentine Seaman mapped the distribution of Yellow Fever cases in New York City, as a means of linking human cases with environmental factors (Howe, 1989). In 1840, Robert Cowan used maps to analyze the

relationship between overpopulation and fever in Glasgow, while in 1843 Robert Perry mapped the prevalence of typhus in neighborhoods of differing socioeconomic status (Sherman et al. 2014; Melnick 2002). A decade later, John Snow's cholera map (1854) would cement him as one of the fathers of modern epidemiology. An early example of spatial epidemiology, Snow's work expanded on the controversial germ theory of disease by linking epidemiology and geographic information to reveal the relationship between humans, their environment, and disease.

Similarly, extending on the pioneering work of William Farr, Alfred Haviland successfully merged mortality statistics and census data to map heart disease and cancer mortality in the 1870s (Exeter 2017). Another critical and overlooked spatial investigation was Burkitt's study of lymphoma in Africa (Moore and Carpenter 1999). While on a safari in Africa in the 1950s, Dr. Denis Burkitt documented that an unusual jaw tumor of children had a limited geographic distribution confined to a particular latitude and altitude range. Burkitt suspected a vector-borne disease as the culprit; however, he discovered that a virus (Epstein-Barr virus) was responsible (Moore and Carpenter 1999). Burkitt was in part correct though because the virus has a synergetic relationship to malaria (Burkitt 1962). Contrary to popular belief, cholera cartographers like Snow were not the first disease mappers, as demonstrated by the work of Seaman. Moreover, often it was physicians, not geographers who were contributing tremendously to methodological advances in disease mapping (Barrett 2000). Disease maps can highlight geographic patterns otherwise hidden to the untrained eye; these maps represent a significant realm of spatial epidemiological research and methodological development (Exeter 2017).

Today, geographers, epidemiologists, and public health professionals must solve increasingly complex health issues in diverse, rapidly changing environments (Melnick and Fleming 1999). Descriptive mapping fused with geospatial analysis is implemented to accomplish public health goals related to: 1) exploratory cluster detection; 2) the identification of environmental risk factors; 3) the quantification of disease risk; 4) etiologic research; 5) and as a means for geographically targeted public health interventions (Sherman et al. 2014). Spatial epidemiology refers to research that describes and analyzes the geographic distribution of overall health in relation to sociodemographic, behavioral, and environmental risk factors (Elliot and Wartenberg 2004). The goal of spatial epidemiological studies is to better understand the social and ecological processes of diseases (Exeter 2017). Spatial epidemiological techniques are standard in geospatial research; the most common are disease mapping, geographical correlations studies; clustering, and surveillance (Exeter 2017).

In grouping the approaches discussed above, a transition from the use of traditional epidemiological techniques (e.g., age-standardized rates) to advanced methods (e.g., LISA) is due to advances in geographic information science (Exeter 2017). These recent approaches, of course, remain closely intertwined with Tobler's First Law of Geography (Tobler 1970), defined as "everything is related to everything else, but near things are more related than distant things" (Tobler 1970, 234). The first law addresses the challenge of spatial autocorrelation and dependency across geographic space. Typically, spatial epidemiological investigations employ exploratory spatial data analysis (ESDA). The six most-common ESDA methods are: (1) mapping and visualizing data; (2) point pattern-analysis; (3) spatial filtering and smoothing; (4) spatial scan statistics;

(5) spatial autocorrelation; and (6) spatial regression (Lentz 2012). Clusters of disease or hotspots can be revealed using ESDA and further examined using traditional epidemiological techniques (Berke 2004).

2.7 Disease Clusters and Detection Methods

A disease cluster is an “unusual aggregation, real or perceived, of health events that are grouped in time and space” (Centers for Disease Control and Prevention, 1990, 1). Knox (1989) expanded on this by defining a cluster as “a geographically bounded group of occurrences of sufficient size and concentration to be unlikely to have occurred by chance” (p. 17), while McLafferty (2015, 127) describes a spatial cluster or hot spot as “an unusual number of cases within a population, place and time period.” In spatial epidemiology, a disease is clustered if even after controlling for known confounders, spatial variation in risk remains constant (Pfeiffer et al. 2008). Investigations of noninfectious disease cluster events are potentially useful in the identification of potential environmental and biological causes (Waxweiler et al. 1976). Interest in detecting and analyzing spatial clusters appeared in the 1970s and 1980s, primarily due to two interlinked social trends: the health impacts of environmental contaminants and an increase in concern about disease hotspots at the local level (Neutra, Swan, and Mack 1992).

Well-known cluster detection methods and software (Table 2) include Openshaw’s geographic analysis machine (GAM) (Openshaw et al. 1988), Turnbull’s test (Turnbull et al. 1990), Besag – Newell’s test (Besag and Newell, 1991), the Disease Mapping and Analysis Program (DMAP) (Rushton and Lolonis 1996), SaTScan (Kulldorff and Nagarwalla 1995; SaTScan 2018) and ClusterSeer (Jacquez 1996;

TerraSeer, Inc. 2018). Currently, there are more than 100 cluster detection methods available (Kingsley, Schmeichel, and Rubin 2007; Ngan-Lam 2012). The Geographical Analysis Machine (GAM), first developed by Openshaw (1988) in the mid-1980s, was composed of four components: (1) spatial hypothesis generation; (2) a significance test procedure; (3) a system for data retrieval; and (4) a graphical system for visualization (Charlton 2008). Openshaw developed the GAM to detect the location of cancer clusters in northern England. Significance tests were based on Hope's Monte Carlo test, with the observed compared to 499 total permutations, and a significance level of 0.002, a development that Openshaw hoped would minimize false positives (Charlton 2008). The GAM considers dozens of overlapping circles and radii as potential clusters; clusters containing at least 2 cases and high rates ($p\text{-value} < 0.002$) will be drawn on the map (Gangon 1998).

Table 2. Cluster detection techniques and software

Cluster Detection Techniques	Reference
Geographic Analysis Machine (GAM)	Openshaw et al. 1988
Turnbull's Test	Turnbull et al. 1990
Besag-Newell's Test	Besag and Newell 1991
Cuzick and Edwards Test	Cuzick and Edwards 1990
Diggle's Test	Diggle 1990
Cluster Detection Software	
ClusterSeer 2.5	Jacquez 1996; TerraSeer, Inc. 2018
DMAP	Rushton and Lolonis 1996
GeoDA 1.12	Anselin 2003
Point Pattern Analysis (PPA)	Alstadt, Chan and Getis 1998
SaTScan v9.6	SaTScan 2005
CrimeStat v.4.02	Ned Levine (2015)

Turnbull et al. (1990) and Besag and Newell (1991) proposed alternatives to the GAM. Their methods specify ‘fixed’ circles of population radius and circles of ‘fixed’ case radius. These circles form through the aggregation of adjacent cells (Gangon 1998). Turnbull, Besag, and Newell designed their methods to be more tractable versions of the GAM since the circles in their techniques are comparable (Gangon 1998). The disease mapping analysis program (DMAP) is a stand-alone platform first developed at the Department of Geography at the University of Iowa in the mid-1990s (Rushton and Lolonis 1996; Lentz 2012). Like spatial scan statistics, the DMAP identifies significant rates of disease and clustering through Monte Carlo simulations (Rushton and Lolonis 1996). The DMAP was initially used to study the geographic distribution of infant mortality but has since been utilized in a variety of health investigations (Rushton et al. 2004; Lentz 2012; Curtis et al. 2010). To identify clusters, the DMAP aggregates point level disease data to a grid surface covering the entire study area, thus creating a spatial filter for the numerator (cases) and denominator (risk population) (Cai 2012; Lentz 2012). Statistical significance is calculated by creating a simulated disease distribution surface, which can then be compared to the actual disease distribution surface (Lentz 2012).

2.8 Geographic Accessibility to Healthcare

The concept of access to healthcare is highly contingent on the geographic context in which the analysis is taking place (Goddard and Smith 2001). For example, in the United States, access is based on whether an individual is insured or can afford a copayment, while in Europe this term takes on a different meaning because almost all

citizens receive coverage; although what cannot be ignored in this analogy is contextual factors and access to transportation (Goddard and Smith 2001). When speaking about a disadvantaged group like farmworkers, the term access again takes on a different meaning. Access to healthcare is grouped into two dichotomous dimensions: potential versus revealed, and spatial versus aspatial, and four categories: potential spatial access, potential aspatial access, revealed spatial access and revealed aspatial access (Khan 1992; Luo and Wang 2003 p. 865). Low levels of geographic accessibility have dramatic impacts on health. However, with advances in GIS technology, a variety of metrics can be used to estimate impedance and travel distance (Kirby, Delmelle, and Eberth 2017; Frizzelle et al. 2009).

Methods for measuring spatial accessibility have developed in unison with GIScience and now have made it possible to determine accessibility at small and large-scale resolutions (Cromley and McLafferty 2002; Kohli et al. 1995; Lovett et al. 2002; Luo et al. 2017). Historically, since the late 1950s, nine models are cited as the cornerstone for studies of geographic utilization, accessibility, and human behavior (Joseph and Phillips 1984; Luo and Wang 2003):

- 1959 – 1960: The Rosenstock model: psychological-motivational determinants of health service utilization.
- 1964 – 1966: The Suchman model: socio-cultural and environmental determinants.
- 1968: The Anderson model: behavioral components.
- 1972: The Gross model: behavioral components.

- 1974: The Aday and Andersen model: a framework for the study of access; the system as a modifier.
- 1976: The Gravity-based method: Weibull (1976) applied to health access by Joseph and Bantock (1982).
- 2000: The Spatial decomposition method (two-step floating catchment area method): Radke and Mu (2000) – a special case of a gravity-based method.
- 2009: The enhanced two-step floating catchment area (E2SFCA) (Luo and Qi 2009).
- 2012: Three-step floating catchment area method (Wan, Zou, and Sternberg 2012).
- 2015: The enhanced variable two-step floating catchment area (EV2SFCA) (Ni et al. 2015).

Geographic accessibility to health services is related to impedance. The higher the impedance, the less likely that the health service will be utilized (Lovett et al. 2002).

Geographic access and spatial behavior include distance decay effects, distance measures, as well as transportation availability and individual activity space (Joseph and Phillips 1984; Nemet and Bailey 2000). Distance measures are referred to as connectivity measures (Geurs and van Wee 2004) and are identified as the most straightforward measure of accessibility from point A to point B (Geurs and van Wee 2004; Zhang et al. 2011). Distance measures merely calculate the minimum travel distance (travel time or cost distance) (Wang 2006; Ahlstrom et al. 2011). The relative proximity of one place i to another place j is defined in a general sense as:

$$A_i = \sum f(W_j d_{ij})$$

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“Where W_j is some index of the attraction of j and d_{ij} is a measure of impedance, typically the distance of travel time of moving from i to j ” (Stahle et al. 2005, pg. 2). Research specifically on immigrant and minority populations and access point to several recurring themes as influencing long-term health outcomes: contextual factors, geography and ‘place.’ For example, Devillanova (2008) found that in immigrant communities, active social networks significantly accelerated the rates of healthcare utilization; while Field and Briggs (2001) determined that locational determinants and the social geography of a population group have a significant influence on the extent in which services satisfy needs. Because of push-pull factors and frequent migration, farmworkers may have difficulties in maintaining strong social networks. In elucidating the role of place in healthcare disparities, White, Haas, and Williams (2012) argue that geographic and place-based inequalities need to be considered when healthcare disparities are studied in immigrant and minority communities. Arcury et al. (2005) integrated concepts from health geography (Joseph and Phillips 1984) with Aday and Andersen’s (1974) health behavior model (HBM) in the examination of rural healthcare utilization in Appalachia.

The HBM incorporates three sets of utilization factors: (a) *predisposing factors* (social structure, health beliefs); (b) *enabling factors* (income, health insurance status, the availability of physicians); and (c) *need for care* (Aday and Andersen 1974; Arcury et al. 2005). The three sets of utilization factors further include the physical, political, and economic environment as predisposing and enabling factors, while personal health factors are grouped as need factors (Andersen 1995). *Predisposing* factors in the HBM include distance, which is measured as the distance along road systems, perceived distance and travel time, and the distance to the nearest healthcare provider (Haynes

1991; Love and Lindquist 1995; Welch, Larson, and Welch 1997). Culture is another predisposing factor, as are contextual factors that consider mobility as constituting ‘activity space’; that is “space in which individuals normally act, including the locations of their homes, and worksites” (Arcury et al. 2005, p. 137). Additionally, transportation is another reoccurring problem among farmworkers, and is an essential *enabling* factor, as are poverty and long-term financial stability. *Need factors* are based on specific medical conditions requiring treatment and reflect chronic disease care, checkups, and acute care (Arcury et al. 2005).

Distance decay describes the effect of distance on the interactions between two locations. Distance decay is an essential aspect of spatial analysis and is inherent in various applications of gravity models (Pun-Cheng 2017). Distance decay constitutes the basis for ‘Tobler’s First Law of Geography’ and as a measurable entity has roots in the ‘social physics’ school of Stewart, Warntz, and Zipf, who together developed the foundation for studies on spatial interaction in the 1960s (Eldridge and Jones 1991). In distance decay measurement, distance becomes friction, the impedance; “if the friction of distance for any given origin varies over space, then equivalent distances in different locations result in varied effects on interaction” (Eldridge and Jones 1991, 500). Mathematically, distance decay is an inverse-square law where I is interaction, A is a constant, d is distance, and c represents the barriers to movement based on d (Nekola and White 1999, 875):

$$I = A * d^{-c}$$

In reviewing the literature on distance and the probability of healthcare utilization, several studies come to mind: the first by Fortney et al. (1999; 1995) reported that travel

distance influenced the likelihood of use of alcoholic and mental health treatment facilities. While Athas et al. (2000) and Nattinger et al. (2001) found that the usage of breast cancer treatment decreased with an increase in travel distance; finally Goodman (1994) found that when distance increased, so did the likelihood of hospital admissions for voluntary medical conditions.

2.9 Problem Statement

Despite advances in knowledge about farmworker health, identifying and describing geographic patterns of disease and health delivery services remains a challenging task. Much of the research on farmworker health focuses on clinical outcomes, community outreach, social advocacy, environmental exposures, occupational injuries, and housing, and less on chronic disease. Severe diseases like diabetes, obesity, and hypertension plague MSFWs and their families, driven primarily by social and economic disparities. There are several research gaps in the literature on the health of farmworkers that need to be investigated. First, no research previously modeled the geographic distribution of farmworker disease, specifically chronic disease (obesity, diabetes, and hypertension). Second, this dissertation employed a cluster detection method specifying local autocorrelation with the end goal of increasing geographic targeted disease surveillance. Third, this study examined the delivery and accessibility of healthcare services to “hidden” and “hard-to-reach” (Ramos 2017) farmworker populations through the lens of geographic information science.

CHAPTER III

THEORY

Introduction

Theoretical frameworks incorporating geospatial and social epidemiological perspectives are vital in examining both space, place and contextual level health determinants of farmworkers. There are two perspectives that I argue are paramount to broaden our understanding of the geography of farmworker health. The first is a geographic information sciences approach built on a foundation of medical and health geography (Phase I). The second is a social epidemiological framework incorporating the ecosocial theory of disease distribution, especially the political economy, ecology and spatiotemporal scale of farmworker health (Phase II). It is important to remember that the health of populations and individuals alike is non-static. Health is a fluid pattern of relations between place, space, and geographic contexts, each forming a dialogue enabling an explanation of the social and physical processes contributing to health.

The emergence of geographical theory was a product of the desire to systematize existing geographic knowledge and to use an established base to explore new avenues of knowledge creation (Golledge 1996). Hudson (1969) argued that theory represents an attempt to inject logic into previously noted regularities. In geographical theory, historically two paths developed, one focusing on form (spatial configuration), the other on 'process' (interrelated activities). Both deterministic and stochastic inferences are combined to develop geographic theories and models. Geographical theory has a mixture of influences in idiographic (Hartshorne 1959) (descriptive) and (Yeates 1968)

nomothetic (law-given). During the 1980s, scale became one of the pillars of social theory in geography, becoming to some geography's central contribution to the social sciences (Jones 2017).

Sayer (1992) argues that research in the social sciences is inherently theory-laden. Eyles (1985) cites facts as the end goal of observation, as theory-laden; while Kuhn (1962), contends that what we see depends on what we look at, and what our previous experiences have taught us (visual-perceptual-conceptual) (Litva and Eyles 1995). "Theory and observation inform one another. Theory thus shapes observation – the way in which data are produced – and thus the whole scientific enterprise" (Litva and Eyles 1995, 6). Theory is not, however, established and proven by observation, nor does theory alone determine what we find (Sayer 1992). Sayer continues by stating that "knowledge never develops in a vacuum but is always embedded in social practices, and we can more fully understand the former if we understand the later" (Sayer 1992, 45).

Phase I: Medical, Health Geography and Geospatial Sciences

Health and medical geography apply geospatial analytical methods to the study of health, disease, and healthcare issues (Kirby, Delmelle, and Eberth 2017). Medical geography traditionally has followed two significant trends: the study of health service delivery, and the study of disease patterns (Mayer 1982). John M. Hunter (1974, 3) describes the geography of health services as the "*sine qua non of medical geography*" and medical geography as "the application of geographical concepts and techniques to health-related problems" (Hunter 1974, p. 3), while McGlashan (1972) claims that medical geography is a tool of bio-medicine influenced by positivist philosophy. Mayer (1996) suggests that 'space' and 'place' should be intrinsic to medical geography; Kearns

and Joseph (1993) echo this sentiment and argue for a mutual synthesis of space and contextual place. Geographic information science is on the frontline of research focusing on the accessibility of healthcare services and geographically based public health risk assessments to improve population health (Cromley and McLafferty 2011). Geographic information science is concerned with space through the inclusion of diverse geospatial datasets identified through geographic coordinates, and place, by molding the interpretation of results from social, political, and historical contexts (Cromley and McLafferty 2011). Geographers have long argued that both should not be studied in unison specifically when studying the geography of health (Kearns 1993). Throughout the literature, where an individual resides is a potential disease determinant (Diez Roux 2001).

When and where to use GIS in examining spatial patterns of disease and to determine routes for improved healthcare assembly are rooted in *place* and *space* (Cromley and McLafferty 2011). For example, women living in rural areas face geographic obstacles in receiving mammographic breast screenings (Nattinger et al. 2001); along the same lines, higher rates of obesity are observed in food deserts, areas characterized by poor-food quality and a lack of fresh food options (Cummins and Macintyre 2006). Furthermore, residents living in proximity to traffic thoroughfares experience higher levels of particulate matter and fuel emissions exposure, which in turn is responsible for cardiovascular and respiratory diseases (McEntee and Ogneva-Himmelberger 2008). For example, in this study, it is hoped that by examining the role of geography in the lives of migratory and seasonal farmworkers that their long-term health outcomes will improve, and hopefully lead to the end goal of reducing broad-scale health

disparities.

In humans, the relationship between morbidity and socioeconomic position is one of the most significant findings in epidemiological research, even when accounting for differences in access to medical services and health behaviors (Kim 2015). Observed spatial variations in the incidence of disease have a long history (Durkheim 1951), as has our understanding of ‘space,’ ‘place,’ and geography; but how does ‘health’ fit into this equation? According to Cromley and McLafferty (2011, 2), health “is not the absence of disease, but a state of physical, social, and emotional well-being. Because people are affected by their environments, health has the environment of the person as its geographical context.” For geographers, ‘space’ and ‘place’ form a synergetic relationship. This connection is further described by Phillips and Verhasselt (1994, 3) as a “complex social interaction between humans and their environment, more particularly between social and economic factors, and their biological and physical environment.”

Jacques May acknowledged this relationship in the early 1940s and was instrumental in developing the concept of disease ecology, explaining the relationship between geographical-environmental factors, or ‘geogens’ (May 1950, 1958). Today, health outcomes strongly influence the complex interactions within societies, rich or poor (Cockerham 2013; Huish 2017). Despite the overwhelming evidence substantiating the relationship between health and geography, “little attention is given to the geographical connection between health to place” (Huish 2017, 1). The overwhelming amount of health research funding internationally and domestically is allocated for curative practices, vaccination routines, and public health interventions through technological development (Huish 2017).

The role of theory in medical, health geography, and geographic information sciences has long been debated for years. Bentham et al. (1991, 10) made the assertion that, “medical geography is often a lonely discipline”, one that prior to the 1980s was identified by just two distinctive streams: disease ecology and the delivery of health services, or the ‘twin streams model’ (Mayer 1982; Jones and Moon 1987; Kearns and Moon 2002). Recent trends in medical geography have intertwined the twin streams model with studies of disease diffusion, distributions, and healthcare provisions (Moon, Gould, and Jones 1998). Medical geography is described theoretically as a ‘magpie discipline,’ incorporating frameworks from multiple outlets in the social and medical sciences (Kearns and Moon 2002).

Health geography, on the contrary, has become a ‘braided river’, a topical study with an increased awareness of ‘place’, and an enhanced sensitivity to difference, and a move away from the two traditions model of medical geography to one in favor of more thematic concepts (Kearns and Moon 2002). Health geographers first recognized the social theoretic context of health and the notion of ‘landscape,’ an intersection of political-economic development as pre-cursor to healthcare (Kearns and Barnett 1997; Litva and Eyles 1995). Geographic information science “is a meta-science: it is not about the geographical world; it is information about the geographical world” (Couclelis 1999, 34). In recent decades, a theoretical turn has emerged in GIS, one that recognizes the impact between GIS and the broader society (Pickles 1999). The first engagements between GIS and social theory were discussions of the social implications of use, and the politics of knowledge (Lake 1993; Miller 1995; Pickles 1991, 1999). Scholars like Taylor (1990) and Openshaw (1991) suggest that GIS is an overarching technology that allows

the geographer to pursue his or her research questions with epistemological and methodological flexibility. Pickles (1999) further contends that the divide between GIS and social theory is a non-issue and that the real gap exists between social theory and empiricism.

Phase II: Social Epidemiology

Social epidemiology encompasses the spatial distribution of disease outcomes, risk factors, their spatial intersection, and social determinants (McDonald 2013). Social epidemiology is concerned with identifying and examining the underlying social factors that explain variations in health outcomes across groups, or the social determinants of health (Ivory 2008; Rothman and Greenland 1998). The term first appeared in an article by Alfred Yankauer in the *American Sociological Review* in 1950 entitled: “The relationship of fetal and infant mortality to residential segregation: an inquiry into social epidemiology” (Yankauer 1950). Subsequently, E. Gartly Jaco published “The Social Epidemiology of Mental Disorders; A Psychiatric Survey of Texas” (Jaco 1960). Continuing on this trend, by 1969 the first major address on social epidemiology called ‘Social epidemiology: an appraisal’ was presented by Leo G. Reeder while speaking to the *American Sociological Association* (Reeder 1972). Reeder defined social epidemiology as “the study of the role of social factors in the etiology of disease” (Reeder 1972, 97). The fields of psychosomatic, social, preventive medicine, medical sociology, and health psychology have all made significant contributions to social epidemiology (Berkman and Kawachi 2000). The seeds of social epidemiology grew within traditional epidemiological studies, starting in the 1960s and 1970s with John Cassel, Mervyn Susser, S. Leonard Syme, Saxon Graham, Lawrence Hinkle, and Leo

Reeder, who is credited for specifying distinct areas of research centered on the health impact of social conditions (Berkman and Kawachi 2000).

Leonard Syme (1965) explained that investigation of the “social etiology of disease attempted to systematically examine variations in the incidence of particular diseases among people differentially located in the social structure and attempt[ed] to explore the ways in which their position in the social structure tended to make them more vulnerable or less, to particular disease” (Syme 1965, 178). According to the general susceptibility hypothesis (Syme and Berman, 1976), societal factors influence disease by creating vulnerability or an added susceptibility to disease in general rather than to any specific disorder (Chandola, Kumari, and Marmot, 2014). The idea that socioeconomic position has a direct effect on health is not a new concept. As early as 1840, Louis Rene Villerme (1840) uncovered evidence of the association between life expectancy and occupation in Mulhouse, France from 1823 to 1834. Villerme’s work *Tableau de l’etat physique et moral des ouvriers employes dans les manufactures de coton, de laine et de sole*, was a crowning achievement in early public health research. Susser, Watson, and Hopper (1985), in writing about the classic principle of society and disease, state that “societies in part create the diseases they experience and, further, they materially shape the way in which disease are to be experienced” (1985, 17). In a 1963 article, Saxon Graham explained the social epidemiology of chronic disease, arguing that “one must understand how membership in a social group relates to behavior patterns, to exposure to vehicles for transmitting agents, to direct tissue changes, and finally to disease” (Graham 1963, 72).

What makes social epidemiology unique is “a focus on the fundamental and dynamic tension between individuals and groups (i.e., the social) and how it ultimately affects health” (Ivory 2008, 2). Social epidemiology shares linkages with contextual effects research. Contextual effects relate to the social context in which a population lives, these effects take into consideration place, area, or region, and examine the environment (physical/social) hypothesized to affect an individual's overall health, and health behaviors (Mujahid and Diez Roux 2010; Kawachi and Berkman 2003). Included in the study of contextual factors are access to health care and the geographic location and characteristics of where people seek such services (Kirby, Delmelle, and Eberth 2017). Identifying contextual-level health determinants of health in farmworker populations should help combat chronic health problems. This identification has in the past worked successfully in studies of obesity (Flegal et al. 2012; Ogden et al. 2010), type 2 diabetes (Cowie et al. 2009), and smoking (CDC 2009).

In farmworker populations, societal constraints are an ever-present reality, one that has potentially disastrous consequences on long-term health outcomes. Castaneda (2015) and Braveman (2012) describe this actuality as social determinants of health. Social determinants of health (SDOH) are measurements which illustrate the significant structural factors of inequalities in health outcomes, by defining the macro level, and upstream elements rooted in the political economy, policies, and institutions (Castaneda et al. 2015 & Braveman et al. 2012). The term SDOH broadly encompasses a variety of non-medical factors such as health-related knowledge, attitudes, beliefs, and behaviors (Braveman, Egerter, and Williams, 2010). Raphael (2009, 2) defines SDOH as “the economic and social conditions that shape the health of individuals, communities, and

jurisdictions.” Investigating the social determinants of farmworker health is crucial for developing effective intervention strategies (Ramos 2017). Farmworkers experienced health inequalities at an individual, group and spatiotemporal scale that transcends generations. Health inequalities are a geographic phenomenon referring to the differences, spatial variations, and disparities among population groups and individuals. Social context represents a broad set of SDOH that encompass access to healthcare, healthcare systems, education and labor policies, political power structures, and environmental factors related to stress, poverty, discrimination, and the adverse health effects of polluted air and water (Ozdenerol 2017; Shi et al. 2007).

The term SDOH appears to have evolved recently, as researchers have tried to quantify differing levels of exposure among groups with varying degrees of socioeconomic status (Raphael, 2009). German physician Rudolf Virchow (1821 – 1902), also known as the “Father of Modern Pathology,” believed as well that health outcomes were deeply rooted in public policy and campaigned for political intervention strategies to prevent disease (Virchow, 1848/1985). The social determinants of health attempt to explain disparities in overall population health among developed nations (Raphael 2009). Historical perspectives on SDOH are recorded as far back as the mid-1800s when political economist Fredrich Engels studied the effects of inadequate housing, diet, clothing, a lack of sanitation, and its correlation to poor health among working class peoples in England (Engels, 1845/1987). Engels remarked in 1847 that: “all conceivable evils are heaped upon the poor. They are given damp dwellings, cellar dens that are not waterproof from below or garrets that leak from above. They are supplied bad, tattered, or rotten clothing, adulterated and indigestible food. They are exposed to the most

exciting changes of mental condition, the most violent vibrations between hope and fear” (Engels, 1845/1987, 129).

Ecosocial Theory of Disease Distribution

Beginning in the mid-1990s, dynamic, multilevel, epidemiologic frameworks linking the distribution of disease to societal, biophysical, and health inequities, across generational and geographic constructs, first appeared in the epidemiologic literature (Krieger, 2001). One of these theories, the “ecosocial theory of disease distribution” first proposed in 1994 by Nancy Kreiger, sets out to answer the central question, “who and what is responsible for population patterns of health, disease and well-being, as manifested in present, past and changing social inequalities” (Krieger 2001, 694). Krieger’s “ecosocial theory of disease distribution” incorporates constructs related to the *political economy*, *political ecology*, and *spatiotemporal scale* (lifecourse epidemiology) of disease production (Krieger 2011). In the ecosocial theory of disease distribution, “the health of populations is primarily a product of ecological circumstance: a product of the interaction of human societies with the wider environment” (McMichael 2001, 16). McMichael further expands on this by stating that the ecosocial theory of disease distribution, conceptually and methodologically establishes approaches for “analyzing the complex social and environmental systems that are the context for health and disease” (McMichael 1999, 887).

Ecosocial theory hearkens back to the social analysis of health trend in the 1830s, 1840s, as well as the 1930s, and 1940s, and schools of thought from the 1960s and 1970s (Doyal 1979). Further influencing the theory are the works of Karl Marx, Louis-Rene Villerme, Rudolf Virchow, Fredrich Engels; and Social Production of Disease (SPD)

theory (Krieger 2011). Examples of the application of ecosocial theory are broad. To date, several disciplines employ ecosocial theory, including epidemiology (Yen and Syme 1999; Thacker and Buffington 2001), environmental and occupational health (Northridge et al. 2003), behavioral science and health promotion (Shi and Starfield 2001), nursing (Abrams 2004), population health (Levins 1996; Levins and Lopez 1999), and urban health and planning (Northridge et al. 2003; Northridge and Sclar 2003). Ecosocial theory assumes that the distribution of disease at multiple levels incorporates the (1) political economy, (2) ecology, and (3) spatiotemporal scale of illness or lifecourse epidemiology.

Political Economy of Farmworker Health

The political economy of health is shaped by the many economic, political, and socio-historical forces which influence the health of populations (Minkler, Wallace and McDonald 1994). Nowhere are the consequences of the political economy seen on a broad scale than among migrant workers or what Syed describes as “market migrants” (Unissa Syed 2016). Market migrants consist of minority workers, immigrants, seasonal and temporary workers (Sharma 2006). Farmworkers fill labor shortages in the United States while contributing to the global economy of remittances estimated at over \$440 billion yearly (World Bank 2011). Migrant workers are especially vulnerable to labor exploitation, work-related injuries, and chronic illnesses like cardiovascular disease (Smith, Chen, and Mustard 2009; Jeemon et al. 2009). For example, in Canada, market migrants are employed as temporary agricultural workers but are paid far less than their domestic counterparts; the results of this can adversely affect long-term health outcomes through the social determinants of health (SDOH) (Mikkonen and Raphael 2010; Unissa

Syed 2016).

With the Bracero Program came a range of interrelated health and social issues. The experience of farmworkers living with chronic disease differs significantly from the public because of their political and economic position. Similar circumstances in South Africa were observed among migrant workers and epidemic outbreaks of tuberculosis. The South African experience “must be seen as a product of a particularly pathological intersection of political, economic, and biological processes that have a much wider distribution” (Packard 1989, 46). According to sociologist Michael Burawoy, “a system of migrant labor is characterized by the institutional differentiation and physical separation of the processes of renewal and maintenance” (Burawoy 1976, 1). Burawoy additionally describes the function of migrant labor in California as the coexistence of three distinct labor systems: “First, there are migrants who circulate between Mexico and California. They constitute a system of *external* migrant labor. Second, some aliens reside in California throughout the year. They make up a system of *internal* migrant labor. Finally, there is a domestic labor force which migrates from *place to place* (nomadic) in search of employment” (Burawoy 1976, 1066).

Transnational flows of migrant labor into the U.S. are dictated by “*push*” and “*pull*” factors associated with the market (e.g., wage differentials or other, non-labor market, failures) (Acevedo-Garcia et al. 2012). In his ‘Laws of Migration,’ Ravenstein (1885) argued that migration was controlled by “push-pull” factors related to unfavorable conditions in one location and favorable conditions in another, each compelling an individual to migrate (Acevedo-Garcia 2012). For example, *push* factors could include natural disasters, widespread poverty, and political violence; common *pull* factors include

increased access to services, economic opportunity, and societal stability (Acedvedo-Garcia 2012; Ramos 2017). For migrant farmworkers, the drive to better themselves and their families compel tens of thousands to migrate each year; most are recruited from small towns with the promise of economic opportunity, only to find poor working conditions, poverty, emotional or physical violence, discrimination, and labor trafficking (Ramos 2017).

Migration for work leads to the proliferation of chronic and infectious diseases among farmworkers and exasperates symptoms, which in turn leads to generational health issues from adolescence to adulthood. The primary determinant of poor health among farmworkers is the socially and politically mediated exclusion from health services, a phenomenon intimately related to healthcare accessibility, a lack of transportation, lack of financial security, and utilization patterns shaped by geographic and policy determinants. Economic, political, and cultural constraints further influence the use of healthcare by farmworkers and contribute to the lack of health literacy and behavioral choices.

Political Ecology of Farmworker Health

Political ecology stresses “that human-environmental relations at local, regional, and global scales can be understood only by analyzing the relationships of patterns of resource use to political, economic forces (Grossman 1993, 348). Several studies have applied political ecology to the study of human-environmental interaction, disease emergence, and refugee health (Kandawire 1982; Bassett 1988; Bryant 1992; Kalipeni and Oppong 1998). However, no research has incorporated this framework in studying farmworker health. The political ecology of health framework has additionally been

applied to investigations on the health of First Nations in British Columbia (Richmond, Elliott, Matthews, and Elliott 2005), respiratory disease in Houston, Texas (Harper 2004), lead poisoning in North Carolina (Hanchette 2008), and political violence in Sri Lanka (Bohle and Funfgeld 2007). Jonathan Mayer (1996, 449) argues that political ecology is “crucial, and overwhelmingly important” in the analysis of disease, mortality, and health, and called on medical geographers to “embrace this emerging conceptual framework.” Political ecology has three central elements. However, only two will be incorporated in this dissertation, those being context and scale. Multi-scale contextual analysis share linkages to human agency and embodiment (Kalipeni and Oppong 1998; McLaren and Hawe 2005). Scales of analysis are predicated upon ‘place’ and locally specific interactions with ideational forces ranging from state policies to environmental ideologies (Atkinson 1991; Kalipeni and Oppong 1998). The phenomena in question must be analyzed from a multi-scale viewpoint emphasizing local and global space, further situated in the broader environmental, social, and economic contexts (Blaikie 1994; Bryant 1992; Kalipeni and Oppong 1998).

The interactions between society and the environment need to be put into the context of local history and ecology (Atkinson 1991). A more profound historical analysis is landmark to political ecology, and “this is important when trying to explain the underlying causes of specific phenomenon” (Kalipeni and Oppong 1998, 1639). The influences of state policy are inherently tied to the political economy, which in turn is related to the political ecology (Mayer 1996). Together, political economic and ecologic analyses are vital for studies documenting “how political and economic systems drive population profiles of disease and patterns of health inequalities (Krieger 2011 223). The

health of the farmworkers must be placed into a broader social and economic context. In different geographic locals where farmworkers live and work, the political and economic environment work in unison to influence migration patterns, healthcare utilization, and the geospatial distribution of disease.

The Spatiotemporal Scale of Health

Spatiotemporal scale and ecosocial theory describe time-scales and the persistence of disease across generations, causal pathways, and lifecourse epidemiology (Krieger 2005). For example, if discrimination and poverty were to be eliminated in farmworker communities overnight, the embodied long-term outcomes would persist long into the future, possibly for generations; this is true with chronic conditions like diabetes, cardiovascular disease, and some forms of cancers which have strong genetic linkages that transcend spatiotemporal scales (Krieger 2005). In lifecourse epidemiology, linkages to adult health and disease risk are attributed to physical and social exposures during gestation, childhood, adolescence, during adulthood and across generations (Kuh and Ben-Shlomo 2004).

Exasperating this generational trend of chronic disease are the barriers to healthcare experienced by farmworkers and their families: all are interrelated to the political economy and ecology of health, thus highlighting the enduring power of social determinants in multi-generational health outcomes. Spanning multiple levels and spatiotemporal scales, the following are examples of different health inequalities delineated by ecosocial theory: economic and social deprivation, discrimination, and inadequate access healthcare (Krieger 1999; Krieger 2006; Krieger 2008). The political economy and ecology of disease distribution operate throughout an individual's

lifecourse to influence health through multiple stages of development. Moreover, this is particularly true for children of low socioeconomic status (SES).

An increasing amount of evidence points to correlations between SES during childhood and adult health; the idea is not new, having emerged during the first half of the 20th century (Poulton et al. 2012; Acedvado-Garcia et al. 2012), and following the Second World War, when the childhood origins of adult-onset bronchitis and cancers were widely discussed and investigated (Reid 1969; Trichopoulos 1990). A classic example of lifecourse studies in health came from investigations on human development and mental health following the Dutch Famine (“Hunger Winter”) of 1944 – 1945 (Stein, Susser, Saenger, & Marolla 1975). The rationale behind lifecourse epidemiology is articulated in the work of Jerry Morris (1975) in his classic *Uses of Epidemiology*; Stein et al. (1975) and ‘The Dutch Famine of 1944 – 1945’; and Mervyn Susser’s 1962 book “Sociology in Medicine” (Susser and Watson 1962).

Stein and her colleagues wrote that “the constitution of each cohort at conception follows from the pattern of fertility at the time and interacts with the succeeding pattern of prenatal and postnatal experience. The surviving adult population carries the imprint of these favorable and unfavorable experiences during development; morbidity has marked them, and mortality has thinned their ranks, in a way specific to each cohort” (Ben-Shlomo and Kuh 2002, 290). The ideas of spatiotemporal scale and lifecourse epidemiology have been embraced in topical areas ranging from cardiovascular disease, cancer, mental health, aging, obesity, smoking, demography and sociology (Berenson et al. 1980; Lauer, Lee, & Clarke 1975; Ben-Shlomo, Mishra, and Kuh, 2014; Giele & Elder 1998).

CHAPTER IV

DATA AND METHODS

4.1 Research Sponsor and Study Areas

Through direct consultation with the National Center for Farmworker Health (NCFH), three locations were identified as high-priority for this research. The National Center for Farmworker Health (NCFH), established in 1975, is a private, not-for-profit corporation located in Buda, Texas. The NCFH has a long history of improving the health status of farmworkers and their families by supplying information services, training, and technical assistance. Additionally, the NCFH provides a variety of products and services to health centers, universities, organizations, and researchers involved in farmworker health initiatives. The study areas include portions of Western Michigan, Northern Indiana, Southern California, and Northeastern Colorado; these states have well-developed and advanced agricultural sectors. The use of migratory and seasonal farmworkers in these states has a long history, dating back to the mid-to-late 19th century.

Colorado

The first significant wave of Hispanic immigration to Colorado (Figure 4) started in the late-1920s. From 1880 to 1920, those migrating to Colorado were enticed by increased demand for labor due to rapid industrialization in the United States, and by the failed economic policies of Mexican President Porfirio Diaz (Chase 2011; Hoffman 1974). In Northeastern Colorado, the production of sugar beets became a significant pull factor for migrants (Chase 2011). The migration and settlement patterns of farmworkers today are strongly influenced by the Great Western Sugar Company, which recruited and

settled large numbers of migrants in Fort Collins and Greeley, CO. By 1909, large populations of German-Russian immigrants worked the sugar beet fields, but by 1927 a demographic shift had commenced, led by increasingly large numbers of families of Mexican and Mexican-American heritage (Chase 2011). Colorado farmworkers have and still harvest a variety of labor-intensive products, including apples, peaches, cherries, onions, melons, potatoes, spinach, lettuce, carrots, tomatoes, broccoli, and squash. It is estimated that 21,000 migrant and 29,000 seasonal farmworkers work in Colorado; 97% of these workers identified as Hispanic, 2% as Native American, and 1% as White (NCFH, 2003).

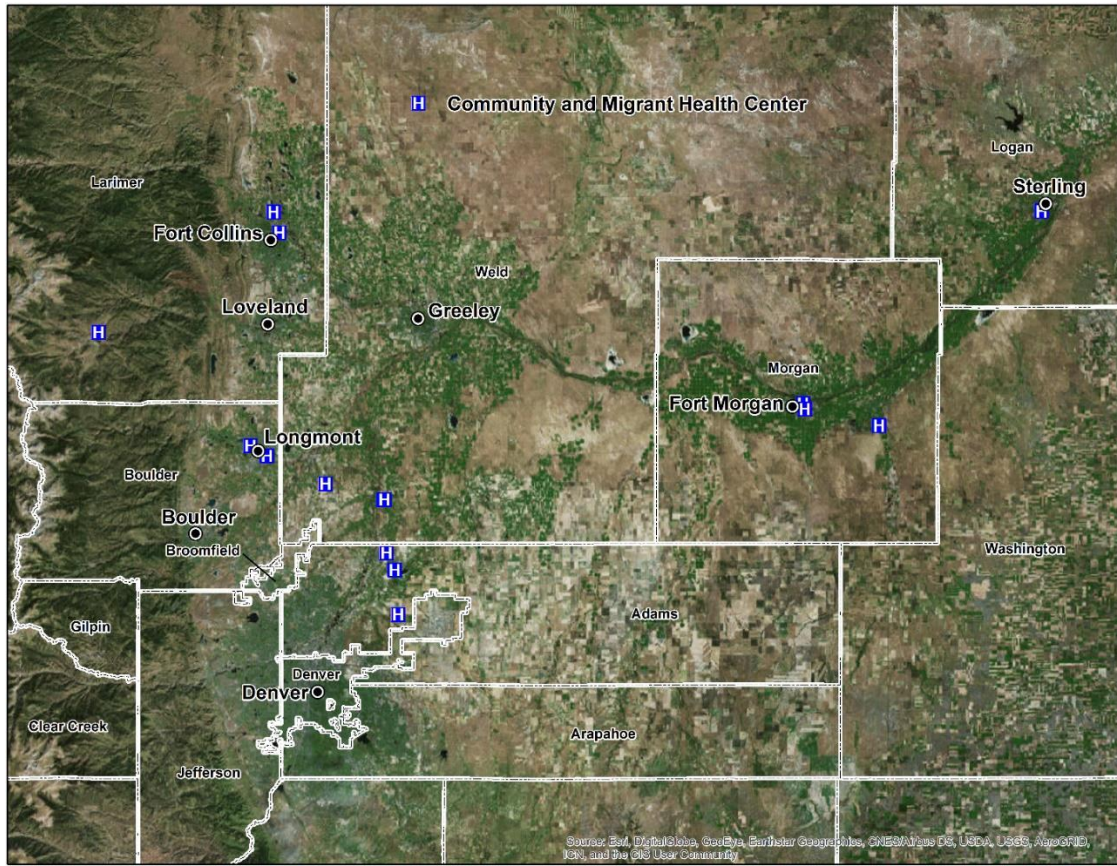


Figure 4. Northeastern Colorado

Michigan

Farmers in Michigan began recruiting farmworkers before 1900 in response to an expansion in fruit, vegetable, and sugar beet production (Rochin, Santiago, & Dickey 1989). In the 1930s, farmworkers in Western Michigan were widely employed to harvest ‘stretch crops’ like strawberries, cherries, apples, and peaches. Labor recruiters from Berrien County, Michigan would travel as far south as Arkansas and South Texas to recruit seasonal farmworkers (Rochin, Santiago, & Dickey 1989). Workers from Arkansas were predominately white and black, while workers from Texas were almost exclusively of Mexican descent, otherwise known as Tejanos (Valdes 1990; Rochin,

Santiago, & Dickey 1989). Following World War II, the 1940s and 1950s witnessed an increased demand for wide-scale corporate canneries, e.g., Green Giant, Libby's, Campbell Soup, Del Monte, Heinz, and Stokely Food (Rochin, Santiago, & Dickey 1989). These organizations spearheaded the rise in demand for farm laborers in the Midwest and portions of Southwest Michigan. Employment of farmworkers in Michigan peaked in 1964 (last year of the Bracero Program) when an estimated 80,000 migrant workers arrived (Michigan Department of Agriculture 1988). Today, Michigan is home to the seventh largest farmworker population in the U.S. and leads the nation in the production of eighteen agriculture commodities. The agricultural industry ranks second to the automotive industry in the state with an estimated \$91 billion in total economic output (NCFH 2017) (Figure 5).

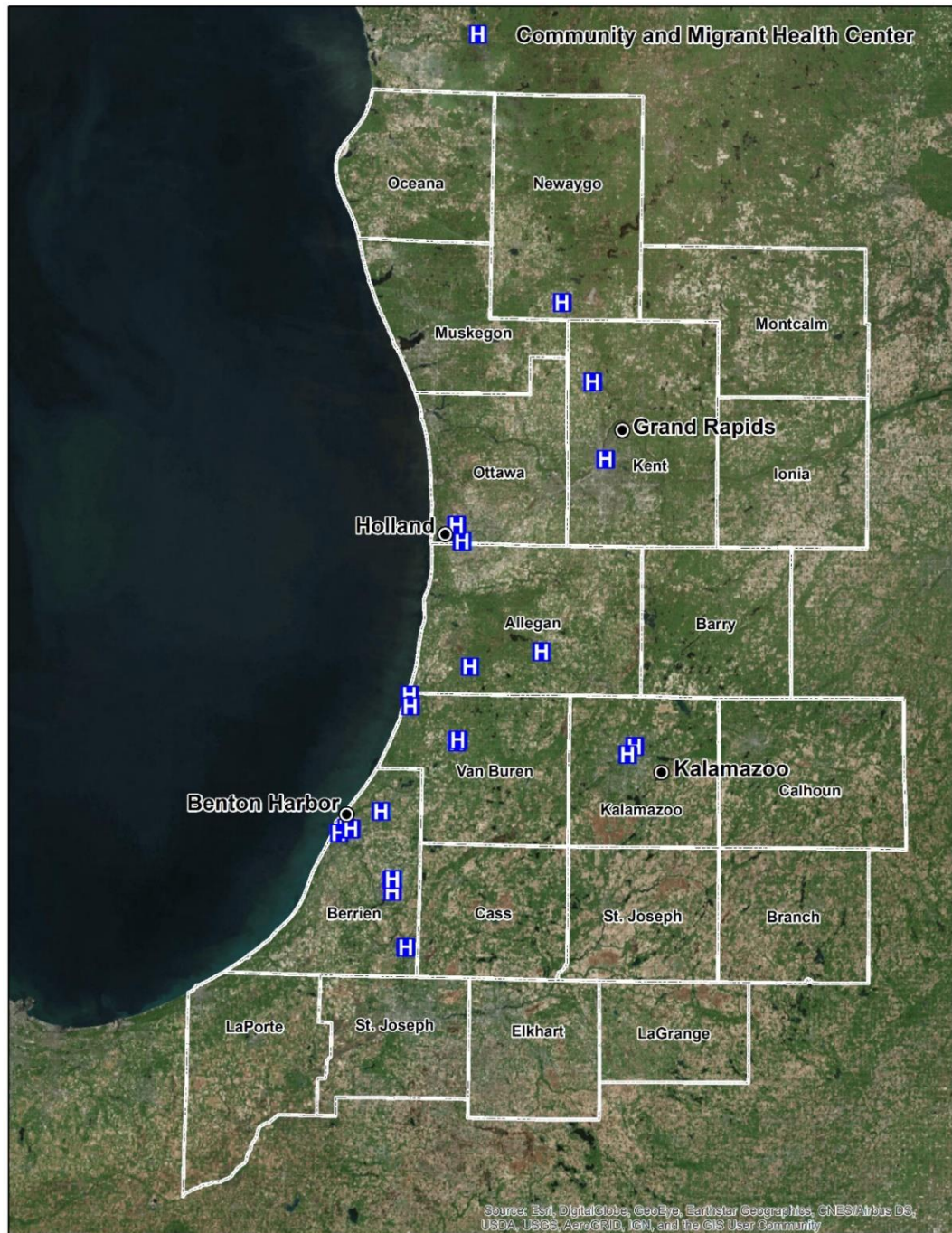


Figure 5. Western Michigan

California

The more than 800,000 farmworkers of California (Figure 6), or one-third of the nation's agricultural force, play a prominent role in powering a statewide agriculture industry that generates \$100 billion in economic activity (California Department of Food and Agriculture 2015). The California economy is massive, with an estimated gross domestic product (GDP) of \$2.623 trillion. If considered separate from the United States, California would rank as the sixth largest economy in the world (The World Bank 2016). Despite the opulence and wealth of California, farmworkers, their families, and their health needs are often ignored. The history of farmworkers in California is complicated and dates to the middle 19th century when the pattern of widespread industrial agriculture began to take shape. Several events have shaped the story of farmworkers in California, starting with the labor organization and reform efforts, the New Deal, the 1933 Cotton Strike, and the formation of the United Farm Workers of America (UFW) in 1962 (Cletus & Daniel 1981).

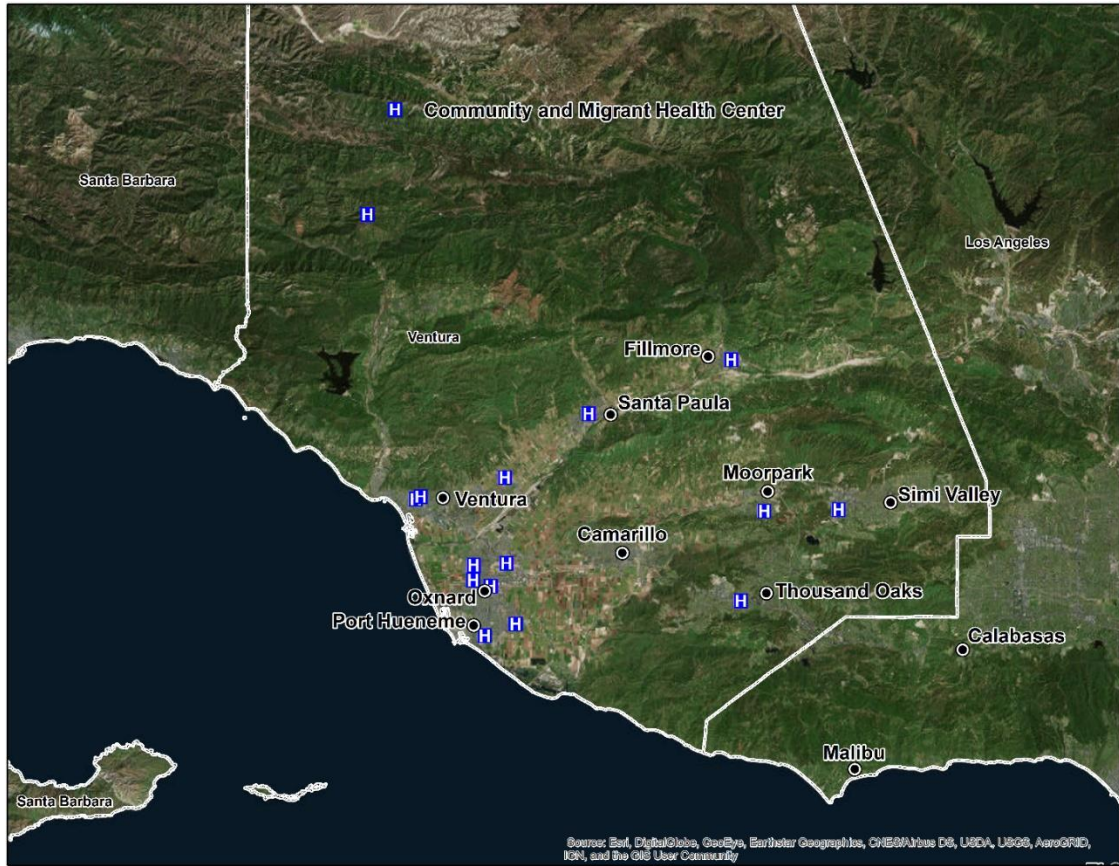


Figure 6. Southern California

4.2 Research Design

The structure of my mixed-method approach follows a sequential explanatory strategy (Figure 7), which is popular for researchers with strong quantitative leanings (Creswell 2013), and is divided into two distinct phases: a) quantitative data collection and analysis (phase I); b) qualitative analysis and mixing phase (phase II), in which both stages are interconnected (Figure 7) (Creswell et al. 2003). The characteristics of the sequential explanatory strategy are cited in health, social, and behavioral science literature (Kinnick and Kemper, 1988; Ceci, 1991; Klassen and Burnaby, 1993; Janz et al. 1996). When used in combination, quantitative and qualitative methods can

complement each other for a complete analysis (Green, Caracelli, and Graham 1989).

The rationale for this approach is that the quantitative results will provide a general view of the research problem, i.e., the geographic distribution of chronic disease and modeling healthcare accessibility; while the qualitative data analysis will explain and further refine the quantitative results in more depth. In mixed methods approaches, researchers build knowledge on pragmatic grounds (Creswell 2003), by choosing variables which are the most appropriate for finding the answers to their research questions (Tashakkori and Teddlie 1998). Creswell et al. (2011, p. 6) and Johnson, Onwuegbuzie, & Turner (2007) define mixed methods research as a methodology:

- Focusing on research questions that call for real-life contextual understandings, multi-level perspectives, and cultural influences;
- Employing rigorous quantitative analysis assessing the magnitude and frequency of constructs and stringent qualitative research exploring the meaning and understanding of constructs;
- Utilizing multiple methods (e.g., intervention trials and in-depth interviews);
- Intentionally integrating or combining these methods to draw on the strengths of each and framing the investigation within philosophical and theoretical positions.

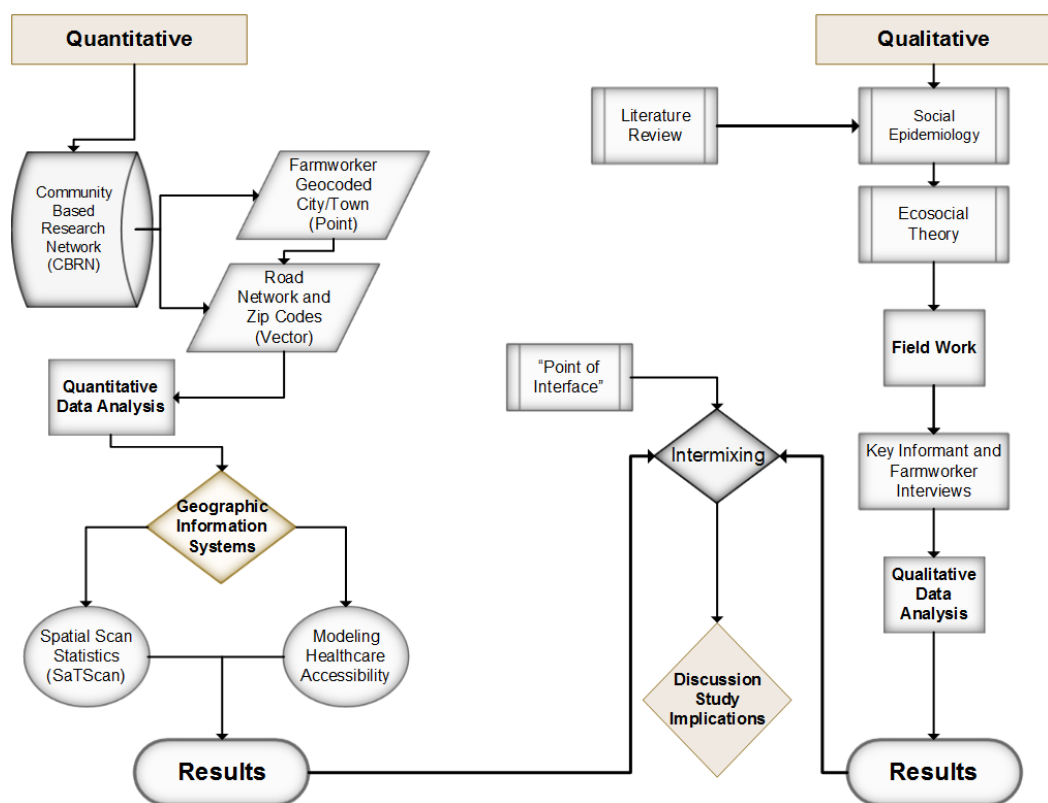


Figure 7. Overview of the Methods (Sequential Explanatory Strategy)

The question of why one would combine qualitative and qualitative methods has a history dating back to the late-1950s with the work of Webb and Campbell and their multitrait-multimethod matrix and unobtrusive measures (Webb & Campbell 1966; Campbell and Fiske 1959). Campbell's work emphasized the convergence and confirmation of results across different methods to come to the same conclusions; this would demonstrate that the results are not merely due to artifact or invalidity (Morgan 1998). Two primary explanations for why it is challenging to combine methods are technical difficulties and conflicts between paradigms. Several scholars describe these difficulties as evolving on the very assumptions of what constitutes epistemology (Creswell 1994; Guba and Lincoln 1994; Smith and Heshusius 1986).

4.3 Phase I: Quantitative Data

In total, 39,135 farmworkers are included in this study. The locations represented the city or town of origin recorded when patients visited participating health centers in Colorado, Michigan, and California. Patient encounter data were collected at three community and migrant health centers (C/MHCs) using an Electronic Health Record (HER) system, defined by HIPPA as a Limited Data Set (LDS) to protect patient confidentiality. The Limited Data Set (45 CFR 164. 514 e) protects health information and excludes direct identifiers of the individual or relatives, employers, or household members of the individual (U.S. Department of Health and Human Services, 2016). Patient encounter data at C/MHCs represent chronic diseases: diabetes mellitus, obesity, essential hypertension (EH); and health risk factors: anxiety, stress, depression, and tobacco use.

Patient encounters for the selected conditions totaled 16,236 (Colorado, n = 6,255; Michigan, n = 3,463, California, n = 6,518); patient encounter and geospatial identifiers were obtained from the Community Based Research Network (CBRN), National Center for Farmworker Health (NCFH), and the Integrated Care Collaboration (ICC). The CBRN consists of three academic institutions (University of Texas - Austin, Texas A&M University, and the Battelle Memorial Institute), two community research partners (National Center for Farmworker Health and Salud Family Health Centers, Ft. Lupton, CO), and a steering committee consisting of one representative from each partner (Cooper et al. 2014). An overview of the data structure and pertinent key patient identifiers are presented in Figure 8.

With support from each committee member, the NCFH identified three C/MHC's in Colorado (Salud Family Health Center - Ft. Lupton), Michigan (Intercare Community Health Network - Bangor), and California (Clinicas del Camino Real - Oxnard), to be included in the CBRN. Facilities were selected based on their willingness to share patient medical records and personal identifiers. Centex Support Systems Services (Centex), a health information Exchange (HIE), established protocols for collecting and securing patient records at each C/MHC (Cooper et al. 2014). Chronic diseases and their modifiable and non-modifiable risk factors diagnostic codes were extracted with guidance from the International Statistical Classification of Diseases and Related Health Problems.

Patient encounters were matched from patient ID numbers (enc_patient_id) through a series of joins and relates in ArcGIS 10.5.2 (Environmental Systems Research Institute; Redlands, California). Farmworker patient encounters were then joined to regional Zip Code Tabulation Area (ZCTAs) polygons based on their relative geographic relationship using the spatial join tool (Analysis toolset) (Environmental Systems Research Institute; Redlands, California). Zip Code Tabulation Areas (ZCTAs) are generalized representations based on the United States Postal Service (USPS) service areas (United States Census Bureau, <https://www.census.gov/geo/reference/zctas.html>, last accessed: May 10, 2017).

According to Health Level Seven International (www.hl7.org/fhir/encounter-definitions.html) and is defined as “an interaction between a patient and healthcare provider(s) for the purpose of providing healthcare services(s) or assessing the health status of a patient.” Spatial data are defined as “any data set where one (or more) of the

characteristics associated with each object or case is a location” (Read et al. 2013, 37). Farmworker city/town/state/zip code information were georeferenced with Geocodio (<https://geocod.io/>). Finally, the demographic information for seasonal and migratory patient encounters were analyzed with IBM SPSS software (Statistical Package for the Social Sciences) (IBM Corporation) (v. 25.0) (<https://www.ibm.com/products/spss-statistics>) based on individual, marital status, city and county of origin, state, language, zip code, ethnicity, and the C/MHC where they received treatment.

Figure 8. Data structure and key identifiers

enc_patient_id	C/MHC	Date	Marital Status	City	County
abddbfcfe6c884df	Fort Morgan Salud Med	1/20/2015	Married	Fort Morgan	Morgan
ac06b3a7ad5cf88	Commerce City Salud M	8/4/2014	Married	Commerce City	Adams
ac06b3a7ad5cf88	Commerce City Salud M	9/2/2014	Married	Commerce City	Adams
ac06b3a7ad5cf88	Commerce City Salud M	7/24/2014	Married	Commerce City	Adams
ae68ceaf7b0dc67	Fort Lupton Salud Med	5/6/2013	Married	Brighton	Adams

State	Language	Ethnicity	Age	Sex	X	Y
CO	Spanish	Hispanic or Latino	69	M	40.262591	-103.847648
CO	Other	Hispanic or Latino	50	M	39.869835	-104.771527
CO	Other	Hispanic or Latino	50	M	39.869835	-104.771527
CO	Other	Hispanic or Latino	50	M	39.869835	-104.771527
CO	Spanish	Hispanic or Latino	65	F	39.942984	-104.786597

Table 3. Chronic disease patient encounters – Colorado

Chronic Disease	Patient Encounters
Seasonal Diabetes	2,083
Seasonal Hypertension	520
Seasonal Obesity	483
Migratory Diabetes	1,431
Migratory Hypertension	339
Migratory Obesity	282

Table 4. Risk factor patient encounters – Colorado

Chronic Disease Risk Factors	Patient Encounters
Seasonal Anxiety	38
Seasonal Depression	276
Seasonal Stress	5
Seasonal Tobacco Use	356
Migratory Anxiety	30
Migratory Depression	190
Migratory Stress	5
Migratory Tobacco Use	217

Table 5. Chronic disease patient encounters – Michigan

Chronic Disease	Patient Encounters
Seasonal Diabetes	962
Seasonal Hypertension	507
Seasonal Obesity	206
Migratory Diabetes	747
Migratory Hypertension	351
Migratory Obesity	146

Table 6. Risk factor patient encounters – Michigan

Chronic Disease Risk Factors	Patient Encounters
Seasonal Anxiety	143
Seasonal Depression	87
Seasonal Stress	34

Seasonal Tobacco Use	74
Migratory Anxiety	96
Migratory Depression	66
Migratory Stress	10
Migratory Tobacco Use	34

Table 7. Chronic disease patient encounters – California

Chronic Disease	Patient Encounters
Seasonal Diabetes	2,351
Seasonal Hypertension	701
Seasonal Obesity	287
Migratory Diabetes	1,642
Migratory Hypertension	514
Migratory Obesity	190

Table 8. Risk factor patient encounters – California

Chronic Disease Risk Factors	Patient Encounters
Seasonal Anxiety	138
Seasonal Depression	273
Seasonal Stress	14
Seasonal Tobacco Use	86
Migratory Anxiety	91
Migratory Depression	157
Migratory Stress	3
Migratory Tobacco Use	71

4.3.1 Spatial Scan Statistics

The spatial scan statistic detects the presence of clusters in a point distribution. For cluster detection of a point process on an interval $[a, b]$, a window $[t, t + w]$ of fixed size $w < b - a$ is moved along the interval (Kulldorff 1997). SaTScan (v9.6) is a stand-alone software that incorporates spatial scan statistics to analyze the presence of spatial, temporal, and spatiotemporal cluster events (Kulldorff M. and Information Management Services, Inc., 2016) (Kulldorff and Nagarwalla, 1995). Depending on the type of data being analyzed, SaTScan can integrate eight different probability models. The spatial scan statistic detects clusters by scanning an isotropic circular window across a study area, while simultaneously documenting the number of observed versus expected disease cases inside of each group (Kulldorff 1997; Kulldorff et al. 1998; Kulldorff and Nagarwalla 1995). Spatial scan statistics is an example of a local indicator of spatial association (LISA), a focused-cluster detection method, one that specifies clusters within the study area and then detects patterns that deviate from neighboring features (local outliers), while testing for spatial heterogeneity (Jackson et al. 2009).

Spatial and spatiotemporal scan statistics play an essential role in public health surveillance (Han et al. 2016). Temporal, spatial, and space-time scan statistics are popular in a variety of interdisciplinary fields ranging from infectious diseases (Chaput, Meek and Heimer 2002; Wylie, Cabral and Jolly 2005), vector-borne diseases (Sugumaran et al. 2009), cancer epidemiology (Hjalmars, Kulldorff and Nargarwalla 1996; Thomas and Calin 2003), parasitology (Odoi et al. 2004; Reperant and Deplazes 2005), veterinary medicine (Heres, Brus and Hagenaars, 2008), history (Wang, Hartmann, Luo and Huang 2006), and astronomy (Bidin et al. 2010). More specifically

the technique is applied to studies on diabetes (Green et al. 2003), Creutzfeldt-Jakob disease (Cousens et al. 2001), granulocytic ehrlichiosis (Chaput, Meek, and Heimer 2002), sclerosis (Sabel et al. 2003), and breast cancer digital mammography data (Priebe, Olson and Healy 1997; Naiman and Priebe 2001). Currently, SaTScan represents the most robust and developed local autocorrelation method published in epidemiology journals (Auchincloss et al. 2012). SaTScan has yet to be applied to identify chronic disease and risk factor clusters and in migratory and seasonal farmworker populations.

The conceptualization of scan statistics appeared under Joseph I. Naus in 1963 while he completed his Ph.D. in statistics at Harvard University (Wallenstein 2009). His dissertation, titled “Clustering of Random Points in the Line and Plane,” and his 1965 paper entitled “Clustering of Random Points in Two Dimensions” are described as the beginning of the legacy that Naus built as the “Father of the Scan Statistic” (Wallenstein 2009, 1 - 2). In 1995, Martin Kulldorff and Neville Nagarwalla added time and a variable size scanning window as the third dimension of the scan statistic (Kulldorff and Nagarwalla, 1995). Kulldorff expanded on the method two-years later in his signature publication “A Spatial Scan Statistic,” published in 1997 (Kulldorff, 1997). Initially, Naus developed scan statistics with an overall notion of restrictions placed on the size of the scanning window; this, however, has been modified considerably, by Loader (1991), who implemented a relaxed constraint, and by Turnbull et al. (1990) with the fixed population size circular scan statistic.

Variable size cluster windows are needed when prior knowledge of the size of the study area is not known. Malleable cluster sizes allow for an arbitrary “but known intensity that governs the distribution of the points under the null hypothesis” (Kulldorff

1997, 1482). Spatial scan statistic can detect the location of clusters (i.e., deterministic), and find the location of clusters on the map when the null hypothesis is rejected (i.e., inferential). Kulldorff's scan statistics extended on Openshaw's GAM by overcoming limitations of multi-testing. Kulldorff (1997, 1487) describes this theorem as holding true for both the Poisson and Bernoulli models as: let $x = \{x_{i,i=1,...,n_G}\}$ denote the set of coordinates of the n_G points in a data set where Z is the most likely cluster, and let $x = \{x_{i,i=1,...,n_G}\}$ be an alternative configuration with the same number of points. Local indicators of spatial association test for clusters at a finer scale compared to their counterpart the global statistic, which operates at a regional scale. "Rather than being a single statistic, the spatial scan statistics is an umbrella term for a collection of related statistics, all sharing a common purpose and a similar method of application" (Read et al. 2011, 3300). Kulldorff's spatial scan statistic is one of the most popular methods for cluster detection (Jung and Park, 2014). The primary features of Kulldorff's spatial scan statistic are as follows:

- The spatial scan statistic adjusts for heterogeneity in the spatial distribution of the underlying risk population and does not rely on pre-defined processing extents, thus bypassing the modifiable aerial unit problem (MAUP) (King and Essick, 2013). Ameliorates issues with pre-selection bias by searching for clusters without specifying their size and location (Kulldorff, 1997).
- The Kulldorff likelihood ratio-based test statistic accounts for multiple instances of testing while still delivering a single p-value when testing the null hypothesis (Kulldorff, 1997). If the null hypothesis is rejected the exact location of the cluster can be specified (Detection and Inference) (Kulldorff, 1997).

- SaTScan employs a Monte Carlo (MC) hypothesis simulation approach to determine cluster statistical significance. The Monte Carlo algorithm is a randomization algorithm, one that is repeatedly run with independent random choices each time. The benefits of randomized algorithms are related to their simplicity and efficiency (Motwani and Raghaven, 2010). Motwani and Raghaven (2010, 22) define the Monte Carlo algorithm as “a randomized algorithm that may produce incorrect results, but with bounded error probability” (p-value: $0.0001 = 1/1,000$). MC hypothesis testing is useful for determining p-values when the null distribution for the spatial test statistic is not known (Jung and Park, 2014). “Monte Carlo simulation offers an alternative to analytical mathematics for understanding a statistic’s sampling distribution and evaluating its behavior in random samples” (Mooney, 1997, 2). MC hypothesis testing was first proposed by Meyer Dwass in his 1957 article “Modified Randomization Tests for Nonparametric Hypotheses” (Dwass, 1957) and first used in scan statistics by Turnbull et al. (1990).

4.3.2 Implementing Spatial Scan Statistic

SaTScan determines if a phenomenon of interest is distributed randomly or if these discrete entities are clustered. I selected the retrospective Poisson and Space-Time Permutation (STPM) models for Phase I. The purely spatial, discrete, retrospective Poisson model in this study reflects the farmworker background or risk population within each enumeration unit, while the discrete STPM was utilized for the space-time analysis of chronic disease risk factors. The outputs of the STPM were analyzed to chart the temporal variations in patient encounters at health centers in Colorado, Michigan, and

California. Spatial scan statistics employs a likelihood-based approach to identify potential clusters while evaluating their statistical significance and adjusting for multiple testing.

Multiple testing is inherent when identifying many possible cluster sizes and locations (Han et al. 2016). The logarithm of the likelihood ratio (LRR) and the relative risk (RR) are the primary measures generated by SaTScan to quantify disease burden for the most likely cluster, and the subsequently identified secondary clusters, statistical significance is determined at a ninety-five percent confidence interval (95%) (Frumkin and Kantrowitz, 1987; Kulldorff, 1997). The scan statistic S is the maximum likelihood ratio over all possible clusters Z ,

$$S = \frac{\max_Z \{L(Z)\}}{L_0} = \max_Z \left\{ \frac{L(Z)}{L_0} \right\},$$

“where $L(Z)$ is the maximum likelihood for circle Z , expressing how likely the observed data are given a differential rate of events within and outside the zone, and where L_0 is the likelihood function under the null hypothesis” (Kulldorff 2001, 64). When the likelihood function is maximized across all locations and window sizes, the cluster with the highest LLR constitutes the most likely cluster (Kulldorff, 2015). High p-values infer a high degree of probability in that the identified pattern is random in distribution. While low p-values (randomness) represent a higher likelihood (probability) of a real cluster phenomenon (Utah Department of Health, 2013; Dietz et al. 2011; Hsu et al. 2004; Wagner et al. 2013; Wheeler, 2007).

In generating predictions of anomalies, SaTScan does not purely identify clusters based on data variability, but instead, pinpoints clusters based on the spatiotemporal

attributes. Spatial scan statistics is a local indicator of spatial association (LISA). Local indicators detect clusters by calculating the association of values locally and in adjacent areas (Exeter 2017). Local indicators must satisfy the following two requirements (Anselin 1995, p 94): the LISA for each observation indicates the extent of significant spatial clustering of similar values around that observation; the sum of LISA's for all observations is proportional to a global indicator of spatial association. LISA is expressed for a variable y_i , observed at location i , as a statistic L_i , such that:

$$L_i = f(y_i, y_{ji}),$$

“where f is a function (possibly including additional parameters), and the y_{ji} are the values observed in the neighborhood J_i of i ” (Anselin 1995, 95). The similarities between LISA and global indicators (G_i/G_i^*) are related to the tests for cluster significance. LISA can be used to test the null hypothesis of no spatial association (Anselin 1995).

The Poisson model is acknowledged for its strong performance when applied to a broad range of disease types and spatiotemporal scales (Cromley and McLafferty, 2012; Neill, 2009). An analysis that is retrospective in nature uses historical data to detect the presence of areas with high disease occurrence. In the Poisson model, point locations generated by an inhomogeneous process assumes that the farmworker population in each zip code is Poisson distributed. The total population count and the total count of confirmed encounters are employed for analysis; under the null hypothesis, the expected number of cases is equal to the underlying population size (Kulldorff, 2006).

Geographers and epidemiologists are interested in the spatial distribution and clustering of disease. To compensate for the unpredictability and unevenness of the population as a whole data employing the scan statistic method must be aggregated into enumeration

units (e.g., zip codes) at the feature centroid and specified through geographic coordinates (Kulldorff 1997). The Poisson model is structured as follows: let $\mu(Z)$ be the expected number of cases under the null hypothesis, while $\mu(A) = N$ for A , be the total study area. It can be shown that,

$$\frac{L(Z)}{L_0} = \left(\frac{n_Z}{\mu(Z)} \right) n_Z \left(\frac{N-n_Z}{N-\mu(Z)} \right) N - n_Z$$

“if $n_Z > \mu(Z)$, and one otherwise” (Lawson et al. 1999, 147). Clusters are identified if “the observed number of cases exceeds the expected number.” The likelihood function in the Poisson model and the STPM under the null hypothesis is equivalent to (Warden 2008, 25):

$$\left(\frac{c}{E[c]} \right) c \left(\frac{C-c}{C-E[c]} \right) C - c I ()$$

“ C is the total number of cases, c equals the total observed cases within the scanning window, $E[c]$ equals the expected number of cases under the null hypothesis, and $I()$ is identified as the indicator function equal to 1 if $c > E[c]$ or 0” (Kulldorff 1997). The Poisson model parameters are in Table 3.

The detection of clusters in both models will be implemented with varying maximum spatial window sizes (MSWS) ranging from 10% - 50%. Cluster performance will be evaluated based on their ranked cumulative relative risk (RR) and log-likelihood ratio (LLR) values. This choice is motivated by the desire to study the differing geospatial characteristics of disease risk between migratory and seasonal farmworkers and cluster sensitivity. The most likely cluster and the subsequent secondary clusters will be ordered according to their LLR test statistic. The p-values for secondary clusters should be interpreted regarding the ability of the secondary cluster to reject the null

hypothesis on its strength (Kulldorff, 2015). The geographic distribution and statistical significance of clusters were investigated with 9999 MC permutations (standard inference) of the data set under the null hypothesis. Replications at a minimum must be greater or equivalent to 999 to ensure maximum statistical power, replications of 9999 are recommended for small to medium size datasets (Kulldorff, 2015).

Table 9. Discrete Poisson method parameters

Maximum Spatial Window Sizes (MSWS):	10% - 50% of the farmworker at-risk population
Time Period:	2011 - 2015
Study Area:	California, Colorado, Michigan
Type of Analysis:	Retrospective Analysis (Scan for high rates)
Inference:	Standard Monte Carlo (9999 replications) & Gumbel Approximations
Cluster Performance:	Highest relative-risk ratio (RR) and log-likelihood ratio (LLR).

The retrospective Space-Time Permutation Model (STPM) uses thousands of overlapping cylinders to identify possible cluster anomalies (Kulldorff et al. 2005). The Space-Time Permutation Model is an essential technique for disease outbreak detection surveillance systems (Costa, Kulldorff and Assuncao 2007). Research incorporating the space-time scan statistic is broad and ranges from studies on the temporal peaks in *Myotis lucifugus* (Little brown bat) activity (Adams and Fenton 2017), the epidemiology of infectious Bronchitis in California (Aleuy, Pitesky and Gallardo 2018), and the geographic distribution of West Nile virus (WNV) in Ontario (Thomas et al. 2017).

The STPM features a probability model that accounts for the absence of an at-risk population. Multiple testing is adjusted by creating random permutations of the spatial and temporal attributes of each case location (Kulldorff et al. 2005). In the context of this study, the STPM will be used to find spatiotemporal patterns for the identified risk factors listed in the data section (anxiety, stress, BMI, nutritional deficiencies, depression, high cholesterol, and tobacco use). The most likely cluster in each study area for both the simulated data and the raw data is calculated. Clusters in the study area are identified if, during a specific period, that area has a more sizeable proportion of cases in that period compared to the remaining portions of the study area (Kulldorff 2005). The STPM parameters can be found in more detail below (Table 10).

Table 10. Space-Time Permutation Method parameters

Maximum Spatial Window Sizes (MSWS):	10% - 50% (Spatial window shape: circular)
Time Period:	2011 - 2015
Study Area:	California, Colorado, Michigan
Type of Analysis:	Retrospective Analysis (Scan for high rates)
Inference:	Standard Monte Carlo (9999 replications) & Gumbel Approximations
Cluster Performance:	Highest relative-risk ratio (RR) and Test Statistic (TS).
Time Aggregation:	Month

Cluster p-values for the Poisson and STPM were calculated by variations in total permutations of the MC randomization through a direct comparison of the real datasets maximum likelihood and the maximum likelihood of the random data sets (Jin et al.

2008). I further evaluated cluster statistical significance for both models through the implementation of *Gumbel* p-value approximation's, an option in the SaTScan model parameters that generate a higher degree of statistical accuracy. With the default of 999 random MC replicates, the lowest attainable p-value under the null hypothesis would equal $1/(999+1) = 0.001$; however, with the use of the *Gumbel* approximation, there exists no lower limit on reported cluster p-values (Kulldorff, 2015). *Gumbel* approximations, which are a specialized form of the extreme value distribution, work well with the purely spatial scan statistic and the discrete Poisson model while reporting p-values with a high degree of precision (Abrams, Kleinman and Kulldorff, 2010). The *Gumbel* p-value approximation distribution is as follows:

$$FG(x) = \exp \left\{ - \exp \left(- \frac{x - \mu}{\sigma} \right) \right\}$$

“where μ is the location parameter and σ the scale parameter. The *Gumbel*-based *p*-value is defined as $p_G = 1 - FG(\lambda)$ and calculated with the parameters estimated by using the test statistic values from the Monte Carlo samples generated under the null hypothesis” (Jung and Park, 2014, 506).

4.3.3 Spatial Scan Statistics Limitations

SaTScan has two primary limitations: (1) SaTScan lacks cartographic support to understand the cluster events in a geographic context; and, (2) the results are sensitive to the chosen model parameters (Chen et al. 2008). Because SaTScan does not provide a visual interface to explore cluster events, a geographic information system is needed to perform any pre-processing analysis (Chen et al. 2008). Furthermore, in recently published research, SaTScan clusters and aggregate data often need to be displayed on separate maps, making interpretation difficult (Fukuda et al. 2005; Hsu, Jacobson, and

Mas 2004; Jemel et al. 2002). It is difficult to determine the optimal software parameters, an issue that is a reoccurring topic of discussion (Fukuda et al. 2005; Hsu, Jacobson, and Mas 2004; Jemel et al. 2002; Boscoe et al. 2003; Waller and Gotway 2004). Model parameters in SaTScan need to be selected carefully and should not be done arbitrarily, as larger cluster sizes (heterogeneous) have the potential of hiding smaller (core) focalized cluster events (Jin et al. 2008).

Han et al. (2016) reiterated this point by stating that setting the MSWS at the default of 50% often results in extensive and less informative cluster phenomenon. SaTScan provides little guidance for the selection of parameters, and their choice is contextually dependent and influenced by the objectives of the analysis (Chen et al. 2008). A remaining limitation is associated with the relationship between the cylindrical scan statistic and the decline of power as clusters become increasingly irregular in shape. Restrictions like this are encountered when cases are clustered near natural and artificial features like rivers, valleys and road networks (Robertson et al. 2010). As in any geospatial study of disease and health risk, uncertainties in data, methods, interpretations, and reactions are an unfortunate occurrence. The consequences of uncertainties can be severe and make it difficult for public health policymakers at multiple scales to design courses of action to combat these problems (Lam 2012). Cox and Ricci (1992) and May (2001) acknowledge that uncertainties exist in environmental risk assessments but believe that through the development of increasingly more advanced geospatial techniques, these uncertainties can be lessened considerably.

4.4. Modeling Geographic Accessibility

A primary barrier farmworkers face is access to community and migrant health centers (C/MHC). To model farmworker accessibility to C/MHC's, I will employ a network data model (i.e., Manhattan - Dijkstra algorithm), which calculates the distance between points (C/MHCs) and farmworker city or town of origin. I will quantify the degree of accessibility as being *excessively distant* at a threshold of greater than 30 minutes, as recommended by Fortney et al. (2011) and by the United States Department of Health and Human Services (1993). Network analysis (ArcGIS 10.5.1) was used to identify served and underserved farmworker populations within defined catchment areas, or the *potential spatial* access to healthcare facilities. Potential spatial accessibility is the probability of utilizing healthcare services but does not ensure the use of the services (Joseph and Phillips 1984; Khan 1992). Guagliardo (2004, 2) defines potential as “existing when a needy population coexists in space and time with a willing and able healthcare delivery system.” Early examples in the United States are provided by Guptill (1975) and Shultz (1975), and in the United Kingdom by Knox (1978). Two standard modeling techniques are the Euclidean (straight-line) and Manhattan (i.e., network) models (Apparico and Seguin 2005; Dede-Bamfo 2017).

The most popular and straightforward approach is the Euclidean distance method, which is the straight-line distance between two points. The Euclidean method assumes that space is isotropic, implying that the distance between locations or points is the same despite direction or impedance (Dede-Bamfo 2017). Euclidean distance measures are popular for urban street networks, but do not work well in rural areas; and do not incorporate topological structures or transportation infrastructure (Omer 2006; Wong et

al. 2012; Zhang et al. 2011; Dede-Bamfo 2017). Other limitations are tied to the isotropic designation of geographic spaces. Geographic space is heterogeneous and varies based on physical and social factors (Ahlstrom et al. 2011; Dede-Bamfo 2017). The Euclidean distance metric is defined as if d is the distance between points i and j with the coordinates (x_i, y_i) and (x_j, y_j) and mathematically as (Couclelis 1999, 31):

$$d_{ij} = \sqrt{[(x_i - x_j)^2 + (y_i - y_j)^2]}$$

Network methods (i.e., Manhattan) describe the minimum travel distance between origin and destination. In comparing Euclidean and Network-based models, the network method is more accurate because it takes into consideration speed limits, road length, topography, and conditions controlling the ease of movement in space (Ahlstrom et al. 2011; Tanser et al. 2006). The Manhattan distance metric, although behaving differently from the Euclidean measure, shares the exact linkages, metrics, and symmetrical properties (Couclelis 1999). Manhattan distance is defined as (Couclelis 1999, 31):

$$d_{ij} = |x_i - x_j| + |y_i - y_j|$$

Network methods use contour measures, to find potential gaps in the delivery of healthcare services (Dede-Bamfo 2017). Contour measures are popular because of their simplicity and ease of communicability and interpretability (Geurs and van Wee 2004). Even with the popularity of contour measures, limitations do exist concerning their theoretical foundation. First, contour measures have difficulties incorporating the combined effects of land-use and transport components (Geurs and van Wee 2004). Second, they do not take into consideration travel or individual behavior and assume that an individual would only patronize the closest geographic location, which is not always correct (Geurs and van Wee 2004; Dede-Bamfo 2017). Algorithms to build accessibility

models are broad but are categorized into two main categories: exact and heuristic (Sanders 2007; Church and Murray 2009). Exact algorithms are based on pre-defined criteria and logical decisions to guarantee the best possible solution to the stated problem (Sanders 2007). Examples include the *Dijkstra* algorithm and linear programming (Church and Murray 2009).

Heuristic algorithms, on the other hand, are based on the ‘best practice’ or ‘rules of thumb,’ and are acknowledged as algorithms that provide optimal solutions but no guarantee for an ideal solution (Sanders 2007; Arifin 2011). Examples of heuristic algorithms include simulated annealing and genetic algorithms (Sanders 2007; Church and Murray 2009). Network data models are very appealing, and recent studies have used this method for research on healthcare accessibility. For example, Comber, Brunsdon, and Radburn (2011) analyzed the relationship between access to general practitioners, car ownership and geographic distance with a network model and geographically weighted regression (GWR); Gibson et al. (2011) calculated the average distance to clinics and the percentage of households outside of health service areas in rural China. Additionally, others have investigated the accessibility to myocardial infarction care (Pedigo and Odoi 2010), health disparities and race (Dai 2010), and the access to colorectal cancer services in Texas (Wan, Zhan, Zou, and Chow 2011).

The Dijkstra algorithm (*single shortest path algorithm*) computes hierarchical routing related to travel impedance (Environmental Systems Research Institute 2008). The *Dijkstra* algorithm, developed in 1959 by Edsger W. Dijkstra, is optimal for finding the shortest path between a pair of vertices in a graph (Bhandari 1999). The Dijkstra algorithm needs weighted values to function and uses a 3 x 3 window or a *queen pattern*

window to link adjacent cells (Dijkstra 1959). In the queen pattern, a neighboring node may be linked only to one of the adjacent cells. The shortest path is calculated by connecting adjacent cells that have the least or smallest weight values (Herzog 2010; Collischonn and Pilar 2000; Dede-Bamfo 2017). The primary network data model is comprised of nodes (points) that are connected by edges (lines). Nodes and edges are the fundamental geometric features defined in the model; any space not falling on the designated network are considered undefined (Delamater et al. 2012). Travel within a network model is calculated as:

$$T_{AD} = \frac{d_{AE}}{S_{AE}} + \frac{d_{ED}}{S_{ED}} + P_R$$

“using edge distance, A-E (d_{AE}), edge distance E-D (d_{ED}), travel speed of edge A-E (S_{AE}), travel speed of edge E-D (S_{ED}), and the turn delay for making a 90° right-hand turn at Node E (P_R)” (Delamater et al. 2012, 3) (Figure 9).

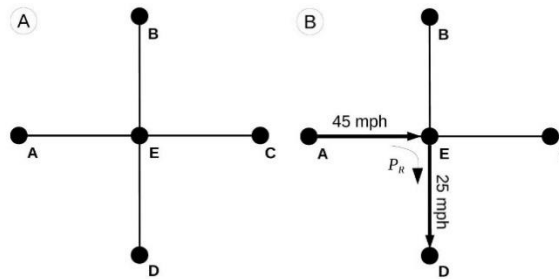


Figure 9. a) Network data model, b) Cost example

4.4.1 Modeling Geographic Accessibility: Limitations

Some limitations and potential pitfalls exist when implementing geographic accessibility methods. First, Stimson (1983) warns researchers to be aware of possible

inaccuracies in their data sets such as misspellings, errors in mailing addresses, or misrepresentations of provider or clinic address. Second is an unwarranted casual inference due to ecological associations. For example, physicians are less frequent in the minority versus non-minority communities, which can imply an inherent prejudice against minority populations (Stimson 1983). However, in many urban areas, the ethnic/racial composition of neighborhoods is correlated with income and crime. Hence, researchers should attempt to determine if possible whether the location of clinical practices is driven by financial or safety concerns (Stimson 1983). Researchers should be aware that transportation system efficiency and the number of transportation options differ between communities (Bostock 2001; Kimes et al. 2004). Third, the data for analysis may not be sufficiently disaggregated to the smallest scale while preserving optimal resolution (Stimson 1983; Guagliardo 2004).

For example, if a study is concerned with the accessibility of farmworkers to healthcare providers on a national scale, then aggregating data to county-level units would suffice. However, if the study focuses on neighborhood level disparities, then census block groups or tracts would be necessary (Guagliardo 2004). Finally, Stimson (1983) warns of data sets that do not correspond correctly to scale or time. A well-known example is urban decay and urban renewal, and the gradual shift of populations and providers over time. It would be inappropriate to compare 1990 provider locations with 2010 U.S. census data for a given city, county, or state.

Modeling human spatial behavior as it pertains to accessibility presents another inherent limitation. Some perspectives are recognized; one is that daily activity spaces are more representative of an individual's 'location' than where they live. Patients may

choose to obtain care near their place of work or preferred shopping locations, a pattern of behavior that is often overlooked (Gesler and Meade 1988; Cromley and Shannon 1986). Kwan (1999) pioneered the visualization of three-dimensional models of daily activity space or ‘aquarium’ visualizations. Kwan determined that space-time interactions and activity spaces differ by race when comparing samples of Asian and African-American women in Portland, Oregon. Additionally, difficulties arise in modeling human behavior in relation to the environmental determinants of human behavior. At the individual level from a human cognitive psychological perspective, an individual's behaviors can be viewed as the outcomes of his/her decision-making process (Pan et al. 2007). These vary based on experience, instinct (Wills 1998), or bounded rationality (March 1994); while from the perspective of social interaction, identity (Braun et al. 2003), personal spaces (Ashcraft and Scheflen 1976), and social proof (Cialdini 1993) strongly influence the behavior patterns of humans.

4.5 Phase II: Qualitative Data

The second, qualitative phase in the study focuses on explaining the quantitative phase through direct anecdotal evidence collected through interviews with key-informants and farmworkers. Guiding the interview questions are the quantitative results and the theoretical framework described in chapter 3. Through direct collaboration with the National Center for Farmworker Health (NCFH), the identification of key informants and farmworkers was completed before the initial visits to selected community and migrant health centers (C/MHCs) in California, Colorado, and Michigan. Key-informant and farmworker interviews were tape recorded with the permission of the interviewee to ensure precise documentation.

4.5.1 Qualitative Methods

Qualitative research interviews describe broad central themes and meaning in the world of the interviewee. Qualitative interviews are a well-established method of research and are divided into three main types: structured, semi-structured, and depth interviews (Britten 2007). The primary task, according to Kvale (1996), is not just the method of interviewing, but what the interviewee has to say. Qualitative interviews seek to cover both the factual and the interviewee's framework of meaning with the explicit goal of not imposing the researcher's assumptions on the interviewee's account of the topic of study (Kvale 1996; Britten 2007). Qualitative interviewing "is about close social interaction where the interviewer has a role of professional as well as sympathetic fellow being" (Barron, 1994, 43). Kvale (1983, 171) similarly defines the qualitative research interview as "an interview, whose purpose is to gather descriptions of the life-world of the interview with respect to interpretation of the meaning of the described phenomena."

Geographers as a group strive to understand the human experience in a socio-spatial setting (Dwyer and Lamb, 2001), and interviews are critical in discovering the story behind the lived experience of the interviewee and are used for follow-up investigations based on their responses (McNamara 1999). Interviews have been advocated for studies of both patients and medical practitioners. For example, Townsend et al. (2003) conducted semi-structured interviews with 23 men and women on their experiences with chronic disease. Results of this study revealed elevated levels of ambivalence to taking their prescribed medications. Interviewees were encouraged to talk about their experiences and strategies for the management of these conditions.

In a survey of the relationship between well-being and distress at work, Huby et al. (2002) interviewed 26 general practitioners and found that morale depended on several factors. However, the relations between elements were more important than any of these factors in isolation, a finding that stressed the importance of practice partnership as a critical factor in mediating workload pressures. Qualitative interviews not only collect several types of data than quantitative studies, but they also address different questions than their counterpart. For example, a quantitative study would measure age-standardized admission rates for south Asian versus white patients (Britten 2007). Griffiths et al. (2001), on the contrary, interviewed south Asian and white patients to explore their experiences with not only coping with asthma but also experiences with hospital admissions and clinicians.

According to Patton (1987), good questions in qualitative interviews should be open-ended, precise, and sensitive to the interviewee. Patton further lists six types of questions, based on behavior, opinion or value, knowledge, feeling, sensory experience, and demographic or background details. The validity of qualitative interviews should be based on whether they are capable of empirical generalizations, but rather their validity should be substantiated based on the casual structures which underpin observable behavior (Winchester 1999). Qualitative interviews are a complementary technique, one that can be combined as part of multiple methods or triangulation (Burgess 1982; Winchester 1999). The triangulation approach has the potential of shedding light on the problem under investigation. Sample sizes for interview participants is an essential topic of discussion in qualitative research.

Numerous factors can determine samples sizes in qualitative studies, and many scholars do not explicitly state a recommended sample size for interviews (Mason 2010). Guest, Bunce, and Johnson (2006, 61) discovered only seven sources providing guidelines for sample sizes (adapted from Mason 2010):

- Ethnography and ethnoscience (Morse 1994, 225): 30 – 50 interviews for both topics. Bernard (2000, 178): 30 – 60 interviews for ethnoscience.
- Grounded theory methodology (Creswell 1998, 64): 20 – 30; Morse (1994, 225): 30 – 50 interviews.
- Phenomenology (Creswell 1998, 64): 5 – 25; Morse (1994, 225): at least six.
- All qualitative research (Bertaux 1981, 35): 15 is the smallest acceptable sample size.

Sample size should not be determined merely by “hard and fast rules,” but by factors such as question depth and the duration required for each interview, and if this is feasible for a single researcher (Britten 2007, 19). Interviews should always be conducted at the convenience of the interviewee, and the setting of the conversation needs to be considered by the researcher, as this will affect the content of the investigation (Britten 2007; Holland et al. 1990). The concept of saturation is regarded as the most critical factor when deciding on the proper sample size (Mason 2010). Saturation is defined as the point in the data collection process in which no new or relevant data is produced (Dworkin 2012). Saturation is not as simple as determining the proper sample size for the chosen study but is instead dependent on factors that are often outside the control of the researcher. Some of these factors include: How homogeneous or heterogeneous is the

population in question? What are the selection criteria? How much money is available in the budget to conduct the study? What is the research timeline? How experienced is the researcher in being able to determine if he or she has reached saturation? (Dworkin 2012, 1319).

Key informant interviews were semi-structured, open-ended, and flexible; the choice can be adjusted based on the research issues of interest. Semi-structured interviews facilitate faster interviews and greater flexibility (Howard 1986). Individually, interviews with key informants are an in-depth and vital source of information in articulating human experience at a broad scale. Key informants are an expert source of information, and due to their position within society can provide more profound insights into the behavior of the community (Marshall, 1996). Farmworker interviews followed a similar structure to the key informant interviews. Interviews were conducted at community and migrant health center locations and mobile health clinics at migrant labor camps.

All interviews were audiotape recorded, with the advantage being that this method is more accurate than writing notes by hand. Writing notes has the potential to cause distractions and problems after the interview in transcription. During interviews, a Spanish-speaking interpreter provided direct translation of all interviews with farmworkers. The informal, open-ended discussion with farmworkers was similar to everyday conversation; this method has shown promise in data validation due to the unpredictable nature of interviews (Chenitz & Swanson, 1986). I followed the guidelines of Bertaux (1981) and interviewed a minimum of 15 key-informants and farmworkers at the following facilities:

- Clinicas del Camino Real, 1040 Flynn Road Camarillo, CA 93012.
- Intercare Community Health Network, 50 Industrial Park Drive, Bangor, MI 49013.
- Salud Family Health Centers, 1115 2nd Street, Fort Lupton, CO 80621.

4.5.2 Farmworker Interviews Questions - Interview questions were developed through direct consultation with the staff at the National Center for Farmworker Health (NCFH).

1. Where do you consider ‘home’? or “Where is your home base”?
2. What year were you born?
3. Do you consider agriculture your primary employment?
 - If yes, what types of agricultural jobs do you perform and in what types of crops or products?
4. Do you migrate to find work in agriculture?
 - If yes, does your family migrate to you?
 - Did migration cause you any adverse health symptoms?
5. What year did you first start working in agriculture?
6. Do you consider yourself to be in poor or good health?
7. On a scale of 1-10 with 1 being poor and 5 being excellent, please rate your overall physical health
 - I experience symptoms daily that interfere with my ability to perform daily functions.
 - I have mild to moderate symptoms.
 - I experience symptoms occasionally throughout the day.
 - I very rarely experience health issues that interfere with my daily living.

- I consider myself to be in excellent health and have no medical problems that.
8. Do you have a medical condition that needs ongoing attention such as a chronic disease? At what age did you first start experiencing symptoms related to this problem?
9. How would you describe your access to fresh fruits and vegetables?
10. How would you describe your access to essential (primary) healthcare services?
- Limited access
 - Moderate access
 - Full access
11. Do you utilize either a community or migrant health center in this area?
- Yes
 - No
12. Do you utilize either a community or migrant health center in any other area of the country?
- Yes, where?
13. What other types of medical care do you use when you need medical assistance?
- Private Medical Office
 - Free Clinic
 - School-based health center
 - Free clinic
 - Hospital or hospital ER
 - Urgent care center

- Other (please specify)

14. How many times a year do you see a physician?
15. How would you best describe your current emotional or mental health? (Rank from worst: 1 – 5: best)
16. Do you experience any symptoms of depression, anxiety, or stress?
17. If applicable, please describe briefly how diabetes, hypertension, or obesity has negatively affected you and your family?
18. What is your name/last name? (optional)
19. Height/weight (BMI calculation) (optional)

4.5.3 Key Informants Interview Questions– Interview questions with key informants were developed based on the ecosocial model of farmworker health and the *macro*, *meso*, and *micro* level determinates to health.

1. How long have you worked at this center?
2. What are the barriers to improved health outcomes experienced by farmworkers in this area?
3. How can we better address the health needs of farmworkers? What are the social determinants of health that detract from farmworkers' health status?
4. What are the social determinants of health that support good health among farmworkers?
5. Do you believe that this or any nearby counties would benefit from an increase in healthcare surveillance? If so, which counties? Monitoring of what conditions?
6. What is the primary demographic composition of farmworkers in this area?

Political Economy (*Fundamental*):

1. How has politics at the local, national level impacted farmworkers?
2. Have push-pull/migration patterns fluctuated in recent years, decades?
3. How many farmworkers here travel alone?
4. Does migration contribute to anxiety, depression, and stress among farmworkers?
5. Have you witnessed or know of labor exploitation?
6. How do social class affect farmworkers and their health outcomes?
7. How would you describe the migration patterns of the farmworkers in this area?
 - a. *Restricted Circuit* (Following traditional migration streams in one geographic area)
 - b. *Point-to-Point* (Travel to the same location for work year after year)
 - c. *Nomadic* (Those who travel seasonally to employment from abroad, non-restrictive geography from either inside or outside the United States)

Political Ecology (*Intermediate*):

1. How long have farmworkers been working in this area?
2. What is the history of farmworkers in this area?
3. When did this clinic open and start serving farmworkers?
4. How do language barriers, cultural practices delay the delivery of healthcare to farmworkers?
5. Where do farmworkers in this area live, where are they from?
6. What is the educational attainment for workers?
7. In general, does a lack of transportation contribute to adverse health outcomes among farmworkers?

8. How can healthcare utilization be improved?
9. Do you believe that a lack of transportation is a prevailing issue among workers utilizing this facility?
10. What solutions exist to overcome transportation barriers?
11. What fresh food options accessible to farmworkers? Are nutritional deficiencies common?

Spatiotemporal scale and Lifecourse epidemiology (*Proximate*):

1. The burden of chronic disease is heavy for patients, family, and community, what is the status of chronic disease among farmworkers in this area?
2. What are the genetic implications of chronic disease; do you see a generational trend in your years on the job?
3. Do you see families and not just individuals who are inflicted with chronic disease?
4. Have you witnessed progression in chronic disease from adolescent to adulthood?
5. Describe the nutritional practices of farmworkers treated here.
6. How many attend follow-up appointments and health screenings?
7. How would you describe the health literacy of farmworkers you have worked with directly?

4.5.4 Qualitative Interview and Data Collection: Limitations

Sample sizes for qualitative studies are much smaller than quantitative studies.

Ritchie, Lewis, and Elam (2003) provide some possible reasons for this. One is related to the point of diminishing return – or as the study continues, the more data collected does

not necessarily lead to an increase in knowledge creation (Mason 2010). This is because one piece of data, or code, is all that is needed to ensure inclusion in an analysis (Mason 2010). Mason (2010) argues that frequencies in qualitative studies are not necessary, due to one record having as much potential as many in the same study. The underlying processes behind the subject can be articulated successfully. Analyzing qualitative data can prove to be very labor intensive and impractical (Mason 2010). Methodological issues associated with mixed methods research are multi-faceted and need to be anticipated. These issues have previously been covered by Creswell et al. (2011, p. 10) and Teddlie & Tashakkori (2009) and are described below:

- Resources – in mixed methods research multiple forms of data are being collected and analyzed; this undoubtedly requires extensive time and monetary resources (Creswell et al. 2011).
- Sampling design issues – challenges of merging quantitative and qualitative concurrent designs include implementing a consistent unit of analysis across the data set, having adequate sample sizes for analysis, and using comparable samples. For sequential designs like this study, problems arise when determining which results from the quantitative phase should be incorporated into the qualitative follow-up phase, choosing reasonable sample size, and the interpretation and intermixing phase or the “point of interface” (Morse & Niehaus 2009).
- Analytic and interpretive issues – when using specific research designs, issues may arise during the analysis and interpretation phases. As with the previous limitations on sampling design, an essential question in a sequential model is

the “point of interface” a step in which the investigator needs to decide which data from the first phase will be the focus for the qualitative phase. The interpretation of integrated results may be challenging because of the different emphasis placed on each dataset by the investigator (Creswell et al. 2011).

Similar limitations and challenges exist in mixed methods research. Collins, Onwuegbuzie & Jiao (2007) describe four limitations. First, the problem of representation is intensified because quantitative and qualitative methods have their inherent limitations. Representation challenges refer to the difficulties involved in capturing and representing lived experience using both numbers and text (Collins, Onwuegbuzie & Jiao 2007). Second, legitimation and validity need to be recognized by the researcher; these limitations range from measured and design-related (Onwuegbuzie & Johnson 2006). The challenge of validity is more significant in mixed-methods research than monomethod studies due to the difficulties of obtaining results or making inferences that are trustworthy, dependable, transferable, and confirmable (Collins, Onwuegbuzie & Jiao 2007). Third, the researcher must acknowledge integration, a concept that often facilitates questions such as: is it appropriate to triangulate, expand, compare, or consolidate quantitative data originating from a large, random sample of qualitative data arising from a small, purposive sample? (Collins, Onwuegbuzie & Jiao 2007, p. 269). Fourth is the challenge of politics, referring to the problem of combining methods.

This difficulty stems from the researcher trying to convince prospective stakeholders and policymakers of not only the findings but also the value of incorporating

the quantitative and qualitative phases (Collins, Onwuegbuzie & Jiao 2007). Qualitative researchers at all levels of experience need to consider how they are perceived by the interviewee based on their race, class, sex, and personal characteristics (Britten 2007). For example, a patient who already knows that a doctor or nurse will interview he or she may strive to please the interviewer by giving responses that he or she thinks the doctor or nurse wants. Common interviewer pitfalls identified by Field and Morse (1989) include awkward questions, competing distractions, outside interruptions, the temptation to counsel interviewees, superficial questions, translation inaccuracies, and stage fright from the interviewer or interviewee.

CHAPTER V.

COLORADO RESULTS: QUANTITATIVE

5.1 Introduction

The following section summarizes the results of the chronic disease and risk factor cluster detection analysis, farmworker healthcare accessibility, and demographic composition of the patient population in Colorado. In total, 1,269 farmworkers lived greater than 30 minutes from a C/MHC, which constituted 7.7% of the total population in the study area (n = 16,419). Chronic disease hot spots were found in 71 zip codes, while risk factor hot spots were found in 44 zip codes. Additionally, 13,289 (81%) farmworkers were found in zip codes designated as chronic disease hot spots, while 10,115 (62%) lived in zip codes identified as risk factor hot spots. Diabetes (56.2%) represented the largest percentage of total patient encounters (n = 6,255), followed by the treatment for chronic disease risk factors (18%), Hypertension (13.7%), and Obesity (12.2%). Further information and the corresponding tables for the chronic disease and risk factor clusters are found in the appendix section. The quantitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 11).

5.2 Quantitative Results

Accessibility to C/MHC's

Geographic accessibility to community and migrant health centers (C/MHC) are presented in Figure 10. Most farmworker population in the study area is concentrated in threshold zones between 10 – 20 minutes' drive time from C/MHC's. It was further

determined that 1,269 farmworkers (7.7%) lived beyond the 30-minute “excessively distant” threshold. The geographic distribution of some patients stretches beyond the 60-minute drive time threshold into Washington, Yuma, Phillips, Park, and Sedgwick counties. For example, from the county seats of Julesburg (Sedgwick) and Holyoke (Phillips) counties to the nearest C/MHC in Sterling, driving times are 58 (61.4 miles) and 54 (50.9 miles) minutes, respectively.

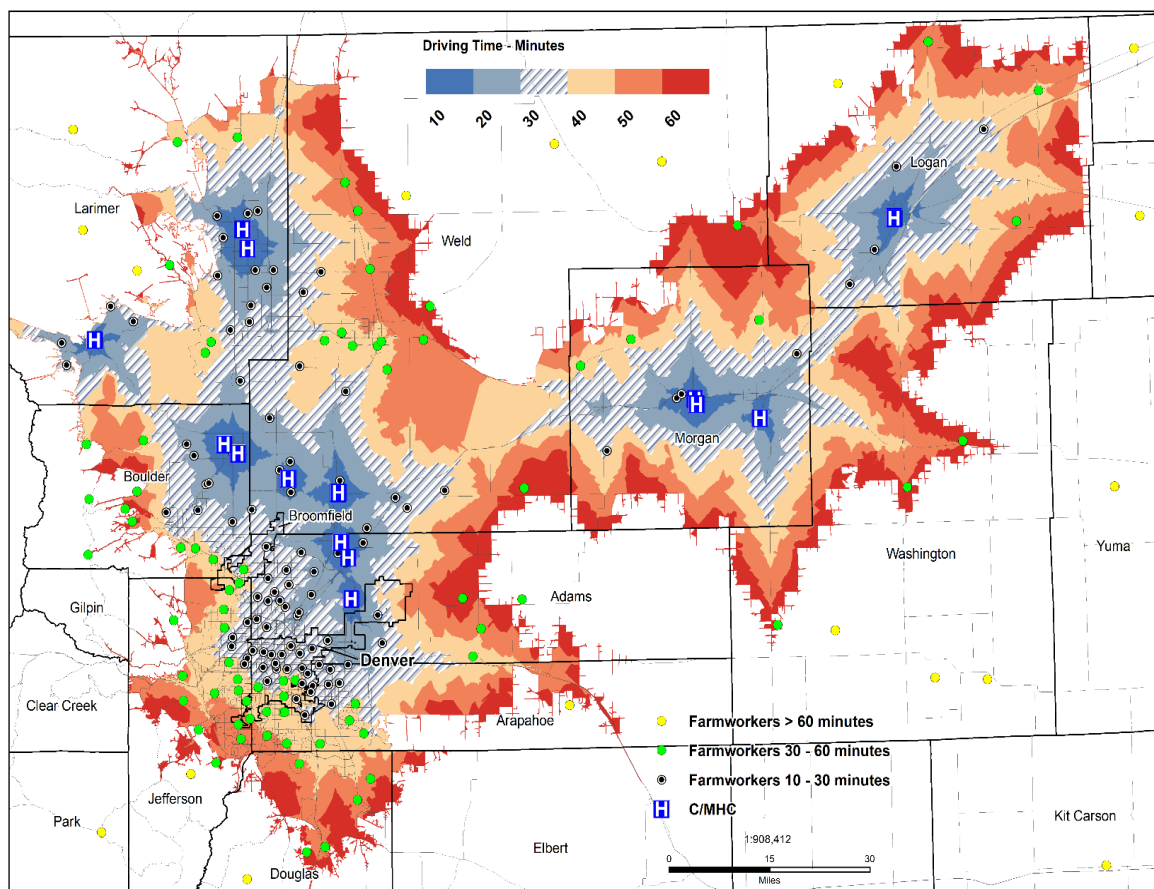


Figure 10. Geographic accessibility to C/MHC's (Colorado)

Chronic Disease and Risk Factor Hot Spots

The geographic distribution of zip codes designated as hot spots for seasonal and migratory farmworker diabetes encounters are presented in Figure 10.1 and 10.2.

Statistically significant clusters between groups are concentrated primarily in the city of Denver and zip codes 80215, 80225, 80226, and 80221. Clusters were further found in the towns of Dacapo (80514), Hudson (80642), Keenesburg (80643), Commerce City (80022), Jamestown (80455), Lafayette (80026), Erie (80516), and Frederick (80530).

Zip codes considered to be outliers were found in Phillips (80731, 80734), Sedgwick (80744), and eastern Logan County (80731). These remote areas were previously identified as areas beyond the 60-minute threshold for driving distance. This excessive driving time constitutes a severe barrier to rural farmworker populations seeking medical care in eastern Colorado. Tests of cluster sensitivity determined that the best performing MSWS for seasonal diabetes encounters was reached at 30% of the at-risk-population (clusters = 12), which totaled 2,005 observed encounters, 1,475 expected encounters (P – Value: < 0.0001 – 0.9963; Gumbel P-Value: 0 – 0.9923), an LLR of 172.01 and a relative risk (RR) of 58.60. Tests on migratory diabetes encounters produced 11 total clusters and robust performance with an MSWS of 40% (P – Value: < 0.0001 – 0.9906; Gumbel P-Value: 0 – 0.9840) of the at-risk population. Observed encounters in these clusters totaled 990, with 732 expected encounters, an LLR of 109.30 and a relative risk (RR) of 26.35.

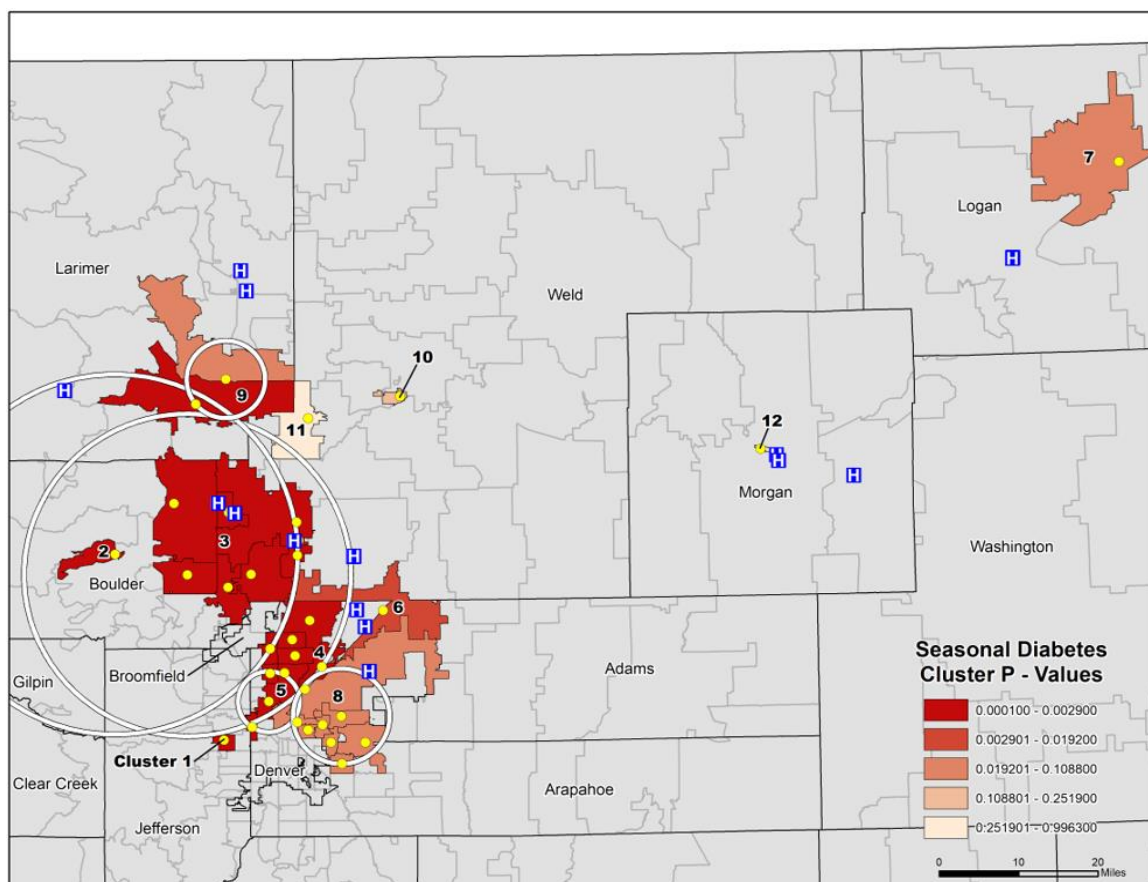


Figure 10.1 – Seasonal diabetes (Colorado)

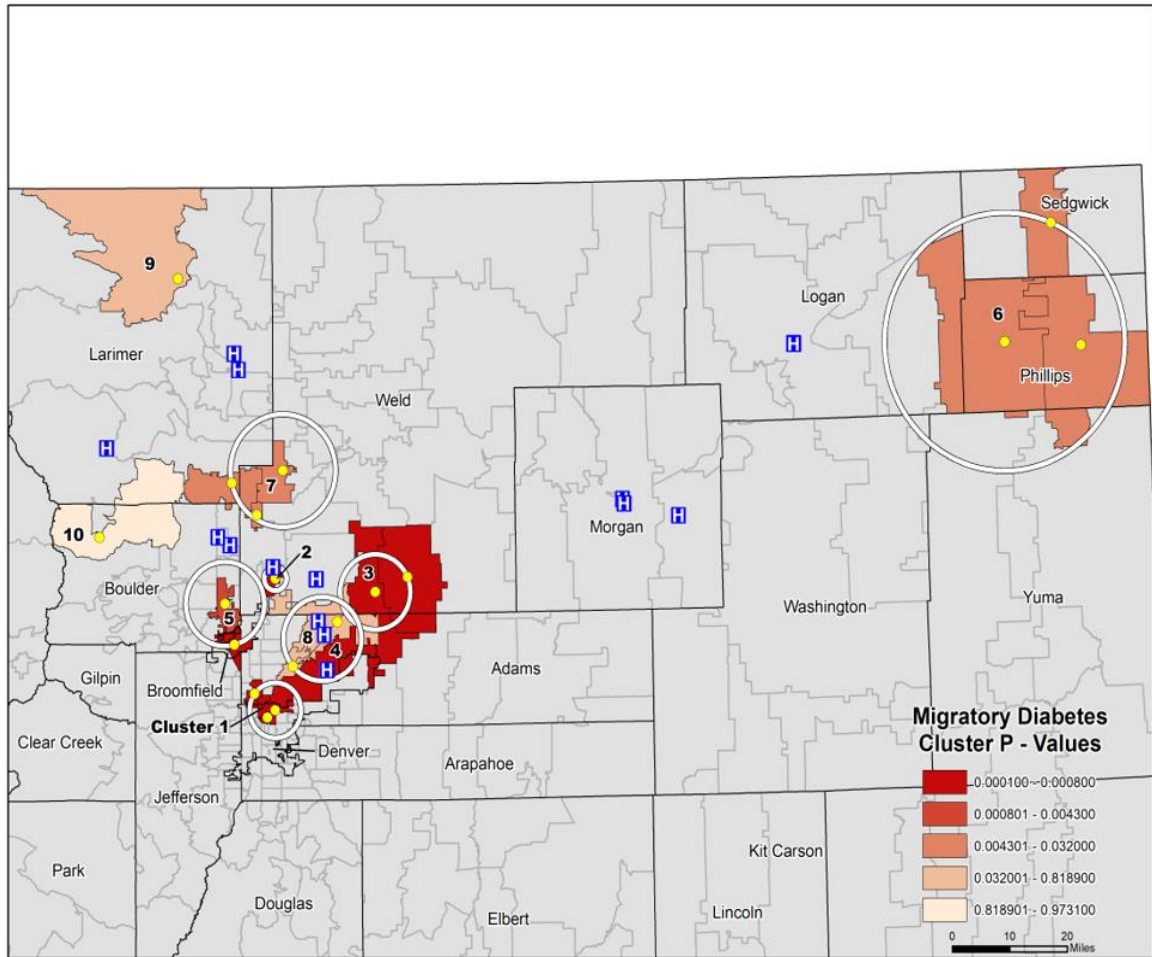


Figure 10.2 - Migratory diabetes (Colorado)

Seasonal and migratory hypertension clusters (Figure 10.3 & 10.4) display a semi-urban distribution, with marked similarities when comparing the distribution of diabetes clusters, particularly in zip codes 80455 (Jamestown) and 80026 (Lafayette). Between groups, clusters were identified in the cities of Denver (80241, 80233, 80215) and Boulder (80302). Rural zip codes with statistically significant clusters ($P - \text{Value} < 0.05$) are found in portions of Washington, Logan, and Larimer Counties. Population centers in these counties include Drake (80515), Sterling (80751), and Otis (80743). Drive time from Otis, Colorado to the nearest C/MHC in Sterling is 43 minutes or 43.1

miles, respectively. Measures of cluster sensitivity for seasonal hypertension encounters favored an MSWS of 30% of the at-risk population. Within these 15 clusters (P – Value: $< 0.0001 - 0.9999$; Gumbel P-Value: $0 - 0.9989$), 558 observed and 352.75 expected patient encounters were recorded; as was an LLR of 103.81, and a relative risk (RR) of 44.48. On the contrary, migratory hypertension encounters performed better with an MSWS of only 10% of the at-risk population. In total, 111 observed and 58.13 expected patient encounters were observed within 9 clusters, which produced a relative risk of 31.73 and an LLR of 23.00. Unlike the seasonal patient encounters which featured multiple statistically significant clusters, only one cluster was significant in this part of the analysis (< 0.008). This is found in zip code 80455 (Jamestown) and featured 25 observed encounters, 2.33 expected encounters and a relative risk (RR) of 2.23.

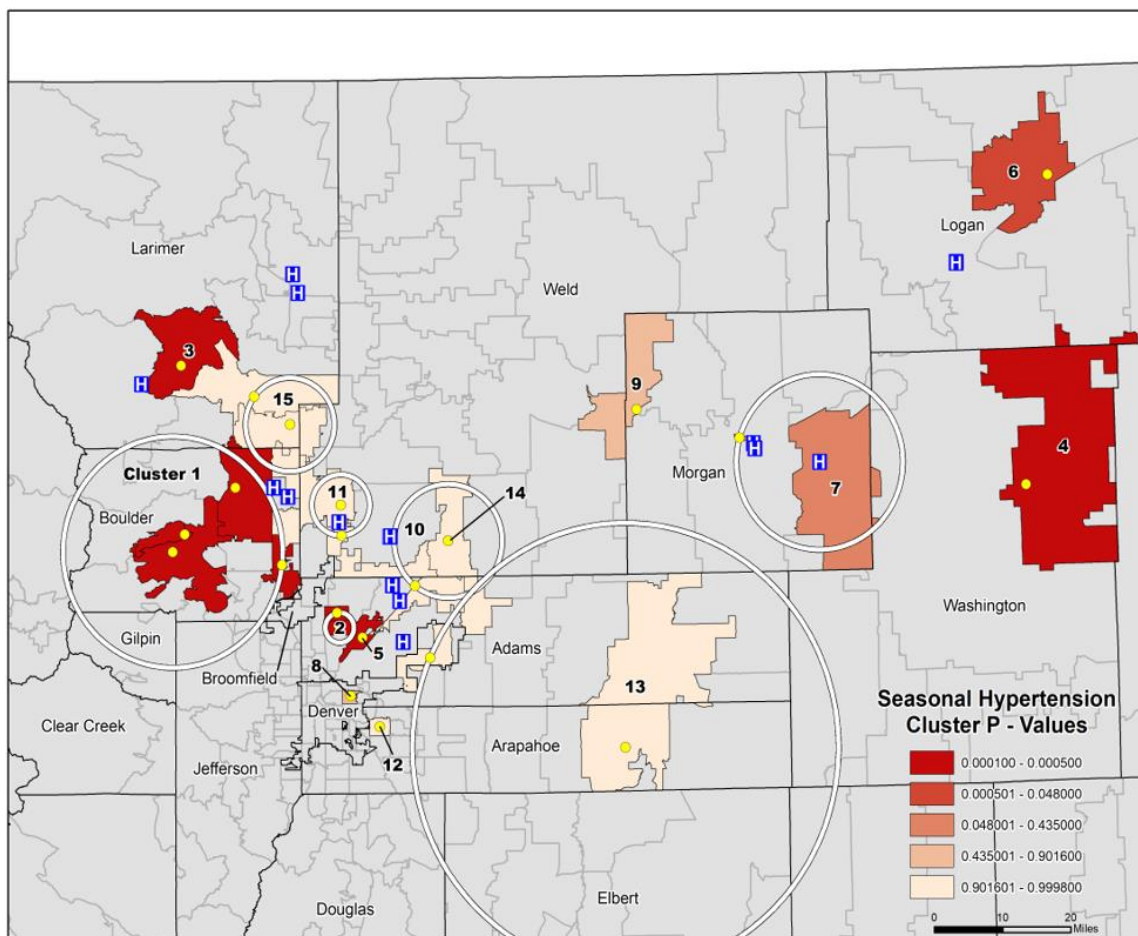


Figure 10.3 – Seasonal hypertension (Colorado)

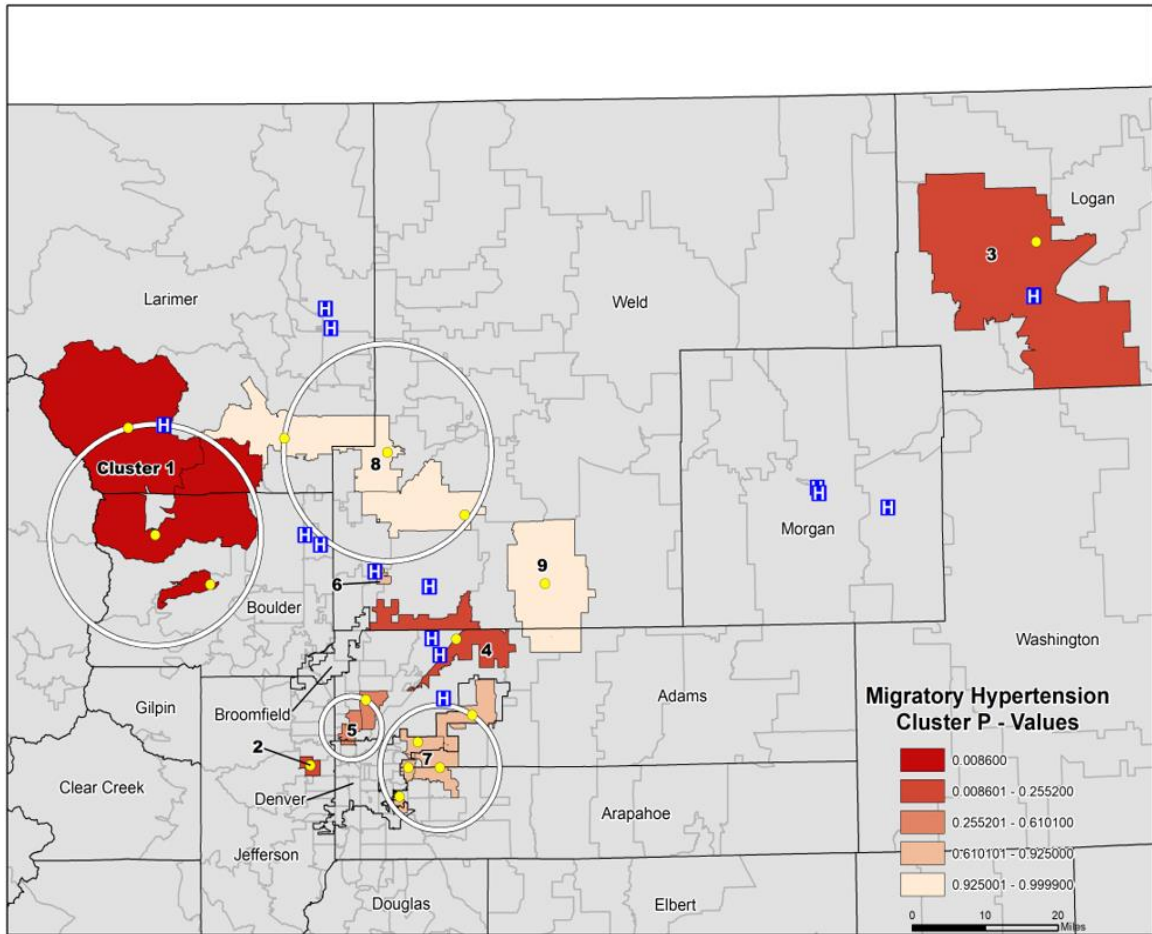


Figure 10.4 – Migrant hypertension (Colorado)

Finally, the distribution of MSFW obesity encounters (Figure 10.5 & 10.6) indicates that between groups the geographic distribution of clusters is similar geospatially. Both are clustered in a north-south orientation stretching from the city of Denver in the south, to the Wyoming – Colorado border and the cities of Wellington (69.1 miles), Livermore (93.5 miles), and Nunn (80.7 miles). The clusters of seasonal obesity primarily encompass three counties (Boulder, Larimer, and Weld), and include the population centers of Longmont (80501, 80503, 80504), Fort Collins (80521), Denver (80211, 80219, 80222) and Mead (80542). Following a similar orientation, statistically

significant migratory clusters are found in Boulder, Larimer, and Weld counties, and the city of Denver (Jefferson County). These clusters include the population centers of Broomfield (80020), Mead (80542), Milliken (80543), Estes Park (80517), Lyons (80540), Erie (80516), Fort Collins (80526), and Denver (80226). Measures of cluster sensitivity for seasonal obesity encounters performed best with an MSWS of 20% of the at-risk-population (clusters = 9). Within these nine clusters, 978 observed and 631.69 expected patient encounters were recorded which accounted for a relative risk (RR) of 18.10 and an LLR of 103.23. Similarities in cluster performance were noted when examining migratory obesity patient encounters. Optimal performance was reached at an MSWS of 30% of the at-risk-population, which produced 5 clusters with a relative risk (RR) of 17.32, LLR of 79.92, and 696 observed and 461 expected patient encounters.

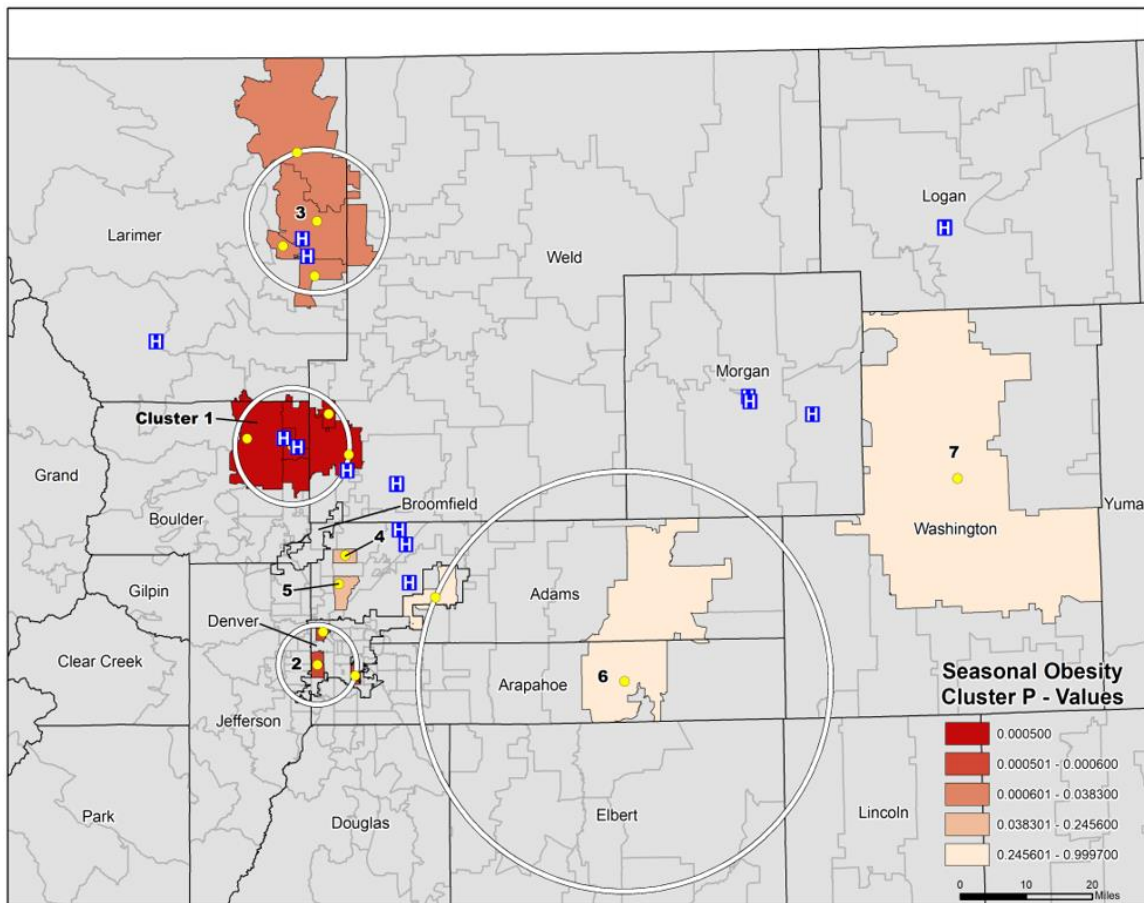


Figure 10.5 – Seasonal obesity (Colorado)

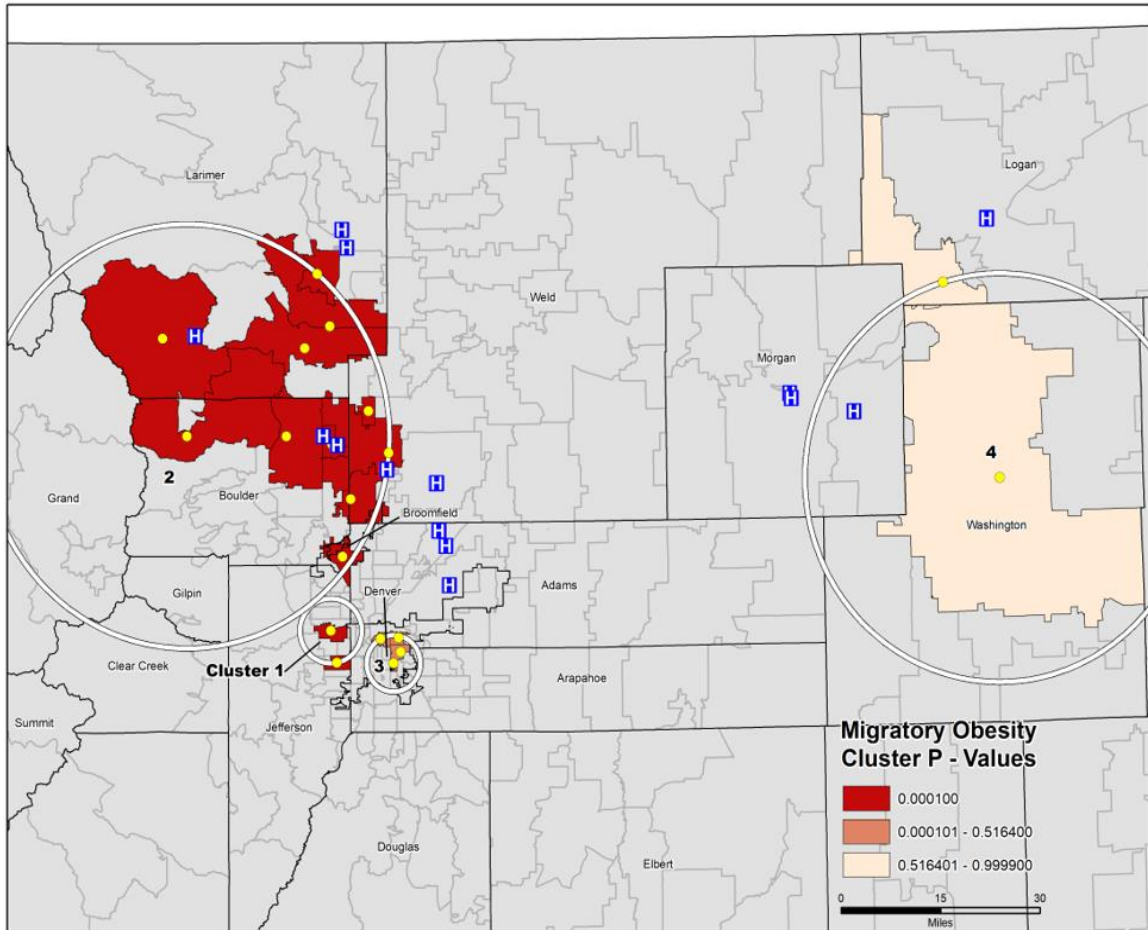


Figure 10.6 – Migratory obesity (Colorado)

The geographic distribution of chronic disease risk factors displays clustering in the eastern counties of Morgan, Washington, and Logan (Figure 10.7). Clustering is visible in zip codes to the north and west of Denver in Boulder, Larimer, and Weld counties, as well as to the east of Denver in the counties of Adams and Arapahoe. In total, 17 clusters were statistically significant (P – Value: < 0.0001) and performed best with an MSWS of 10% of the at-risk population. The top clusters were found in the municipalities of Brighton (80601), Fort Collins (80524), Longmont (80504), Dacono (80514), Frederick (80530), Fort Lupton (80621), Bennett (80102), Strasburg (80136),

and Denver (80249). The observed encounters in these 4 clusters were 341, versus 32.64 expected, a relative risk (RR) of 57.08, and a test statistic (TS) of 589.48. Furthermore, in analyzing the temporal range of risk factor patient encounters from 2011 - 2015, January, February, April, May, October, and December witnessed the most demand for patient services at C/MHC's. A noticeable dip in patient encounters is visible during the hottest months of the year when compared to the long-term temperature averages for Ft. Lupton from 1981 – 2010 (Figure 10.8) (NOAA – National Climatic Data Center, 2018).

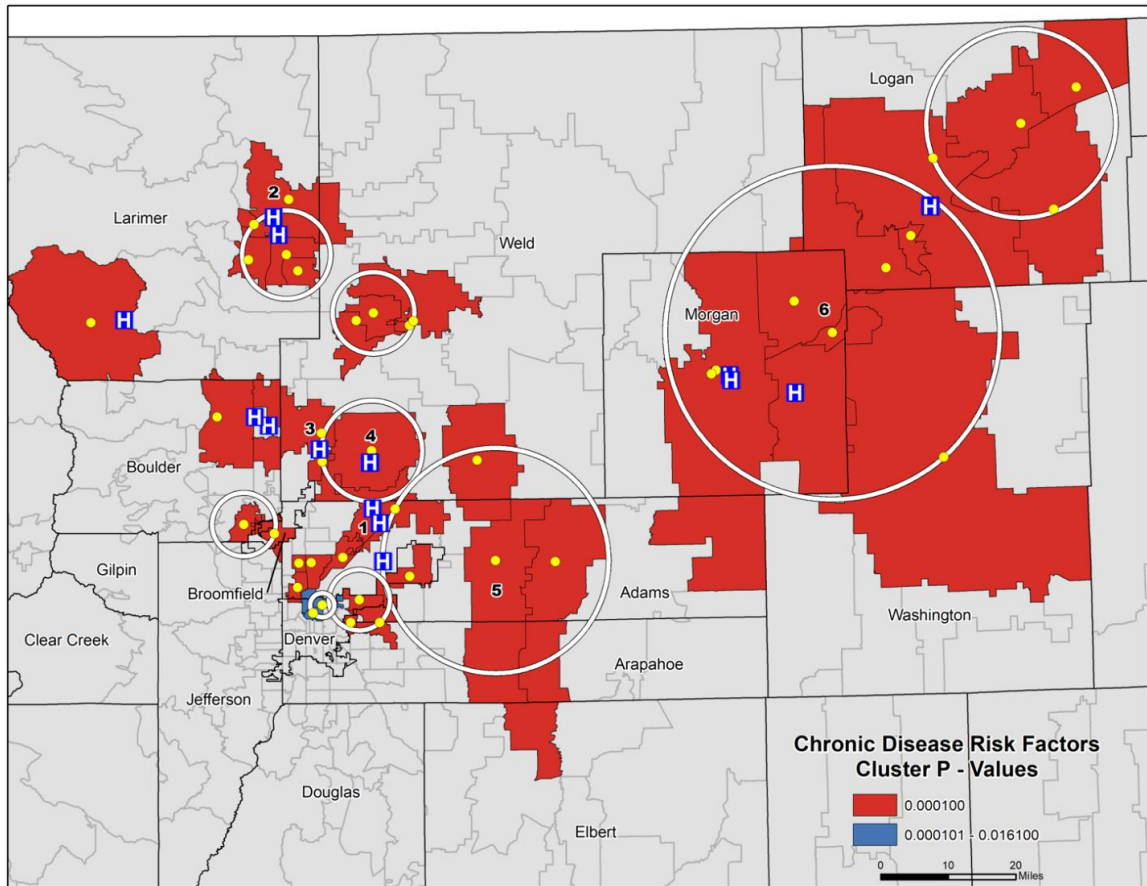


Figure 10.7 – Chronic disease risk factors (Colorado)

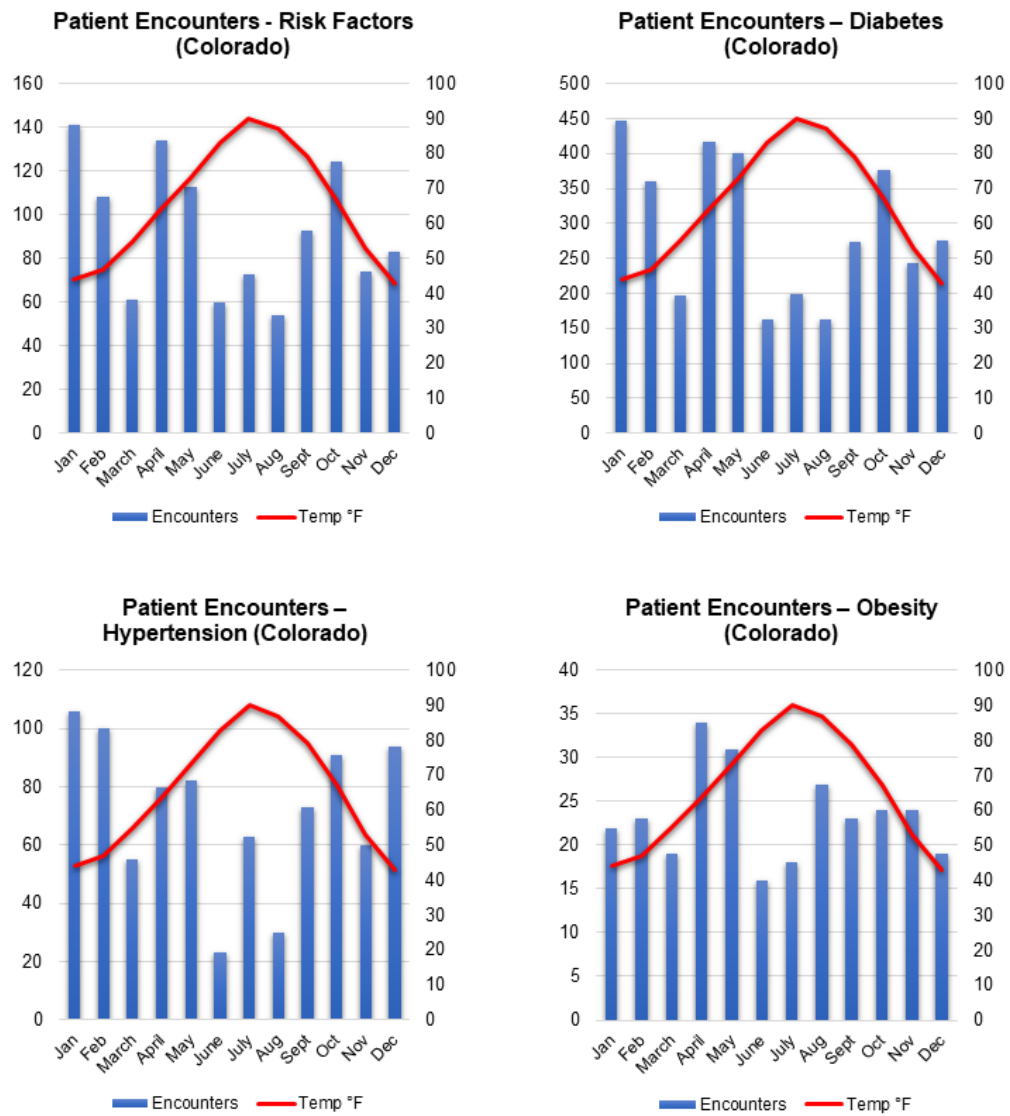


Figure 10.8 – Colorado patient encounters in relation to temperature averages

Demographics

Demographics for the farmworker population in Colorado (Figure 10.9) were analyzed based on patient encounters for the treatment of chronic disease and their associated risk factors. Statistics for diabetes encounters (n = 3,514) determined that the mean age for seasonal and migratory farmworkers was 59 years of age (max: 93; min: 14) and that the patient population was primarily female (58%) (42% - male). The predominant ethnic composition was Hispanic/Latino (69%), followed by non-Hispanic/Latino (31%). Most of the patients spoke English (51.2%) and Spanish (46%); however, languages like Somali and Hindi were also documented. Many of the patients were married (53%), while 32.5% were classified as single, another 0.08% were divorced, and 0.03% were widowed. The most frequently visited C/MHC's for diabetes were Commerce City Salud (28%), Longmont Salud (20%), Brighton Salud (13.2%), Fort Lupton Salud (11%), Fort Morgan Salud (8.5%), and Fort Collins Salud (8%). The city of origin for these patients constitute 51% of the total population, was Longmont (21%), Commerce City (19%), and Brighton (11%).

Demographics for hypertension encounters (n = 859) revealed that the mean age was slightly younger than the diabetes patients at 42 years old (Max: 92; Min: 5). Ethnically, the composition was again predominately Hispanic/Latino (59.6%) and non-Hispanic/Latino (39.9%), with a small portion of the population (0.013%) refusing to report. Languages spoken favored English (57.3%) and Spanish (40%), however, there were Arabic, Hindi, and Portuguese speakers as well. Unlike diabetes encounters, patients being treated for hypertension were predominantly single (51%), 35% were married, and 9% reported being divorced. These farmworkers were again predominately

female (58%), with males making up 42% of the population. Patients primarily lived in Longmont (23.2%), Commerce City (14%), and Fort Collins (12.7%), and the most visited C/MHC's were again Longmont Salud (22.2%), Commerce City Salud (21.1%), and Fort Collins Salud (14.7%).

Obesity demographics (n = 765) reveal an even younger population, with a mean age for patient encounters of 34 years old (Max: 86; Min: 4). Ethnically, 66.2% reported Hispanic/Latino ancestry, while another 32% identified as non-Hispanic/Latino. English was the predominant spoken language of patients at 57.2%, followed by Spanish at 41%; there were also Hindi and Portuguese speakers. In even higher numbers in comparison to diabetes and hypertension patients, obesity patients were single (62.7%), 29% identified as being married. Additionally, 61.3% of the population were female followed by males at 39%. Patients primarily lived in Longmont (27%), Commerce City (13.8%), Fort Collins (16.2%) and Denver (6%). Similarities were noted when comparing the most visited C/MHC's between diabetes and hypertension encounters; these were Longmont Salud (30%), Commerce City Salud (22%), Fort Collins Salud (20%), and Brighton Salud (10%). As with diabetes and hypertension patient population, obesity patients were to an even higher degree female at 61%, in comparison to males at 39%.

Demographic analysis of the patient encounters (n = 1,117) for chronic disease risk factors reveals that nearly half of the population (49%) identified as single, 31.2% as married, and the remaining 11.2% as divorced. The population was on average 47 years old (Max: 91; Min: 12) and primarily non-Hispanic/Latino (62.4%), with an additional 35.3% identifying as Hispanic/Latino. Additionally, 59.6% of these encounters were female, while another 40.3% of patients were male. English speakers represented 79% of

the population, followed by Spanish speakers at 19.4%. Languages also spoken by patients in this risk-factor group were Tigrinya, Nepali, Arabic, and Hindi. Patients from this group in higher numbers (19.1%) lived in Longmont, Fort Collins (12.7%), Brighton (12.1%), and Commerce City (11.8%). Health centers serving as a repository for many of the patient encounters were again Longmont Salud (22%), Brighton Salud (16.5%) Commerce City Salud (15.3%) and Fort Collins Salud (16%).

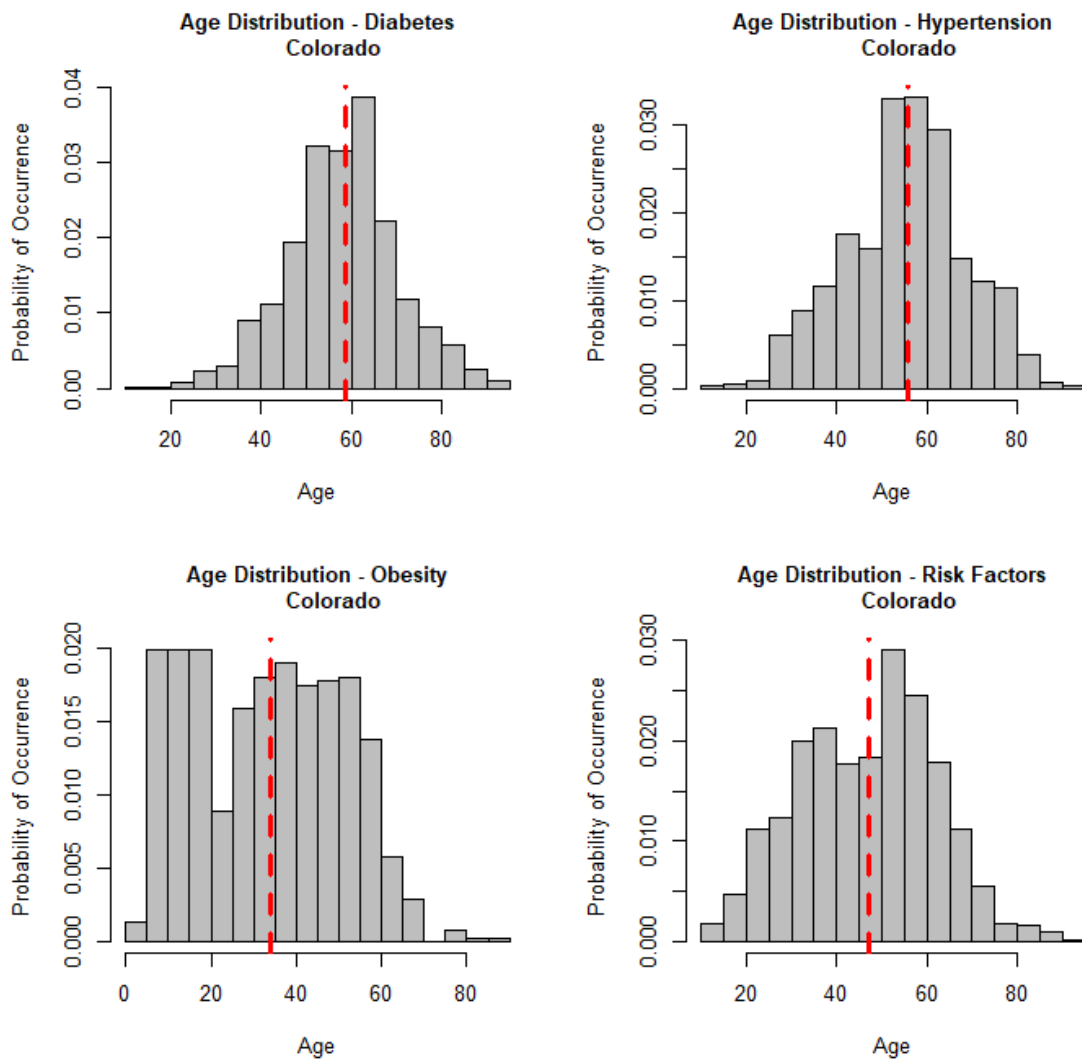


Figure 10.9 - Age distribution for MSFW patient encounters in Colorado. Notice the normal bell-shaped distribution for diabetes and hypertension, in contrast to the high density of younger patients in relation to obesity (skewed right) especially those under age 20. The favorable right-skewed distribution is defined by mean values that are greater than the median values (outliers is less than the mode).

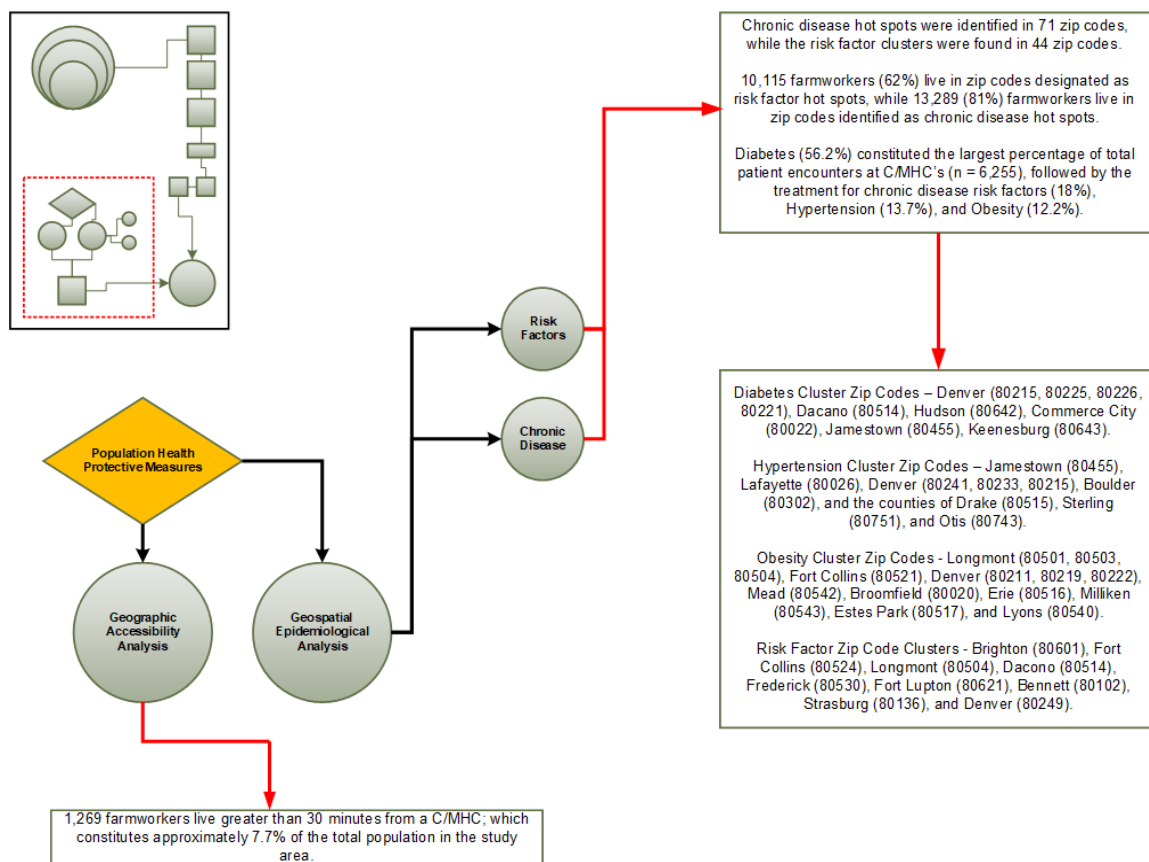


Figure 11 - Ecosocial model of farmworker health (quantitative)

CHAPTER VI.

COLORADO RESULTS: QUALITATIVE

6.1 Introduction

Fieldwork in the Greater Denver area began on June 26, 2018, at the Salud Family Health Center in Ft. Lupton, Colorado. The interviews with key informants and farmworkers ended on June 29. In total, ten interviews were conducted, including three key informants and seven farmworkers. The key informants featured the director of environmental health at the Salud Family Health Center in Ft. Lupton, an employee of the Workforce Commission of Adams County, and the manager of Petrocco Farms in Brighton, Colorado. Combined these key informants have 63 years of experience working with the farmworkers. The interviewed workers ranged in age between 25 and 62 years (average 42.5), all were men and all originated from the state of Guanajuato (*traditional sending state*) and the municipalities of Valle de Santiago and Leon. These farmworkers because of their short, repetitive, and long-term movements from Mexico (home) to the United States (host) for work practice *circular migration*. These *push-pull* factors are dictated by the demand for low-skill migrant labor in the Colorado agriculture industry and the economic incentive of higher hourly wages. The qualitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 11.1).

6.2 The Social Epidemiology of Farmworker Health

Historically, farming in Northeastern Colorado and the High Plains region have roots dating back to the late 1880s. It was not, however, until 1975 that the first community and migrant health center serving farmworkers opened in Ft. Lupton. Today,

the most abundant crop regionally is onions, with annual revenues of over \$200 million. Farmworkers in the Ft. Lupton and Brighton area live and work in the fertile South Platte River drainage basin, in the populated Colorado Front Range, while those working in the eastern part of the study area live in the Eastern Plains, which are known as the westernmost portion of the Great Plains. The climate of Northeastern Colorado and the Denver metropolitan area is characterized as a middle-latitude semi-arid (Koppen climate classification - BSk) with a total of 10 -20 inches of precipitation annually and four distinct seasons (Colorado Climate Center, 2012).

The regions aridity means that substantial financial resources go directly to water irrigation projects, much of which must be pumped directly from the Ogallala Aquifer (United States Geological Survey 2010). The smooth, isolating and seemingly endless expanses of the High Plains are problematic for farmworkers, especially those in need of medical care working in the region without access to a vehicle. This fact is evident when examining geographic accessibility, especially in eastern Colorado, where the drive time from Phillips and Sedgwick counties to the nearest C/MHC in Sterling is 61.4 and 50.9 miles, respectively.

The barriers to care for farmworkers and their families in Northeastern Colorado are numerous, as is the burden of chronic disease among both children and adults. The social determinants of farmworker health regionally range from socio-economic factors like poverty, lack of transportation, language barriers, and the availability of health information for the improvement of healthcare literacy. Often the healthcare information disseminated by care providers is too technical and advanced for the workers when compared to their level of education: one key informant estimated that 90% of the MSFW

population in the Greater Denver area did not have a high school diploma. It is common for the children of farmworkers to serve as the translators for their parents in clinical settings. Those seeking treatment at C/MHC's are often woman and children, while men only visit the doctor when they are severely ill or injured.

Distrust of the healthcare system is relatively common, as are low levels of educational attainment (4 - 6th grade), healthcare costs, and the continued reliance on cultural practices which promote self-medication and the usage of natural home remedies and herbal products from Mexico. These barriers in the past included lack of community health funding, which caused significant issues in treating the population in the mid - 1980s and early 1990s. This was followed by a marked increase in funding for community and migrant health in Colorado, which now is estimated at over \$200 million annually (\$11 million for migrant health), with strong bi-partisan support at the state and local level. Transportation options are limited, and the funding towards transportation services for farmworkers has moved away from such programs and more into improving clinical outcomes and mobile services. Solutions to solving transportation problems produced limited responses from the key informants; one informant believed that the problem was "too big" to solve and that there is "not much interest" in investing funds into the issue.

Access to fresh foods and vegetables is another dominant issue for the population, especially along the I-25 corridor, stretching from Denver to Wellington. The director of environmental health at the Salud Family Health Center in Ft. Lupton described the dietary habits of the farmworkers in this area as practicing what he called the "I-25 diet", due to the propensity for MSFW's to consume fast food and processed food products.

Additionally, he described the situation with diabetes as being one that has accelerated since he first started working with the population in 1985, with many more cases among both adults and children, as well as an increase in the BMI of farmworker children due to the availability of sweets. Likewise, the manager of Petrocco Farms commented that in the last two years, more people had been diagnosed with diabetes than she could remember in the past. These marked increases are also related to cultural practices like the continued reliance on traditional foods from Mexico and Central America, and the mixing of these dietary habits with those of the staple American diet.

Demographics shifts regionally were also reported by the key informants. These shifts first started in the early-1990s with the decrease in European immigrants from the Czech Republic and the former Soviet Union, as well as indigenous Kickapoo people (Algonquian-speaking) and Haitians. Areas near Ft. Lupton were also the site of WWII Japanese internment camps. Upon release, some of the Japanese-Americans worked as farmworkers and further purchased land for local commercial agricultural production. Today the population is composed primarily of young men in their 20s and 30s from Mexico and Central America who travel alone. It is not typical to find many older workers especially if they are working in the fields; however, this was not the case in this study, where a wide range of older (62) and younger (25) men were interviewed. Women are commonly seen in the preliminary stages of planting in the spring and by the start of the summer move to warehouses and greenhouses scattered throughout the Western South Platte River basin. Outside of a majority Mexican and Central American population, small pockets of immigrants from Myanmar and Syria work in commercial horticulture greenhouses in Brighton and Denver.

Locally, farmworkers in the Greater Denver area have experienced a variety of responses politically when it comes to their representation. Locally in the counties from Denver to Fort Collins, government officials are supportive to farmworkers and understand how critical these workers are to the agriculture industry in Colorado. One key informant described the situation as ‘mixed,’ with the clear majority (9 out of 10) of the non-farmworker civilian population supporting farmworkers. This may be due to their historical presence in the area since the late-19th and early 20th century. The manager of Petrocco Farms commented that the men who work on the farm are not aware of the current political climate and would only be concerned if it hurt their health directly. Unfortunately, the legal workers (H2A – visa) are grouped in with ‘illegal’ immigrant population, which has led to a misrepresentation of the MSFW population both locally and nationally.

Like the demographic shifts of the early-1990s, migration patterns have fluctuated towards increasing numbers of solo male H2A workers and fewer family units. The traditional migrant streams previously featured workers from Texas, New Mexico, Florida, and Michigan. Today this is not the case as the traditional streams have ultimately “disseminated” outward and have been replaced by mixed streams of workers primarily from Guanajuato, Chihuahua and Jalisco, Mexico. Different responses from the key informants on the total number of workers traveling alone to the area ranged from 700 – 7,500 per season, with 15 – 20% of the total MSFW population classified as migrating alone. *Point-to-Point* migration is the most common form of migration according to the key informants, with migrant workers traveling to the same location for work year after year from Mexico. These migration patterns are a contributing factor to

high rates of anxiety, depression, and stress due to the pressures of frequent travel, lack of family support, and uncertainty of future job security.

Often the stress, anxiety, and depression of these workers increase when they enter the United States for work. A key informant stated that the farmworkers “envision when they leave Mexico that their stress will go away” and that their social class in Mexico is “much higher” until they enter the United States when their social class drops considerably. Furthermore, stress, anxiety, and depression among the population is amplified by cases of labor trafficking, and in the past, child exploitation. All three key informants believed that by improving healthcare and disease surveillance programs, that this would improve the delivery of healthcare services to MSFW’s. Local counties with large farmworker populations would benefit from the implementation of programs emphasizing not only increased surveillance but also a better understanding of underserved geographic areas. Previous efforts in Colorado by the Centers for Disease Control (CDC) were centered on HIV/AIDS surveillance programs within farmworker populations and less on examining the burden of chronic disease.

Interviews with farmworkers took place on-site with the assistance of an Ft. Lupton Salud mobile clinical staff at a farmhouse northwest of Ft. Lupton. This mobile unit consisted of three registered nurses, two physician’s assistants, and a driver who served as a liaison between the farmworkers and staff. The small, two-bedroom dilapidated farmhouse, which appeared abandoned from the road, housed fifteen men from Petrocco Farms, the largest employer for both migratory and seasonal farmworkers in the area. These workers shared mixed perspectives when asked about their access to healthcare. Most of the workers (n = 5) expressed that they have “full access” to essential

(primary) healthcare services; while a minority of respondents ($n = 2$) communicated their access as limited due to an inability to find a ride to a local health center or being unable to obtain a personal vehicle.

The majority of respondents also expressed that they have “full access” to fresh fruits and vegetables, while one farmworker claimed that following a healthy diet was difficult due to the long hours, he worked each day. In assessing migratory or seasonal status and agriculture as their primary source of employment, 6 out of the 7 interviewees migrated alone each year for work in Colorado from Mexico and worked in agriculture year-round in both the U.S. and Mexico. One respondent lived in the Ft. Lupton area year-round, while another worked full-time as a plumber and electrician when he returned to Mexico in the winter. The mean age for starting work in agriculture for all respondents was 13 years of age (lowest = ten years old), and all expressed that they were in “good to very good health.” Emotional health was strong among the workers, and all expressed that they had experienced little stress, anxiety, or depression, with one respondent expressing that he “tries not to think of his issues,” and instead “stays busy.”

In asking about their experience with chronic disease, only two respondents had diagnosed conditions related to diabetes (Type 2) and Essential Hypertension. One farmworker shared that he believed that he “did not have a bad form of diabetes,” while another said that he had “felt more tired” and lethargic since his diagnosis and that this had negatively affected his personal and work life. The obvious lack of healthcare literacy among this group was evident, and the staff at Salud is tasked with providing educational resources to these men on how to properly use toiletries like toothpaste, lotion, and over the counter medications like ibuprofen. Regarding how often the workers

visited a physician, the responses ranged from “very rare,” to “up to 3 times per year”. However, many of the farmworkers did not use the local community and migrant health centers in the area for treatment, and either did not know about the location of the clinic in Ft. Lupton or used an emergency room or urgent care facility for their healthcare needs.

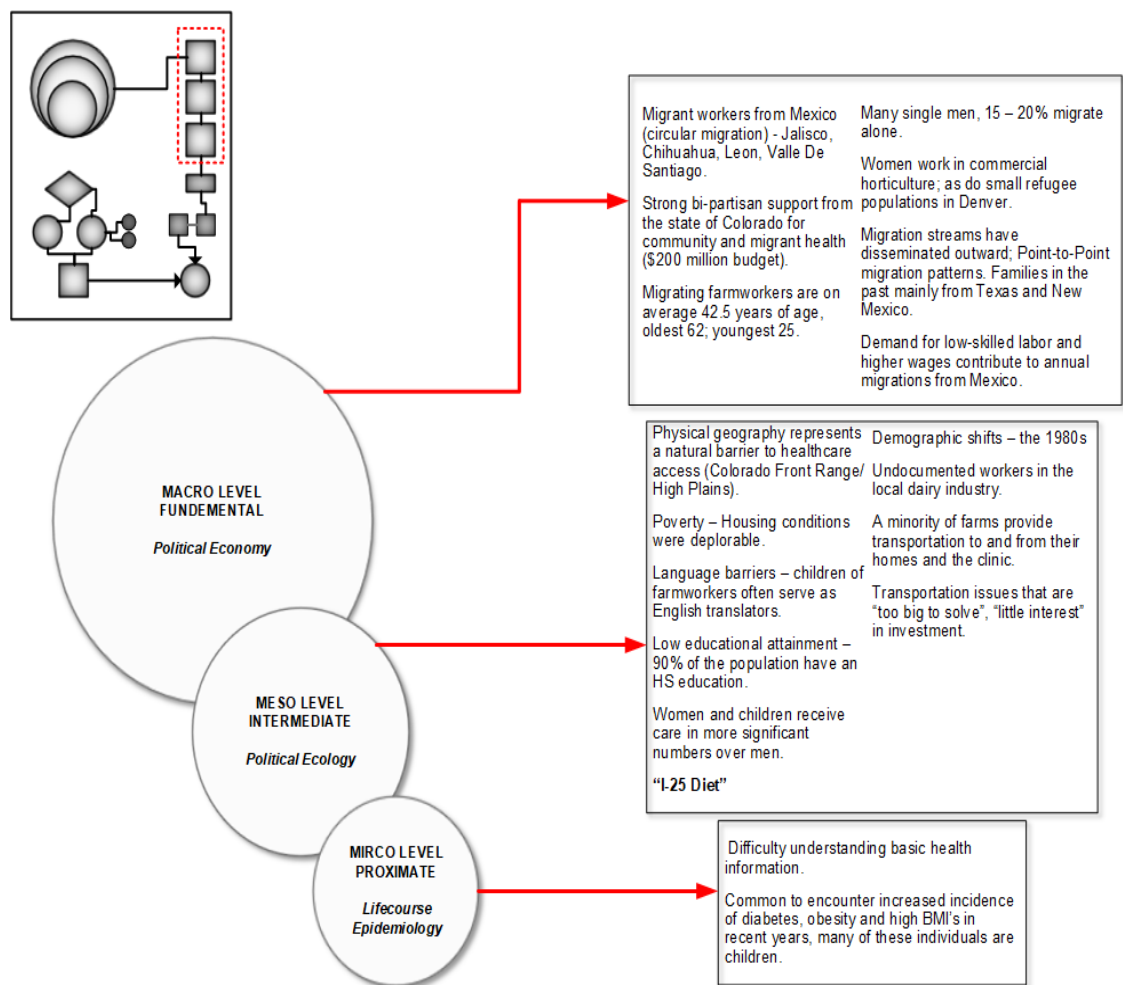


Figure 11.1 - Ecosocial model of farmworker health (qualitative)

CHAPTER VII.

MICHIGAN RESULTS: QUANTITATIVE

7.1 Introduction

The following section summarizes the results of the chronic disease and risk factor cluster detection, healthcare accessibility, and demographic analysis in Michigan. In total, 825 farmworkers lived greater than 30 minutes from a C/MHC; this constituted 10.2% of the total population in the study area (n = 8,048). Chronic disease hot spots were found in 64 zip codes, while the risk factor clusters encompassed 36, respectively. Additionally, 7,809 farmworkers (97%) were in zip codes designated as chronic disease hot spots, while 4,632 (57%) live in risk factor zip codes. Diabetes (49.3%) constituted that largest percentage of total patient encounters (n = 3,463), followed by hypertension (25%), chronic disease risk factors (16%), and obesity (10.1%). Further information and the corresponding tables for the chronic disease and risk factor clusters are found in the appendix section. The quantitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 12.2).

7.2 Quantitative Results

Accessibility to C/MHC's

Geographic accessibility to community and migrant health centers (C/MHC) are presented in Figure 11.2. Most farmworker populations in the study area are concentrated in threshold zones between 10 – 20 minutes' drive time from C/MHC's. It was further determined that 825 farmworkers lived beyond the 30-minute "excessively distant"

threshold. In comparison to Colorado, farmworkers in Michigan as a percentage of the total population have a higher number of workers (10.2%) living at least 30 minutes or greater from a C/MHC. This fact coupled with the rurality of Western Michigan guarantees that many farmworkers may not have an opportunity to visit a local C/MHC for medical treatment. The geographic distribution of some patients stretches beyond the 60-minute drive time threshold into portions of Cass, St. Joseph, Branch, Calhoun, Barry, Ionia, Montcalm Newaygo, and Muskegon counties, and further into parts of the northern Indiana counties of Elkhart, LaGrange LaPorte, and St. Joseph.

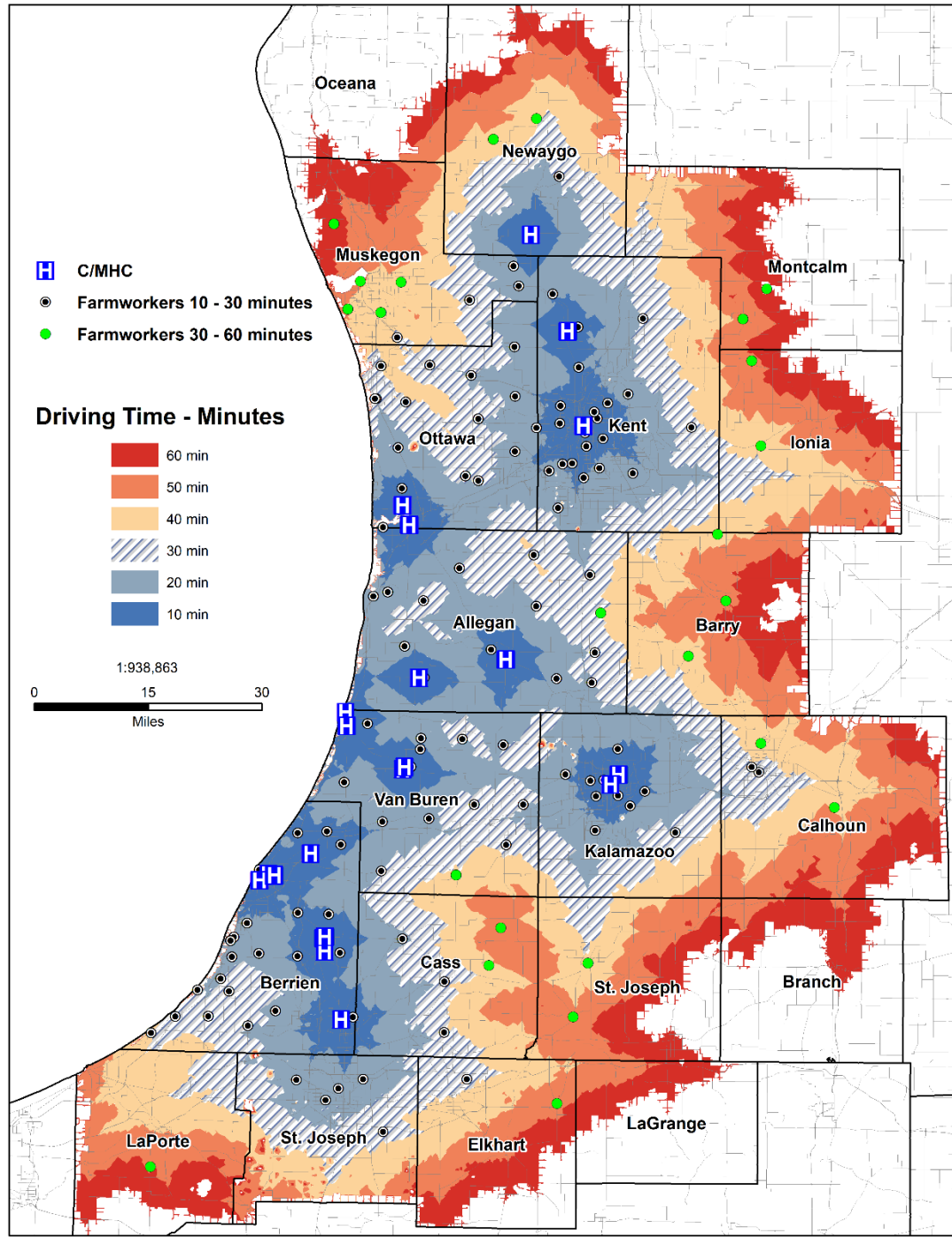


Figure 11.2 - Geographic accessibility to C/MHC's (Michigan)

Chronic Disease and Risk Factor Hot Spots

In Western Michigan, the geographic distribution of zip codes designated as hot spots for seasonal and migratory farmworker diabetes encounters are presented in figures 11.3 and 11.4. The top clusters, when compared between groups, are concentrated in the south and central portion of the study area, in the counties of Berrien, Cass, Van Buren, Kalamazoo, Allegan, Ottawa, Muskegon, and Newaygo. Tests of cluster sensitivity determined that the best performing MSWS for seasonal diabetes encounters was reached at 40% of the at-risk-population (P -Value: < 0.0001 – 0.9955; Gumbel P-Value: 0 – 0.9879) (clusters = 9), which totaled 171 observed and 79.77 expected encounters, an LLR of 51.59, and a relative risk (RR) of 27.29. Tests on the migratory diabetes dataset produced 12 clusters (P -Value: < 0.0001 – 0.9997; Gumbel P-Value: 0 – 0.9957) and robust performance when the MSWS was set to include 30% of the at-risk population. Observed encounters in these clusters totaled 206, with 71 expected, an LLR of 111.36, and a relative risk (RR) of 78.76. Communities making up these zip codes include Benton Harbor (49022), Saint Joseph (49085), Baroda (49101), Eau Claire (49111), Sodus (49126), Holland (49423), Coloma (49038), and Covert (49043). Clusters were also found in Decatur (49045), Dowagiac (49047), Hartford (49057), Lawton (49065), Byron Center (49315), Pullman (49450), Wyoming (49519), Bailey (49303), Fremont (49412) and Berrien Center (49102).

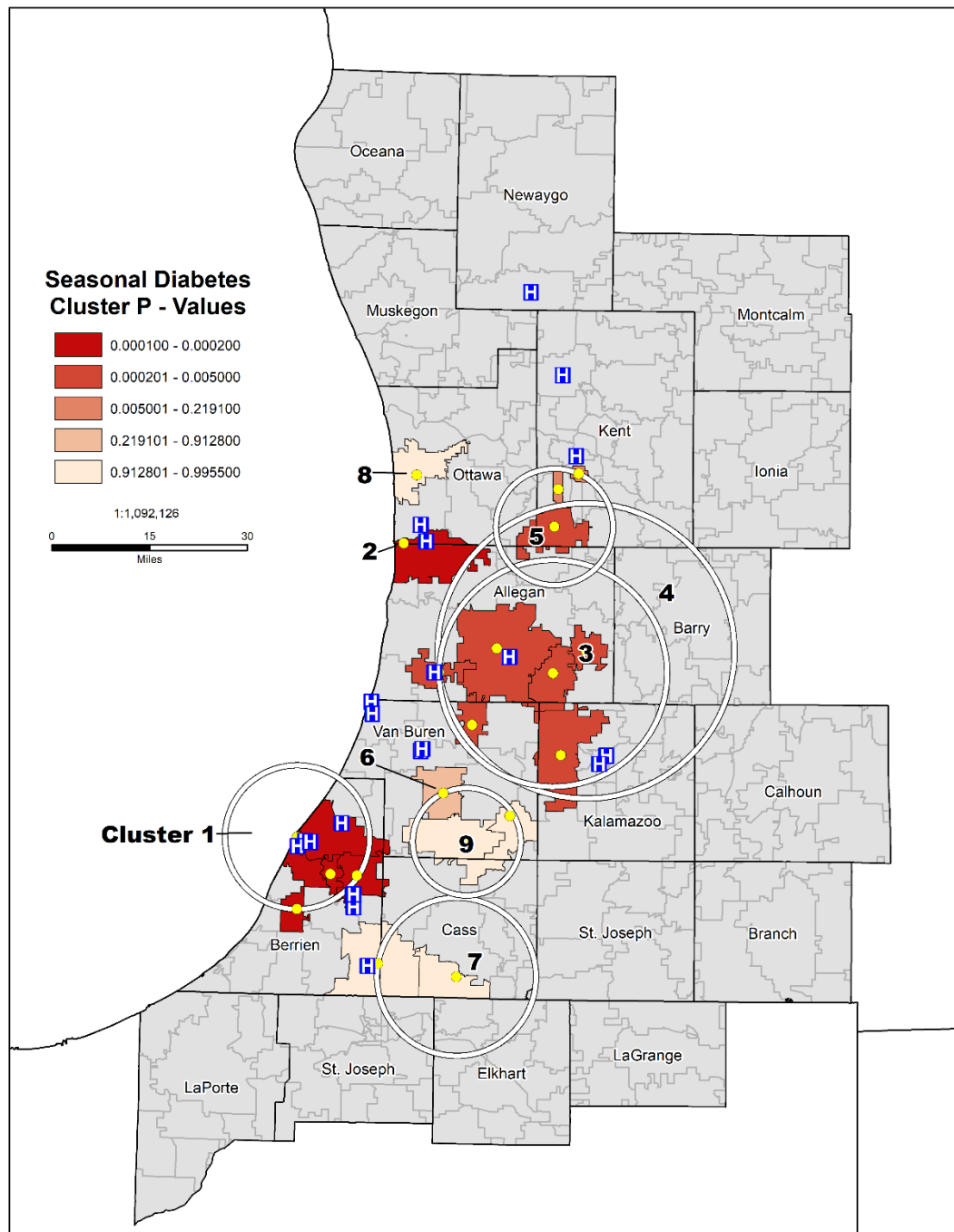


Figure 11.3 – Seasonal diabetes (Michigan)

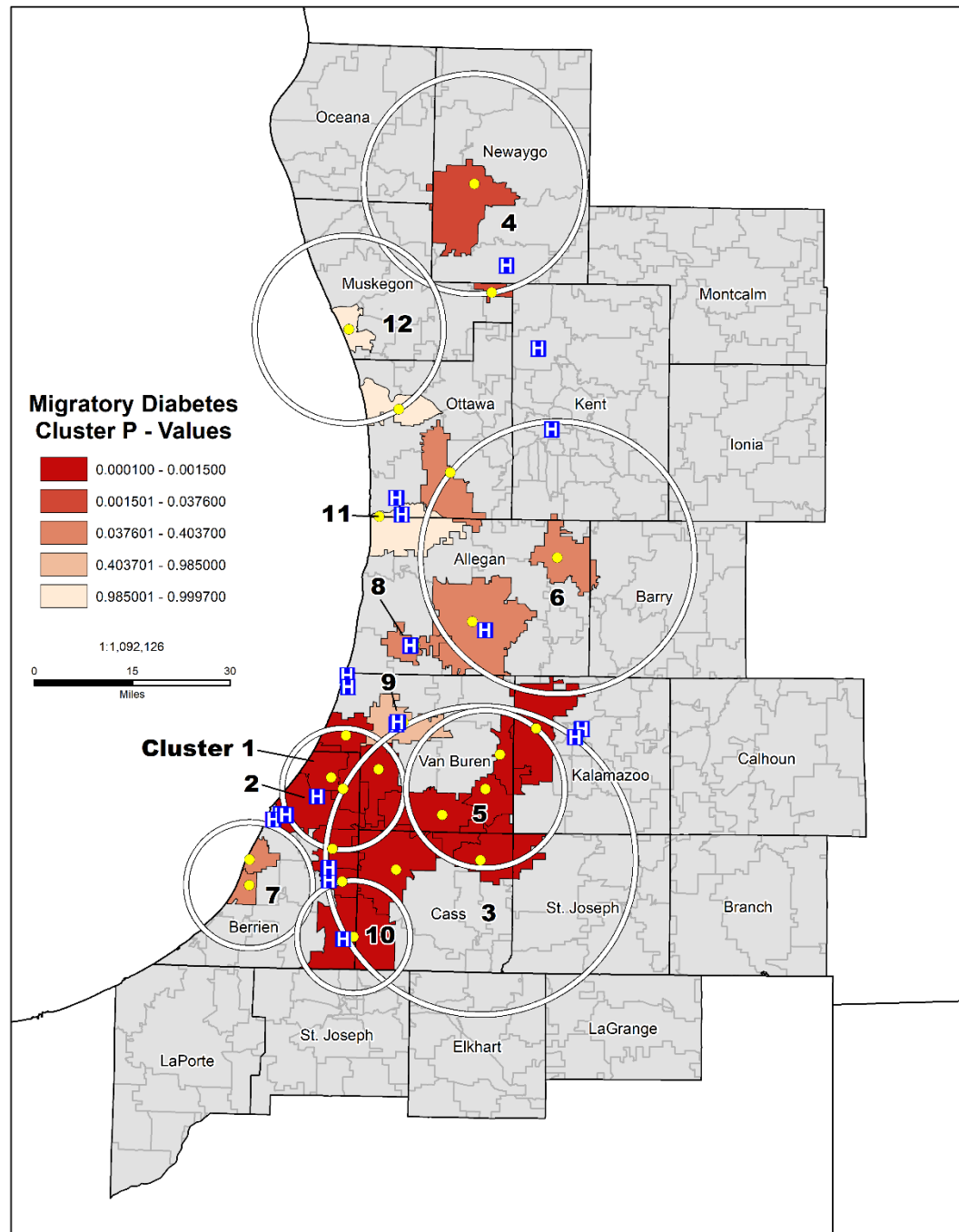


Figure 11.4 – Migratory diabetes (Michigan)

Seasonal and migratory hypertension clusters (Figure 11.5 & 11.6) are concentrated in a north-south orientation, with the highest concentration of zip codes in Berrien, Van Buren, Cass, Allegan, Kent, Muskegon, and Ottawa counties. Measures of cluster sensitivity for seasonal hypertension encounters favored an MSWS of 30% of the at-risk population for optimal performance. In their entirety, these 4 clusters (P – Value: $< 0.0001 - 0.0024$; Gumbel P-Value: $0 - 0.0018$) featured 281 observed versus 63.75 expected patient encounters, an LLR of 250.88 and a relative risk (RR) of 39.20. Communities included in these clusters include Kalamazoo (49007), Allegan (49010), Bangor (49013), Portage (49024), Grand Junction (49056), Benton Harbor (49022), Saint Joseph (49085), Bloomingdale (49026), Ravenna (49451), Eau Claire (49111), Dowagiac (49047), Cassopolis (49031) and Paw Paw (49079). On the contrary, migratory hypertension encounters performed better with an MSWS of only 20% of the at-risk population, which produced clusters ($n = 6$) with 226 observed and 63.56 expected patient encounters as well as a relative risk of 40.19 and an LLR of 177.84. Communities within these clusters include Benton Harbor (49022), Saint Joseph (49085), Allegan (49010), South Haven (49090), Fennville (49408), Pullman (49450) and Saugatuck (49453). The geographic distribution displays stronger spatial dependency in the southern portion of the study area in the counties of Allegan, Van Buren and Berrien.

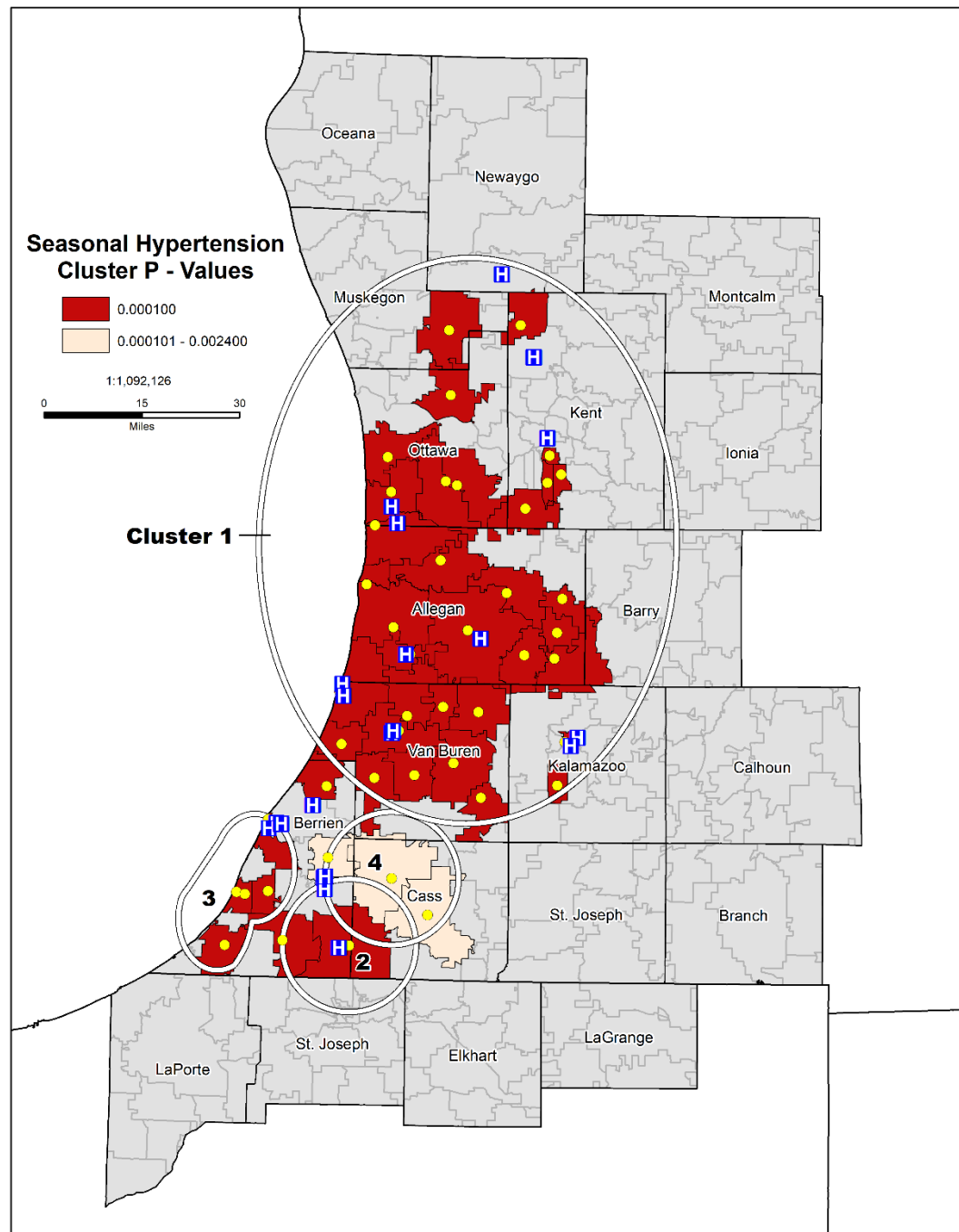


Figure 11.5 – Seasonal hypertension (Michigan)

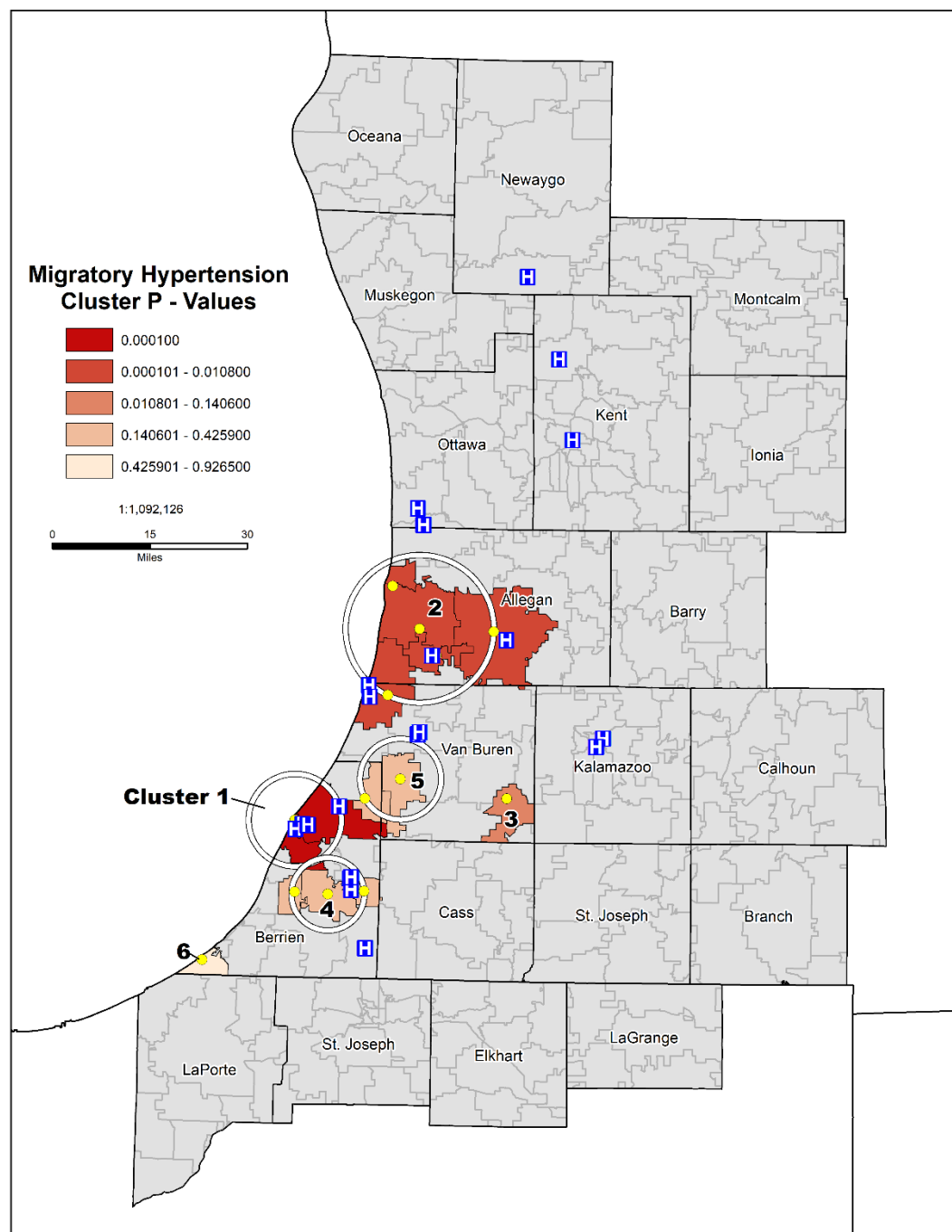


Figure 11.6 – Migratory hypertension (Michigan)

The geographic distribution of MSFW obesity encounters displays (Figure 11.7 & 11.8) similarities and considerable overlap. Similarities are clear when comparing zip code clusters in Van Buren, Berrien, Ottawa, and Cass counties. Measures of cluster sensitivity for seasonal encounters determined that an MSWS of 40% of the at-risk-population (clusters = 6) as the strongest parameter when ranking the MSWS from 10 – 50%. These six clusters (P – Value: < 0.0001 – 0.7542; Gumbel P-Value: 0 – 0.7524) featured 160 observed and 79.69 expected patient encounters, a relative risk (RR) of 30.94 and an LLR of 69.05. Communities included in these zip codes include Lawrence (49064), Decatur (49045), Benton Harbor (49022), Dowagiac (49047), Hartford (49057), Coloma (49038), Lawton (49065), Martin (49070), Grand Haven (49417), Hamilton (49419), Holland (49424) and Paw Paw (49079). Similarities in cluster performance were noted when examining migratory patient encounters. Optimal SaTScan performance was reached when the MSWS is set at 40% of the at-risk-population, which in turn produced 5 clusters (P – Value: < 0.0001 – 0.9998; Gumbel P-Value: 0 – 0.9952) with a relative risk (RR) of 48.96, an LLR of 42.47, and 103 observed versus 48.70 expected patient encounters. Communities included in the number 1 obesity cluster include Bangor (49013), Benton Harbor (49022), Coloma (49038), Covert (49038), Dowagiac (49047), Hartford (49057), Eau Claire (49111) and Sodus (49126).

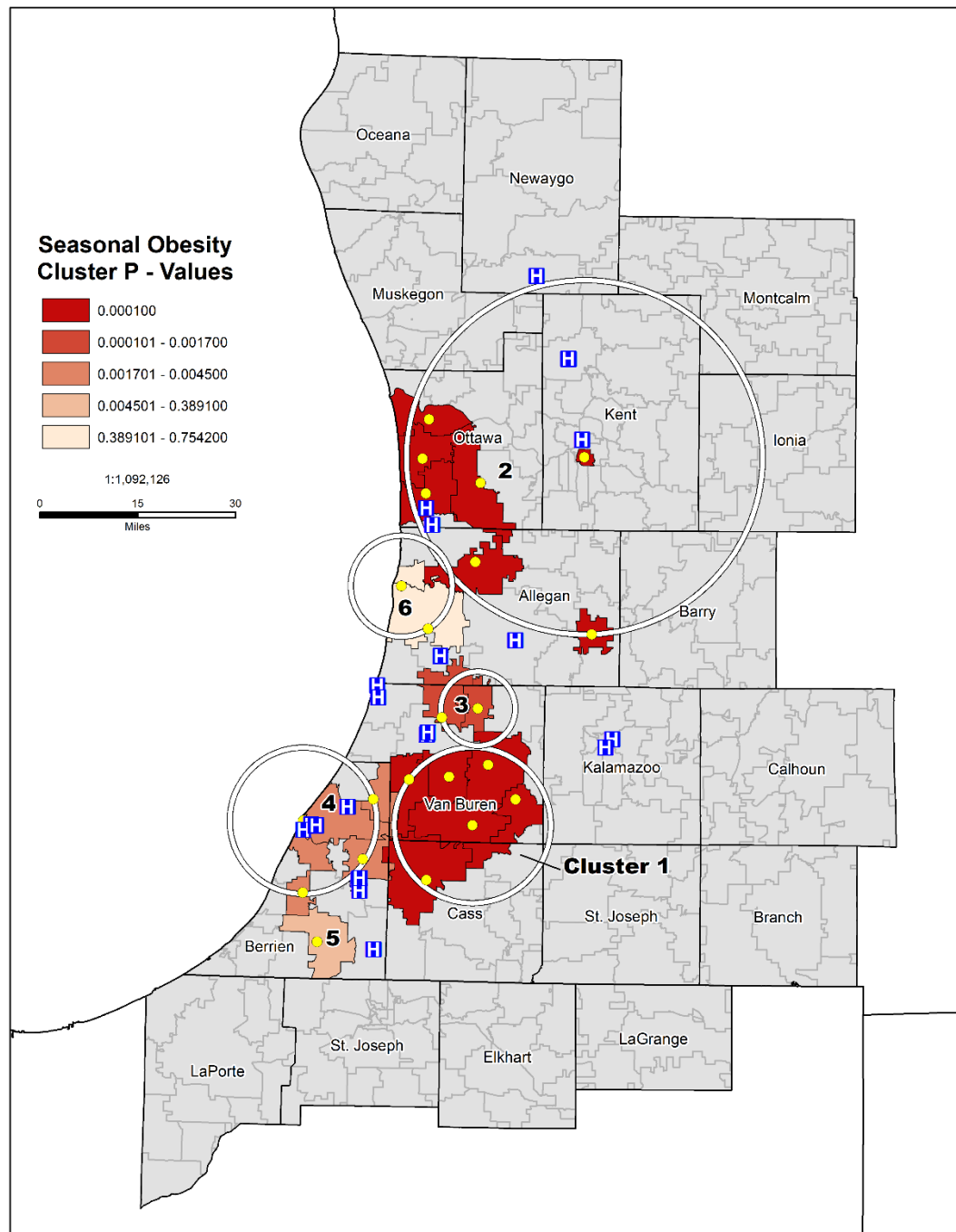


Figure 11.7 – Seasonal obesity (Michigan)

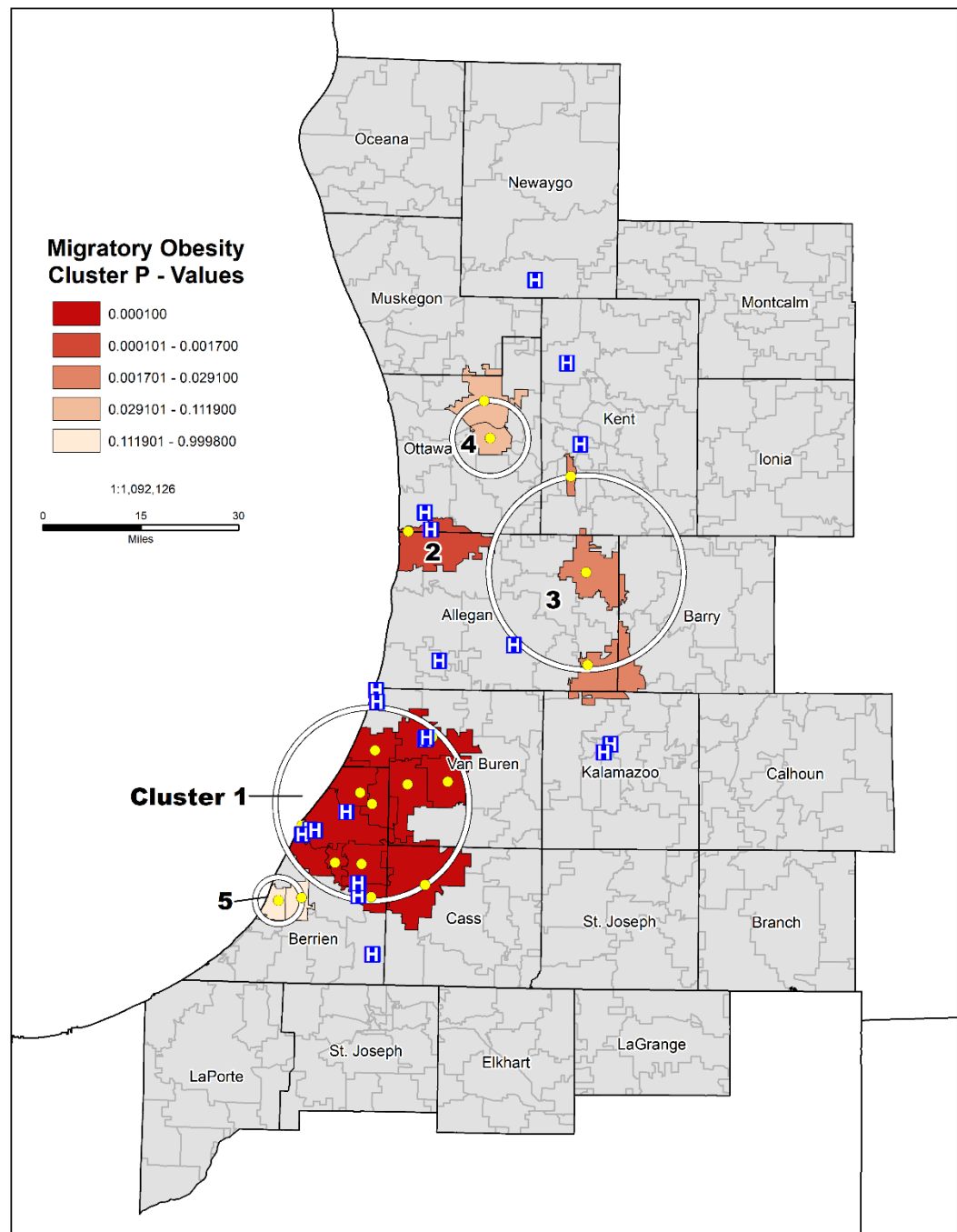


Figure 11.8 – Migratory obesity (Michigan)

The geographic distribution of chronic disease risk factors related to anxiety, depression, stress, and tobacco use like seasonal hypertension encounters is widespread and displays clustering in Ottawa, Kent, Allegan, Van Buren, Kalamazoo, Berrien, and Cass counties (Figure 11.9). Many communities and zip codes in this dataset overlap with those of the chronic disease analysis; however, variations are present, particularly in rural St. Joseph County (49091 – Sturgis; 49093 - Three Rivers). Measures of cluster sensitivity for chronic disease risk factors indicate strong performance when an MSWS of 10% of the at-risk-population was selected (clusters = 12). Within these 12 clusters (P – Value: < 0.0001 – 0.0004; Gumbel P-Value: 0 – 0.0002), 166 observed and 15.36 expected patient encounters were recorded, accounting for a relative risk (RR) of 302.30 and a test statistic (TS) of 276.92. Zip codes included in these clusters include Berrien Center (49012), Eau Claire (49111), Sodus (49126), Holland (49423), Kalamazoo (49004), Cassopolis (49031) and Decatur (49045). Additionally, patient encounters for both seasonal and migratory farmworkers were compared to the long-term temperature averages for Eau Claire, Michigan from 1981 – 2010 (Figure 12) (NOAA – National Climatic Data Center, 2018), which reveals that temporally, as in Colorado, dips in patient encounters are observed during the summer months, while the months of January through May are the most active periods for visits to C/MHCs for both the treatment of chronic disease and their associated risk factors.

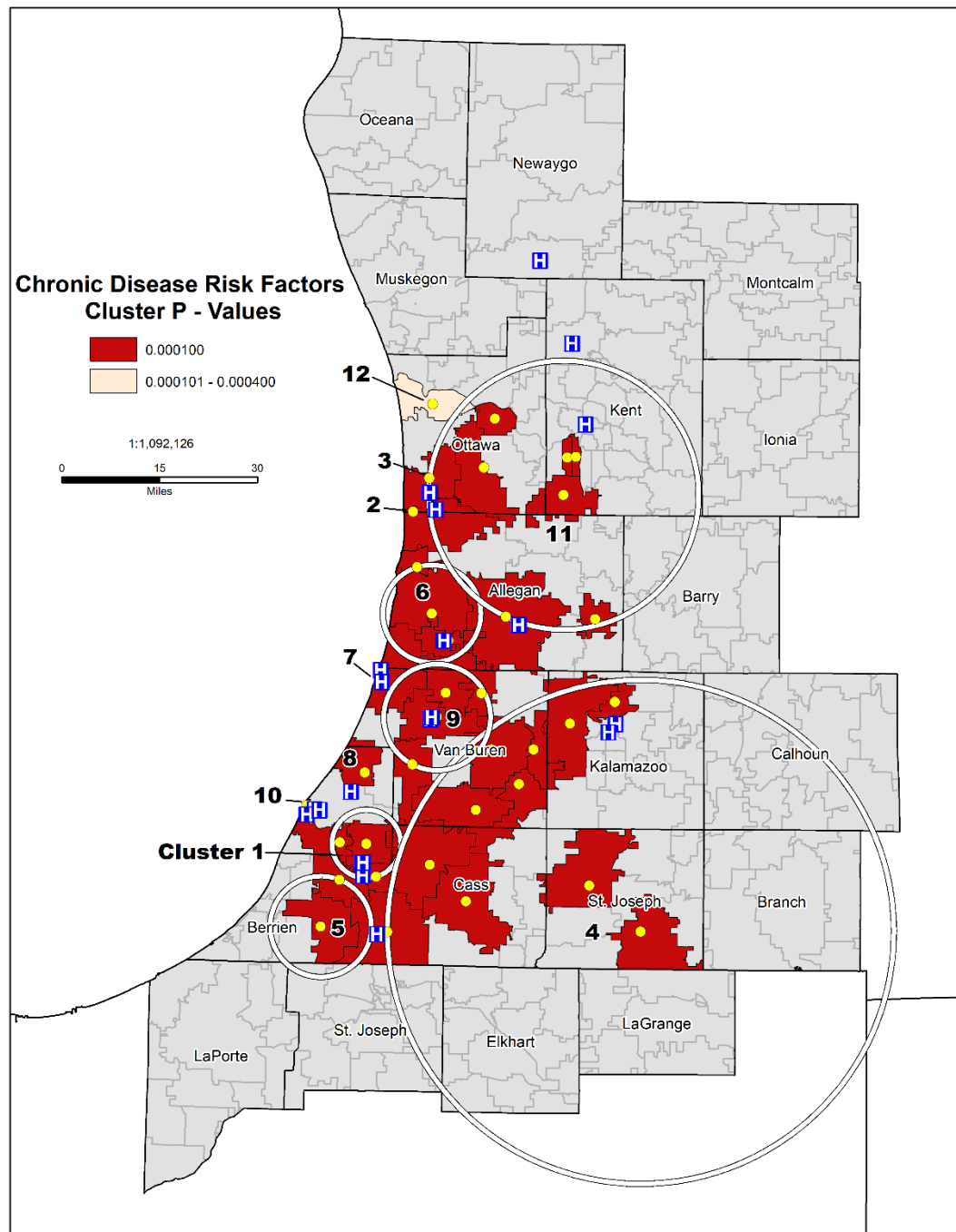


Figure 11.9 – Chronic disease risk factors (Michigan)

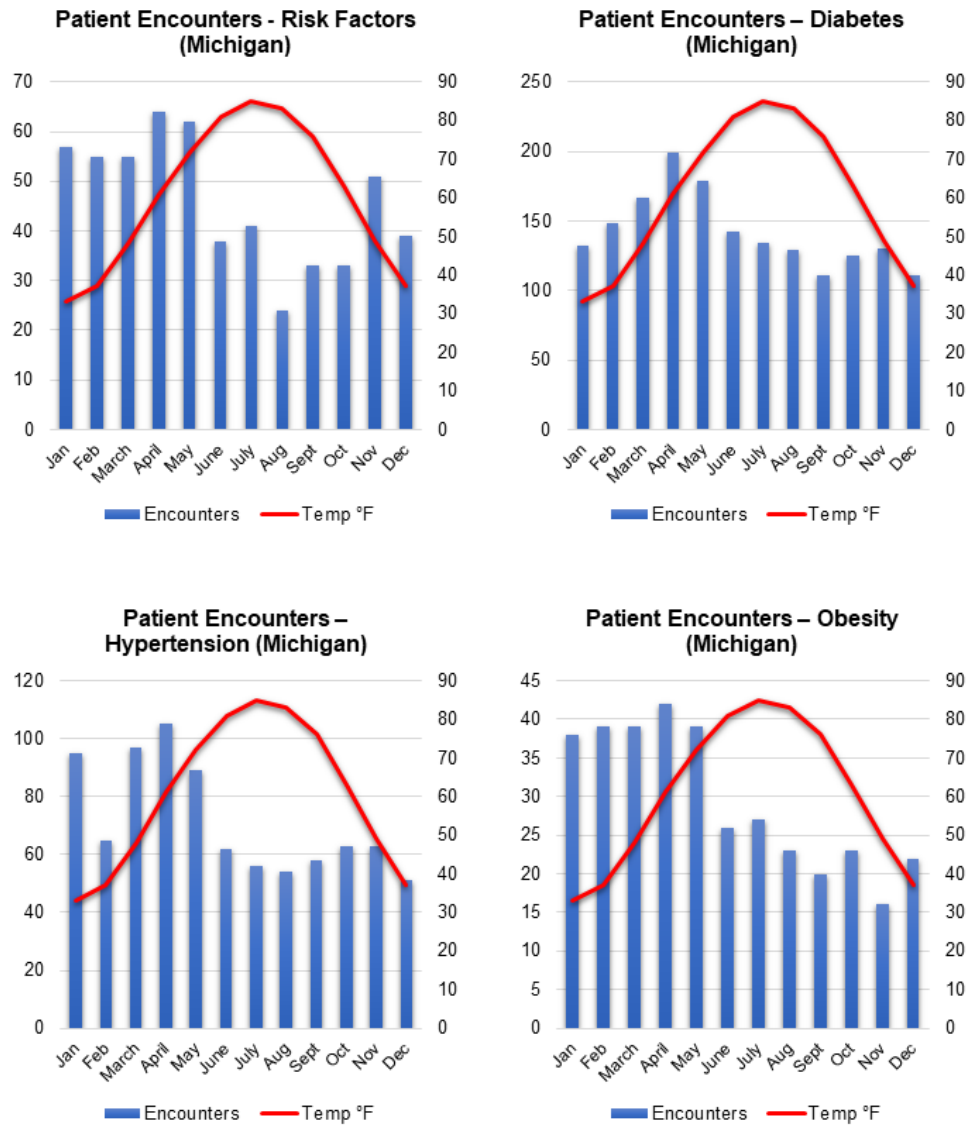


Figure 12 - Michigan patient encounters in relation to temperature averages

Demographics

Demographics for farmworkers from both groups were analyzed based on encounters for the treatment of chronic disease and their associated risk factors (Figure 12.1). Statistics for diabetes encounters (n = 1,709) determined that the mean age for seasonal and migratory farmworkers was 57 years of age (max: 97; min: 14) and that the patient population was primarily female (59%) (male – 39%). The predominant ethnic composition was non-Hispanic/Latino (72.5%), followed by Hispanic/Latino (26%). Many patients spoke English (80.4%) and Spanish (18%), however, a small minority spoke Chinese (0.006%; 11 people) and Portuguese. Nearly 40% of all patients were married, 38.3% were single, and another 0.09% divorced. The most frequently visited C/MHC's were in East Benton Harbor (ICH) (46.6%), Holland (ICH) (20.7%), Bangor (ICH) (12%), Pullman (ICH) (0.09%), and Eau Claire (ICH) (0.08%). These farmworkers lived in Benton Harbor (40%), Holland (15.3%), and Bangor (0.03%).

Demographics for hypertension encounters (n = 858) revealed that the mean age of all patients was 56 years old (Max: 97; Min: 13). Ethnically, the composition was predominately non-Hispanic/Latino (82%) and 18% Hispanic/Latino. Languages spoken again favored English (87%) and Spanish (12%); however, there were also Cambodian, Chinese, Haitian, Portuguese, Thai, and Russian speakers. Marital status was nearly evenly split between single respondents (39%) and married respondents (36%), with nearly 15% identifying as divorced. These farmworkers were again predominately female (54.5%), while males made up 45.4% of the population. The bulk of these individuals again lived in Benton Harbor (41.3%), and Holland (11.3%), and the most visited C/MHC's regionally for hypertension treatment were East Benton Harbor (ICH) (51%),

Eau Claire (ICH) (10.2%), Holland (ICH) (8%), and Bangor (ICH) (7%).

Obesity encounter demographics (n = 352) reveal a younger population, with a mean age of 44 years old (Max: 86; Min: 8). Ethnically, 63.2% reported non-Hispanic/Latino ancestry, while 34.7% identified as Hispanic/Latino. English was the predominant spoken language of patients again at 74.5%, followed by Spanish at 25.4%. Patients were primarily single (48%), 38% identified as being married, and 11% divorced. Unlike the previous data on Diabetes and Hypertension encounters, 7 of 10 patient were female (71.4%), with males only making up 28.5% of the population. These patients again had a higher propensity of living in Benton Harbor (36%) and Holland (14%). The most visited C/MHC's were identical to those health centers treating patients for Diabetes and Hypertension. Benton Harbor (ICH) received 36% of all patient encounters followed by Eau Claire (ICH) (12.4%), and Holland (ICH) (10%).

Demographic analysis of the patient encounters (n = 544) for chronic disease risk factors reveals that half of the population (51%) identified as single, 27.3% as married, and the remaining 14% as divorced; while an additional 70% were female and 30% male. The population had the same mean age as Obesity patients at 44 years old (Max: 94; Min: 11), but was comprised of 83% non-Hispanic/Latino, and 15.7% Hispanic/Latino, a complete reversal from the chronic disease patients. English speakers represented 90% of the population, followed by Spanish speakers at 8.6%. Languages also spoken include Cambodian, Russian, and Chinese. Patients from this group lived in Benton Harbor (26%), Holland (15.2%), and Saint Joseph (5%). The bulk of these patients received treatment at the East Benton Harbor (ICH) (26.2%), Holland (ICH) (16.3%), and Bangor (ICH) (12.5%).

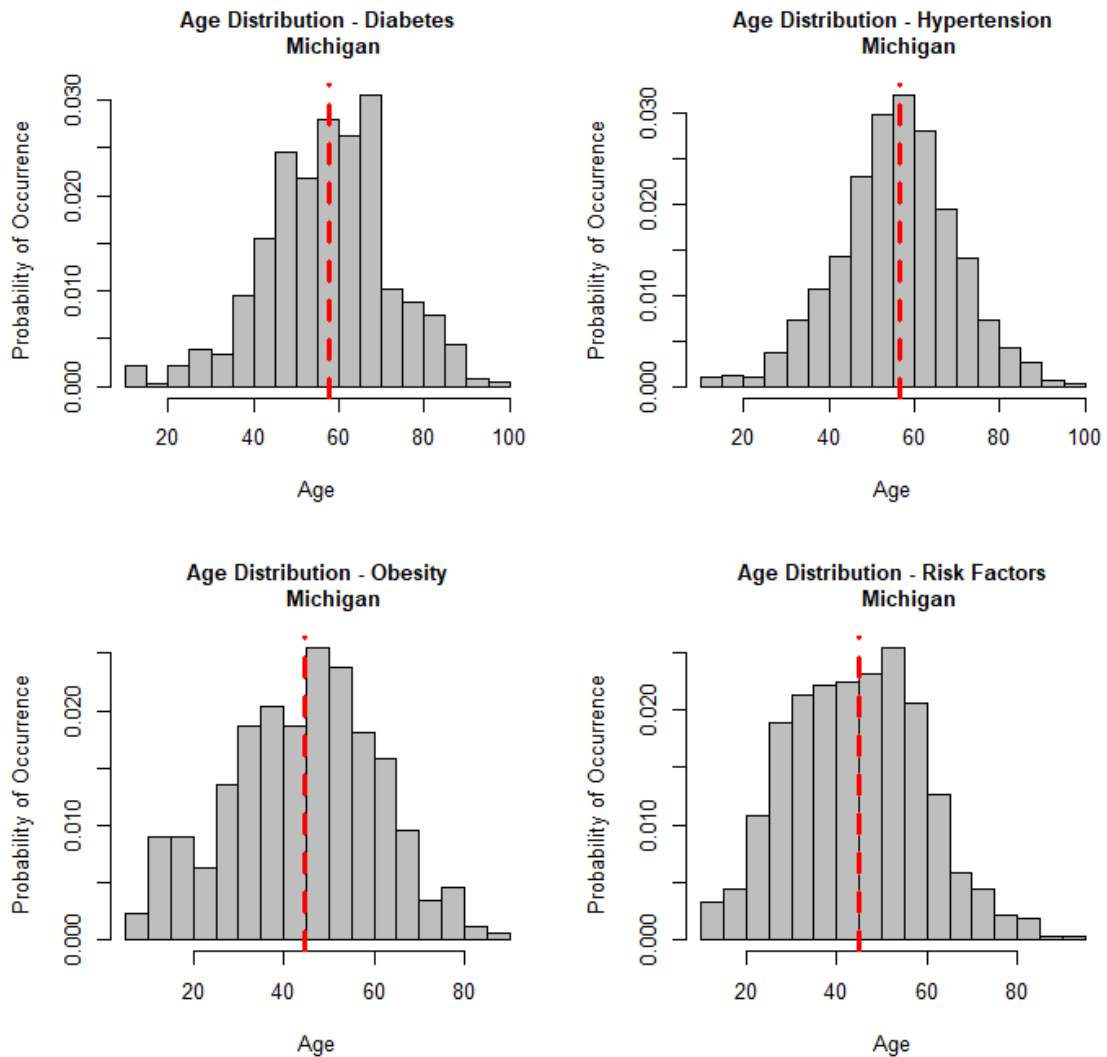


Figure 12.1 - Age distribution for MSFW patient encounters in Michigan. In comparison to Colorado, the population for obesity encounters, is older, with less probability of younger patients. The distribution of diabetes, hypertension and risk factor patients is nearly identical when compared for age alone. Diabetes, hypertension, and obesity values are represented as a bell-shaped normal distribution, while risk factors are positively skewed to the right.

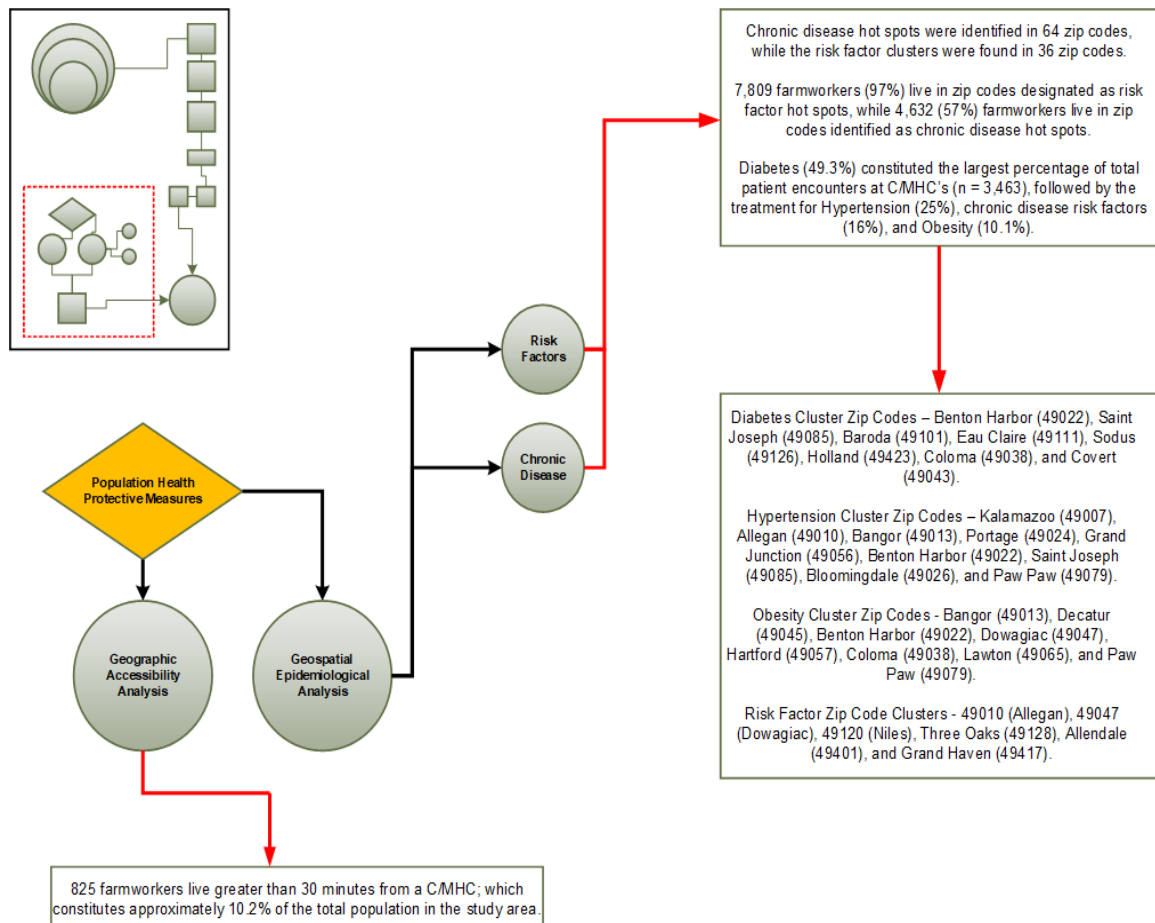


Figure 12.2 - Ecosocial model of farmworker health (quantitative)

CHAPTER VIII.

MICHIGAN RESULTS: QUALITATIVE

8.1 Introduction

Fieldwork in Michigan began on August 15, 2018, at the Intercare Community Health Center (ICH) in Bangor, Michigan. The interviews with key informants and farmworkers ended on August 16, 2018. In total, twelve interviews were conducted, with two key informants and ten farmworkers. The key informants were the regional outreach coordinator and community service manager. Combined both have over three decades of experience providing healthcare services to farmworkers and their families. In comparison to Colorado, the farmworkers in the region were younger and ranged in age between 21 and 38 years old (average 29.8 years). Similarities were seen in that these workers like their Colorado counterparts migrated yearly for work from the southern Mexican states of Morelos and Guerrero (*non-traditional* sending states). These workers practice both domestic migration (eastern stream), and *circular migration* because of their propensity to travel from Mexico to the United States for short periods for employment. Workers domestically make their homes in Plant City and Defuniak Springs, Florida, Mississippi, and Georgia. The qualitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 12.3).

8.2 The Social Epidemiology of Farmworker Health

The relationship between migratory and seasonal farmworkers and the communities of Western Michigan has deep roots dating back to the late-19th century. From the past through the contemporary, farmworkers and their families have migrated year after year to take part in the harvest of a wide variety of agricultural commodities. The undeniable mark left by this continued intermixing of Hispanic – American cultures is visible when traveling through Berrien and Van Buren County. Interspersed among the rural, sparsely populated towns, between neatly oriented farmhouses and field crops, you will come across small enclaves featuring local churches and corner stores with Spanish signage, as well as generations of farmworkers who have settled in the area permanently.

Locally, farmworkers have been treated by the InterCare Community Health Network since the center first opened its doors in 1972. The barriers to farmworkers include a lack of reliable transportation options, language barriers, and healthcare literacy. In a similar fashion as the Colorado responses to this question, the key informants describe the transportation issues as a multifaceted problem that is “daunting” in scope. Transportation is difficult because families often carpool together and are dependent on others if they need to travel to a C/MHC for treatment. In some areas, public bus service is standard; however, in rural areas, it is difficult to service the population effectively and evenly, especially during the winter months when the weather hampers movement.

Language barriers present a significant issue for both healthcare providers and farmworkers, even though the key informants estimated that “90%” of the population speaks Spanish. Locally there is a large population of Mixteco and Haitian migrant

workers, all of which need translation services to be treated. Language services take place over the phone and not in person with the coordination of community healthcare workers. It is common for the children of some workers to serve as the direct translator between their parents and the medical staff; this observation was also recorded in interviews with key informants in Colorado. The key informants commented that in Benton Harbor it is not uncommon for some farmworkers to speak Chinese, Thai, Vietnamese, Armenian, and Arabic because of the proximity to the Chicago metropolitan area and northwestern Indiana.

The ethnic diversity and overall size of Chicago and its hinterland counties means that ‘push factors’ could be at work influencing the regional migration of various ethnic and linguistic groups. This phenomenon has been prevalent in the United States as it relates to large-scale farming and sources of cheap labor from a variety of markets. As early as 1935, journalist Carey McWilliams, author of “Factories in the Field”, described the ethnic diversity of farmworkers as from China, Japan, the Philippines, Puerto Rico, and Mexico as “sources of cheap labor”, all of whom have been “generously tapped to recruit” the ever “expanding farmworker ranks” (Hernandez, 1999, p. 1). The political environment for farmworkers according to the key informants have not been kind to them in recent years. Farmworkers in Michigan fear being stopped by law enforcement and will not seek medical attention because of this fact. This has been coupled with demographic and migratory shifts for the past two decades, with more young, solo male workers, and fewer family units migrating to the area, another similarity to the Colorado portion of this study. The dominant migration pattern favors a restricted circuit and point-to-point pattern. Families from Texas are more likely to travel alone to Michigan yearly

for work, while those from Florida travel with multiple family units for safety.

Questions on labor exploitation revealed that it is a complex subject that is unpredictable and non-homogenous. It is commonplace for the relationship between farmworkers and the farm owner to be facilitated through the ‘crew leader’ who acts as a middle-man for all negotiations between grower and worker. In certain instances, farmworkers may not try to negotiate with the grower out of fear of losing their jobs for the following growing season. Social class and health outcomes are another prevailing issue farmworkers are tasked with overcoming when they enter the United States. As was the situation in Colorado, farmworkers in Michigan experience depressive symptoms from a combination of frequent migration, poverty, and poor living conditions according to the key informants, although it is admitted that documenting the full scope of manifestation of emotional to physical conditions is difficult to quantify.

The key informants commented that it was not uncommon to meet workers who were ‘very’ educated and worked previously as teachers and nurses in Mexico. The average educational attainment for the workers varies and depends on age, but most of the young H2A workers have some education, while in isolated instances individuals have been unable even to write their name or birthdate. Low healthcare literacy contributes to a misunderstanding of proper nutritional practices. Many diabetic farmworkers in the area tend to gravitate towards processed foods that are convenient; these include fast food and ‘ramen noodles,’ all of which contain high levels of sodium and saturated fats. This behavior is related to the schedule of the workers during the growing season, which usually involves working from sun-up to sunset in rural, isolated locations without access to transportation. These proximate (*micro*) level behaviors have

now transcended individual level cases; it is not uncommon for whole families to be diabetic, obese, and displaying hypertensive symptoms. The key informants believe that substantial portions of the population are “unaware” of their chronic disease status, either as pre-diabetic or hypertensive because of a general misunderstanding of preventive measures, and a strong preference to follow traditional cultural practices as it relates to dietary habits and medication regimens.

Interviews with farmworkers were conducted at two migrant camps near Breedsville and Bloomingdale, Michigan. Each camp featured clusters of mobile homes interspersed among wooded areas. The camp in Breedsville is home to both family units and solo workers. The farmworkers in Bloomingdale, on the contrary, lived in cramped mobile trailers of six to eight men with no vehicles for transportation, a phenomenon similar to the living conditions observed in Colorado. These workers engage in the harvesting of corn, onions, zucchini, tomatoes, beans, carrots, peas, and ‘stretch crops’ like apples, blueberries, cherries, and strawberries. Farmworkers at both camps responded favorably to their ‘access’ to healthcare services and as being in ‘good’ to ‘excellent’ health even with no access to transportation. Seven out of ten (70%) reported ‘full access’ to C/MHC’s and mobile clinics, while the other three respondents reported ‘moderate’ access and one admitted to only visiting a clinic when sick or injured. Even with the apparent lack of transportation, these workers are transported to mobile-clinical units by the staff of Intercare; this, however, is not consistent because these units move around the area to various locations throughout the week. Eight out of ten (80%) farmworkers visited a doctor ‘1 to 2 times’ a year, with only one worker responding that he had not gone to the doctor in over “4 years”, while another claimed to visit every “4 months”.

The most obvious characteristic of these workers was their age. One worker told me that he first started working in agriculture at only 3 years old; while others began at age 7, 9, and 14. Another difference between these workers and the Colorado workers was the migration patterns still favored the traditional migrant streams common to the east coast of the United States. Geographic variations in farmworker origin were apparent; these migrant workers were originally from the *non-traditional* Mexican states of Morelos and Guerrero. On the contrary, Colorado farmworkers workers originated in northern (Chihuahua) and south-central Mexico (Jalisco, Guanajuato – *traditional* sending states). Most workers reported good overall mental health; only one worker admitted to suffering from mental distress, due to an earlier addiction to alcohol. Only two farmworkers in this sample were pre-diabetic; both were currently prescribed Metformin to control their symptoms; these men happen to be the oldest of the interviewees (38 years old). Each commented that their diabetes was under control “as long as they took their medication” and admitted that they relied on the help of the Intercare staff to fill their prescriptions due to a lack of transportation. All ten respondents visited either InterCare Bangor or the mobile clinics when they could find transportation, which usually came in the form of the Intercare staff in Bangor.

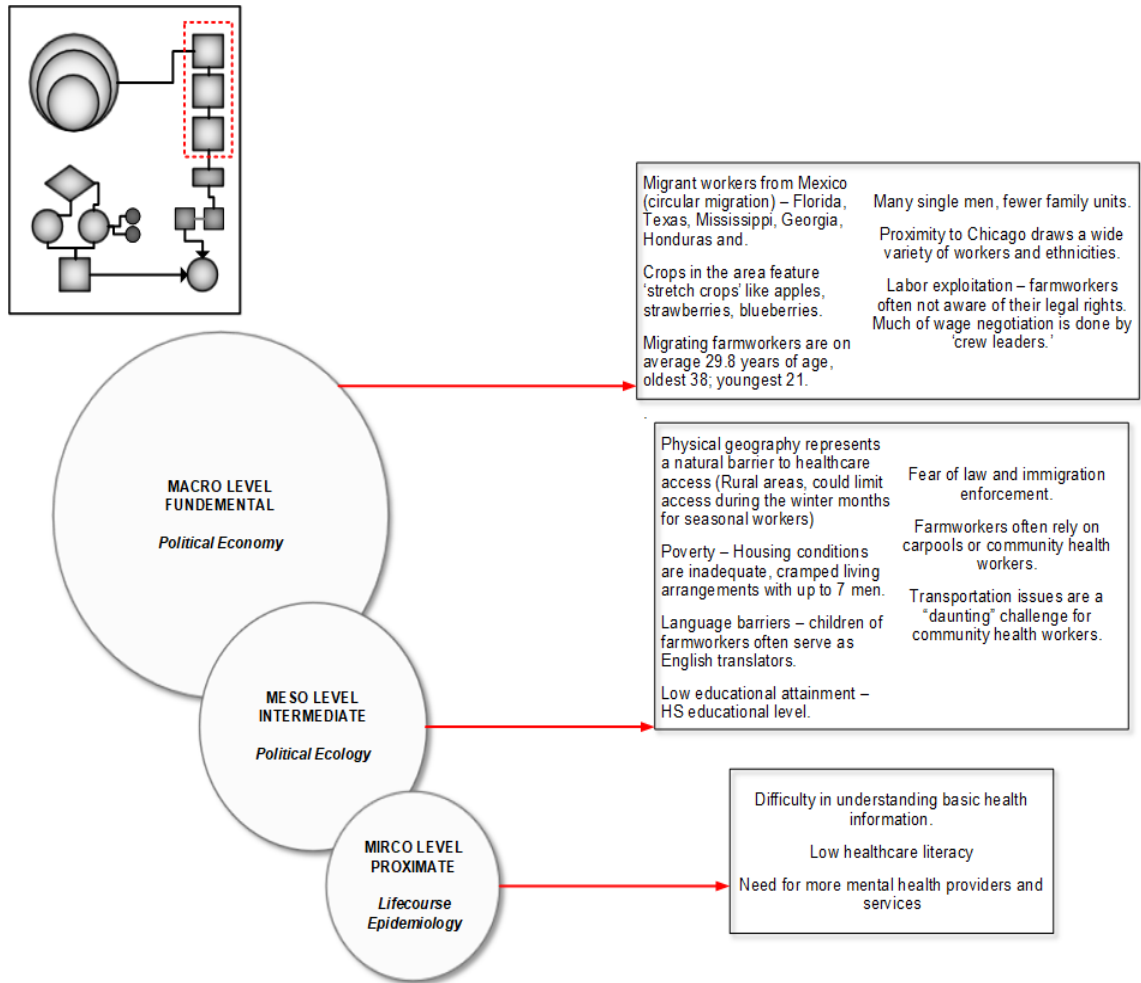


Figure 12.3 - Ecosocial model of farmworker health (qualitative)

CHAPTER IX.

CALIFORNIA RESULTS: QUANTITATIVE

9.1 Introduction

The following section summarizes the results of the chronic disease and risk factor cluster detection, healthcare accessibility, and demographic analysis in California. In total, 638 farmworkers lived greater than 30 minutes from a C/MHC; this constituted 4.3% of the total population in the study area (n = 14,668). Chronic disease hot spots were found in 26 zip codes, while an additional 18 zip codes featured chronic disease risk factor clusters. Additionally, 13,970 farmworkers (95.2%) lived in zip codes designated as chronic disease hot spots, while 13,957 (95.1%) were found in risk factor hot spots. Diabetes (61.2%) constituted the largest percentage of total patient encounters (n = 6,523), followed by hypertension (18.7%), chronic disease risk factors (12.9%) and obesity (7.3%). Further information and the corresponding tables for the chronic disease and risk factor clusters are found in the appendix section. The quantitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 13.4).

9.2 Quantitative Results

Accessibility to C/MHC's

Geographic accessibility in Southern California to community and migrant health centers (C/MHC) are presented in Figure 12.4. Farmworkers in the Southern California CBRN database live predominantly in Ventura and neighboring Los Angeles County. In total, 638 farmworkers lived beyond the 30-minute “excessively distant” threshold, which

constituted 4.3% of the total population. Unlike the analysis in Colorado and Michigan in which an urban-rural component is present, much of localities in Ventura and Los Angeles Counties feature a variety of urban and suburban development and feature wide-reaching road infrastructure and public transportation options, especially in the cities of Ventura, Oxnard, and Los Angeles. This fact cannot be overlooked when viewing the results for this section. The geographic distribution of farmworkers in this study is vast in comparison to Colorado and Michigan; in fact, workers as far north as Humboldt County and as far south as Chula Vista, San Diego County were documented. However, even with such a dispersed population, 99.2% of all farmworkers in this study lived in Ventura or Los Angeles Counties.

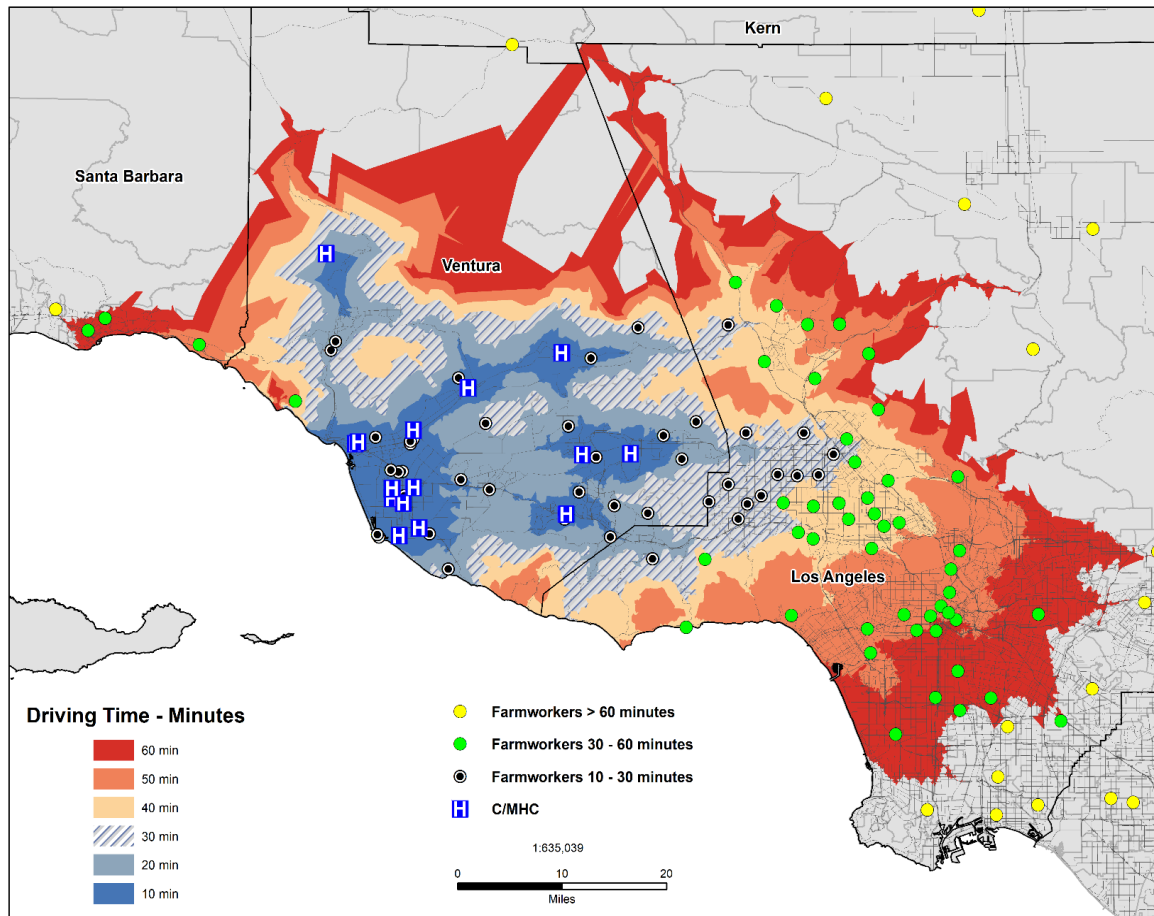


Figure 12.4 - Geographic accessibility to C/MHC's (California)

Chronic Disease and Risk Factor Hot Spots

The geographic distribution of zip codes designated as hot spots according to SaTScan for seasonal and migratory farmworker diabetes encounters ($n = 3,993$) are presented in figures 12.5 and 12.6. The top clusters, when compared between groups, are concentrated in Ventura County. Tests of cluster sensitivity determined that the best performing MSWS for seasonal diabetes encounters was 40% and 50% of the at-risk-population (P -Value: $< 0.0001 - 0.987$; Gumbel P -Value: $0 - 0.9737$) (clusters = 12), with a total of 3,529 observed encounters, 2,073 expected encounters, an LLR of 666.93, and a relative risk (RR) of 17.36. Communities found in these zip codes include

Thousand Oaks (91360), Ventura (93004), Camarillo (93010, 93012), Moorpark (93021), Oxnard (93030, 93033, 93036), Point Mugu Nw (93042), Santa Paula (93060), Somis (93066), Simi Valley (93065) and Ojai (93023). Migratory diabetes clusters totaled 5 and (P -Value: $< 0.0001 - 0.6303$; Gumbel P-Value: $0 - 0.6330$) displayed the most robust performance when the MSWS was set to only 10% of the at-risk population. Observed encounters in these clusters totaled 728 observed, 338.52 expected an LLR of 188.77 and a relative risk (RR) of 11.31. Communities found within the migratory clusters are like the seasonal diabetes clusters, these include Thousand Oaks (91360), Moorpark (93021), Simi Valley (93065), Ventura (93003) and Oxnard (93036). Communities not featured in the seasonal clusters include Newbury Park (91320) and Fillmore (93015).

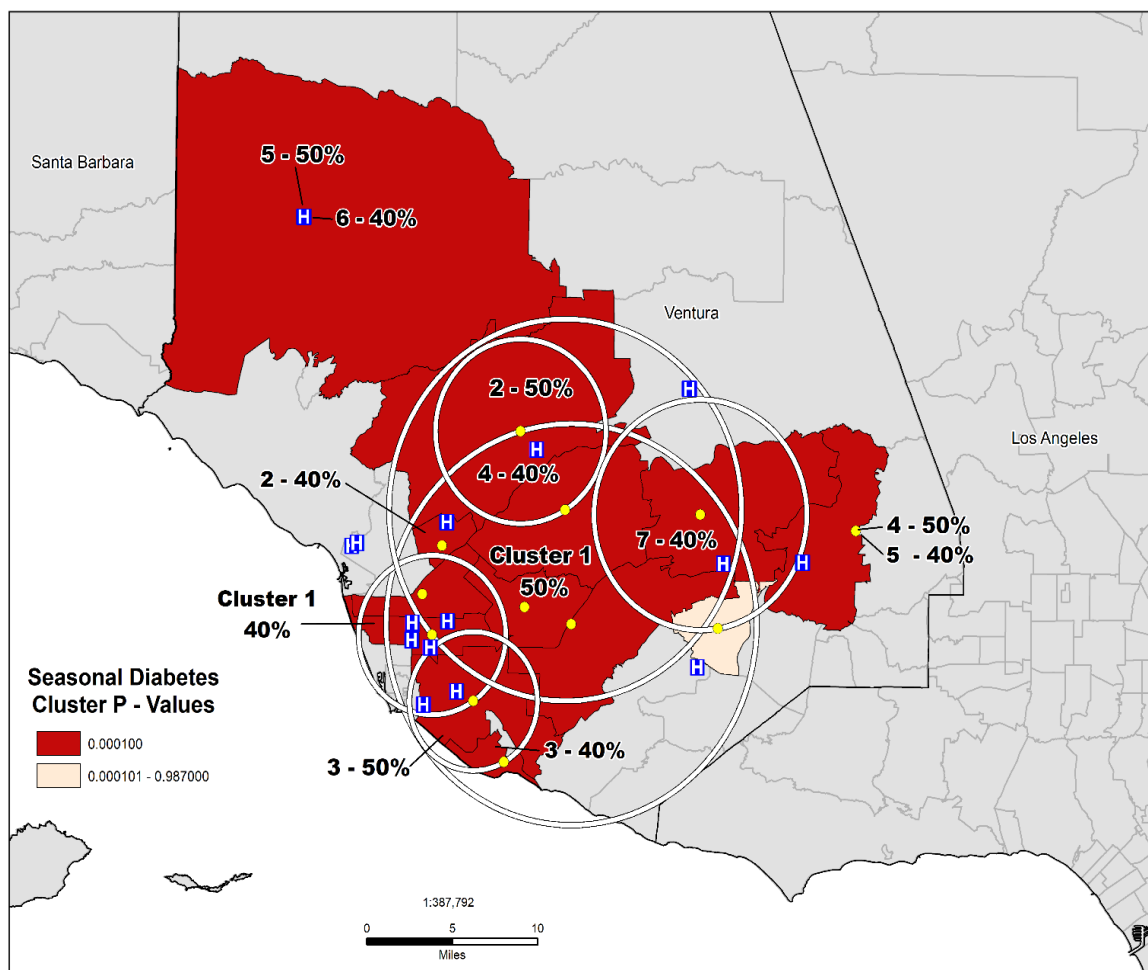
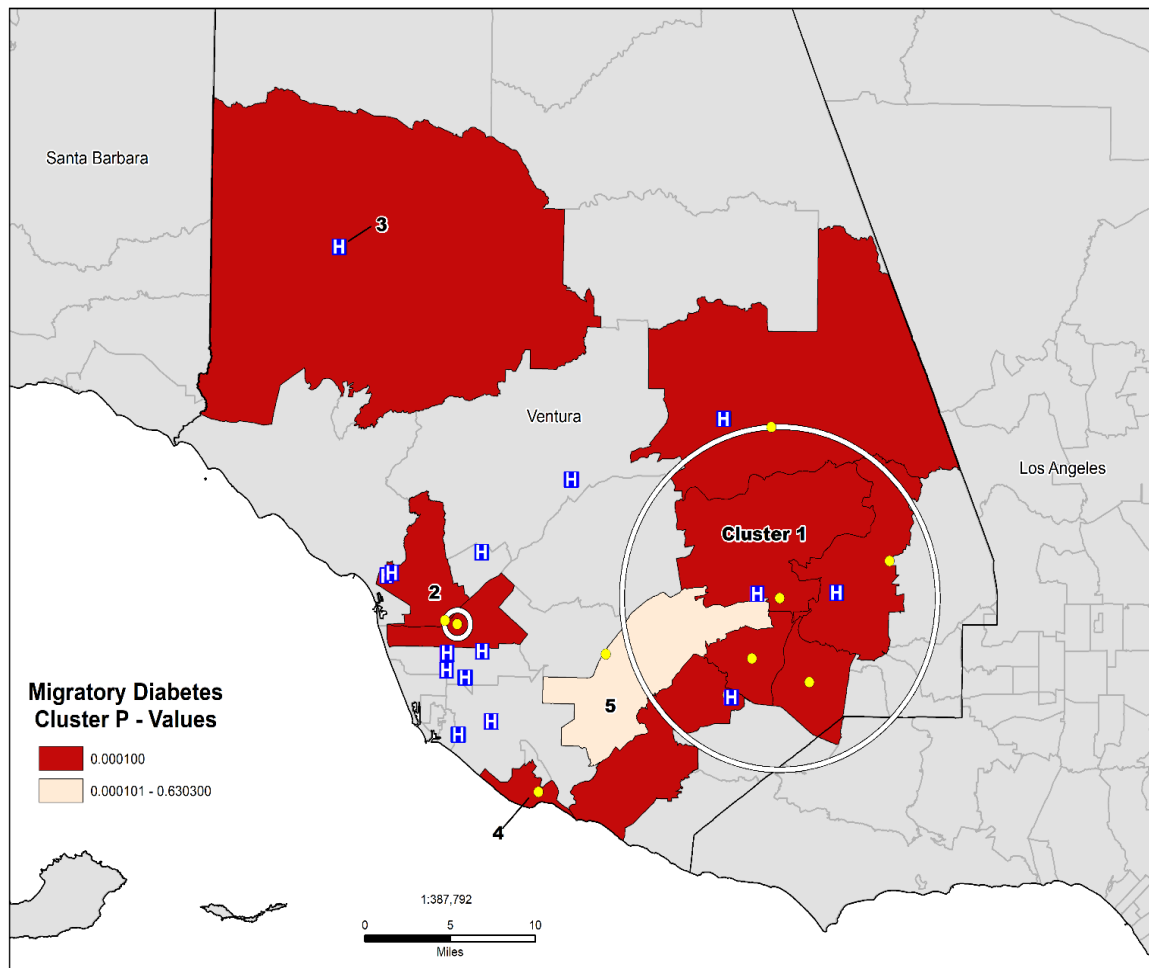


Figure 12.5 – Seasonal diabetes (California)



(93010, 93012), Moorpark (93021), North Hollywood (91601), Oxnard (93035), Somis (93066), Santa Clarita (91350), Santa Paula (93060), and Simi Valley (93065). SaTScan model parameters for migratory hypertension encounters performed best when the MSWS was set at 40% of the farmworker at-risk population. In total, 130 observed and 56.57 expected patient encounters were observed within 4 clusters, which accounted for a relative risk of 15.89 and an LLR of 54.98. The overlap between the seasonal hypertension clusters is evident in Ventura County, as are the communities in these zip codes which include Fillmore (93015), Oxnard (93036), Santa Paula (93060), Simi Valley (93065), Somis (93066) and Ventura (93001).

An interesting location was zip code 91601, an area within the Los Angeles neighborhood of North Hollywood, bordering Burbank to the west. North Hollywood's population, in comparison to the City of Los Angeles and the county, has a higher percentage of residents born abroad at 46.4% with Mexico (43.2%) and El Salvador (16%) the most common countries of origin. Additionally, this area is home to one of the highest percentages of residents aged 19 to 34 in Los Angeles County, and the highest percentage of never-married males and females (North Hollywood Profile – Mapping L.A. – Los Angeles Times, 2017). In total, four farmworkers named North Hollywood as their place of residence; these workers ranged in age from 13 to 35 years old.

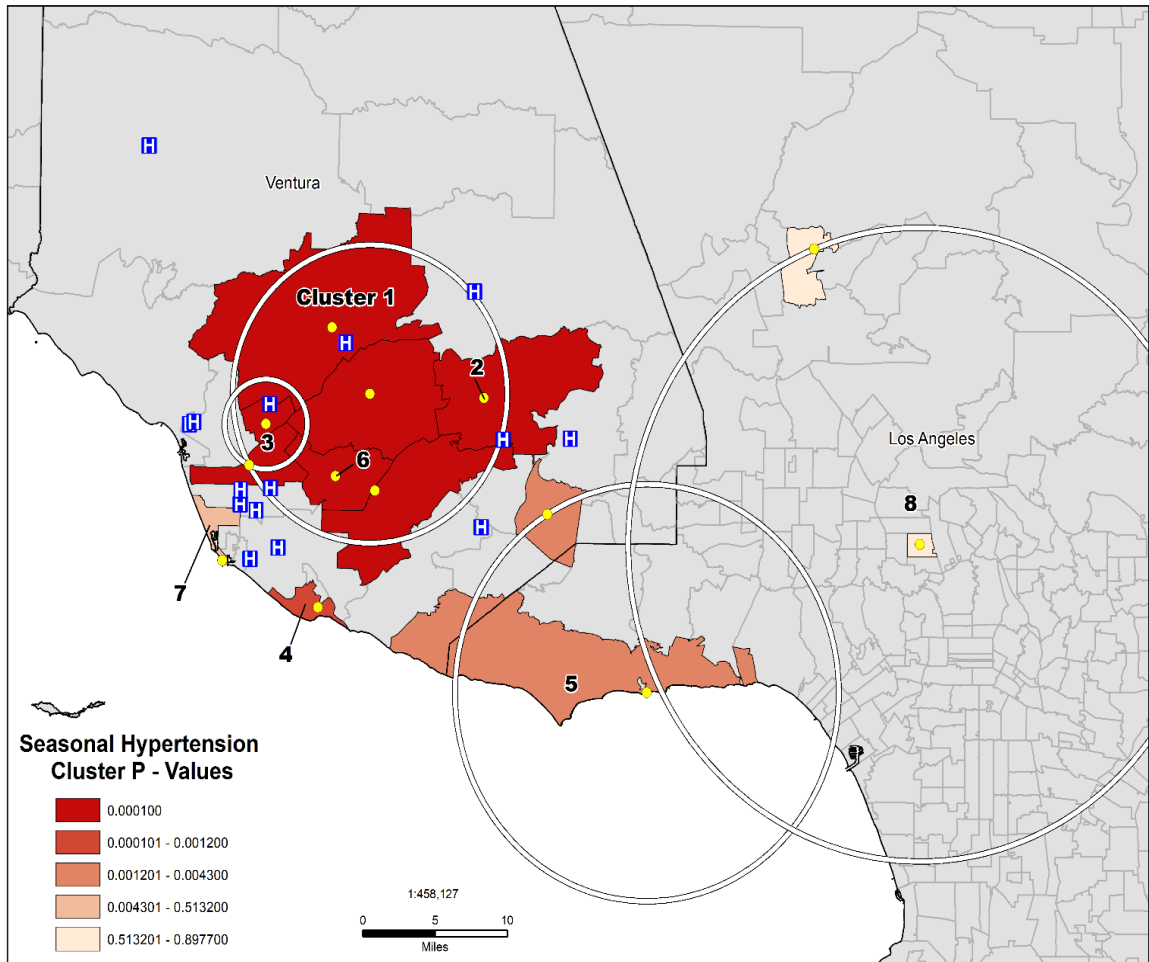


Figure 12.7 – Seasonal hypertension (California)

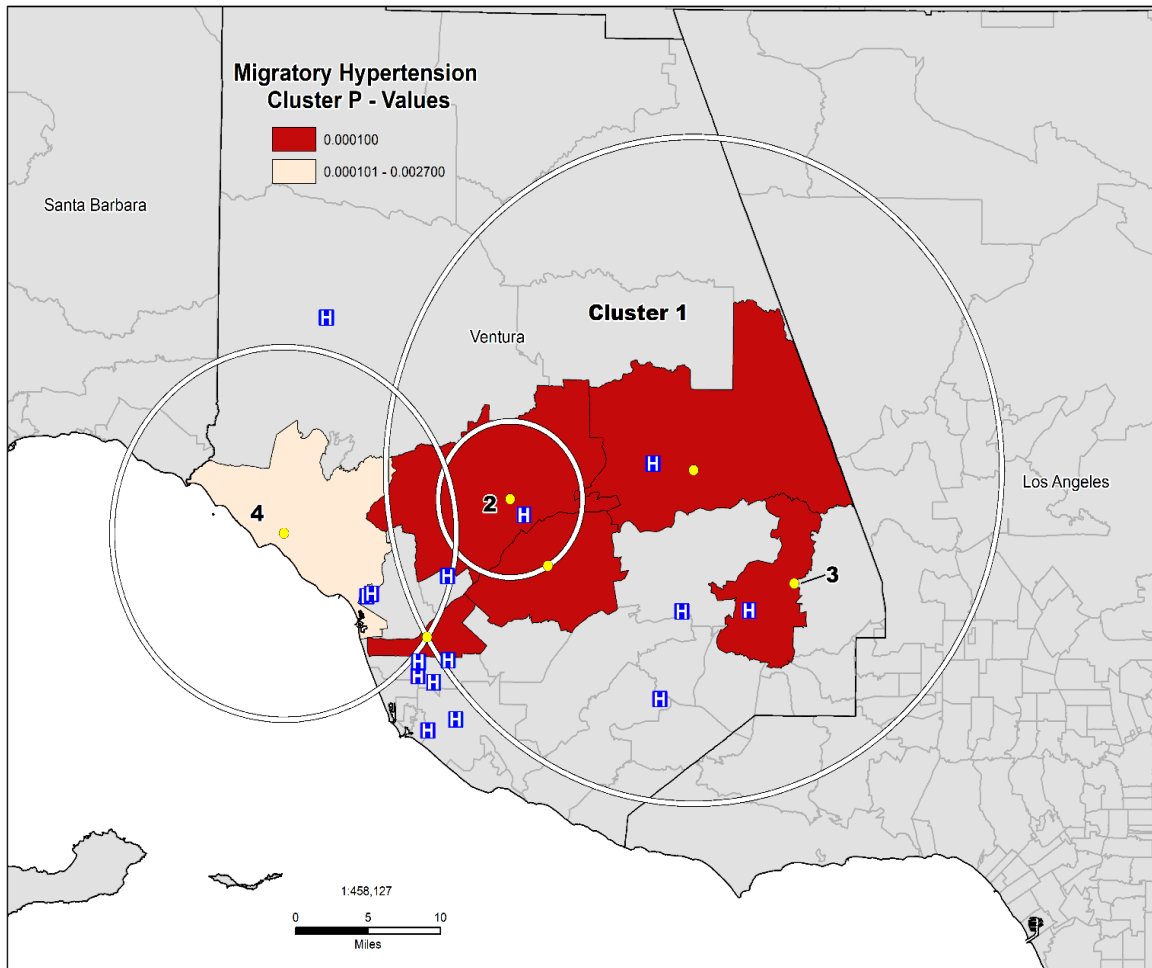


Figure 12.8 – Migratory hypertension (California)

The geographic distribution of obesity encounter (n = 477) clusters (Figure 12.9 & 13) are found primarily in Ventura County; however, for the first-time, zip codes in northern Los Angeles (Acton) and Kern County (Bakersfield) were identified. Measures of cluster sensitivity for seasonal patient encounters determined that an MSWS of 20% of the at-risk-population was ideal (clusters = 5). Within these five clusters (P – Value: < 0.04 – 0.999; Gumbel P-Value: 0.04 – 0.9849), 70 observed and 48.90 expected patient encounters were recorded, accounting for a relative risk (RR) of 7.59 and an LLR of 5.99.

Statistically significant zip codes are centrally located near C/MHC's in Oxnard (93030, 93035, 93036) and further south along the coast in Point Mugu Nawc (93042). The optimal performance for migratory obesity encounters was reached again with an MSWS of 10% of the at-risk-population, which produced 4 clusters (P – Value: < 0.0001 – 0.9925; Gumbel P-Value: 0 – 0.9624) with a relative risk (RR) of 9.58, an LLR of 20.23, and 123 observed and 69.23 expected patient encounters. Zip codes identified include those in Kern (Bakersfield – 933306, 933309) and Los Angeles County (Acton – 93510), as well as locations in Ventura County, Point Mugu Nawc (93042), Thousand Oaks (91362) and Oak Park (91377).

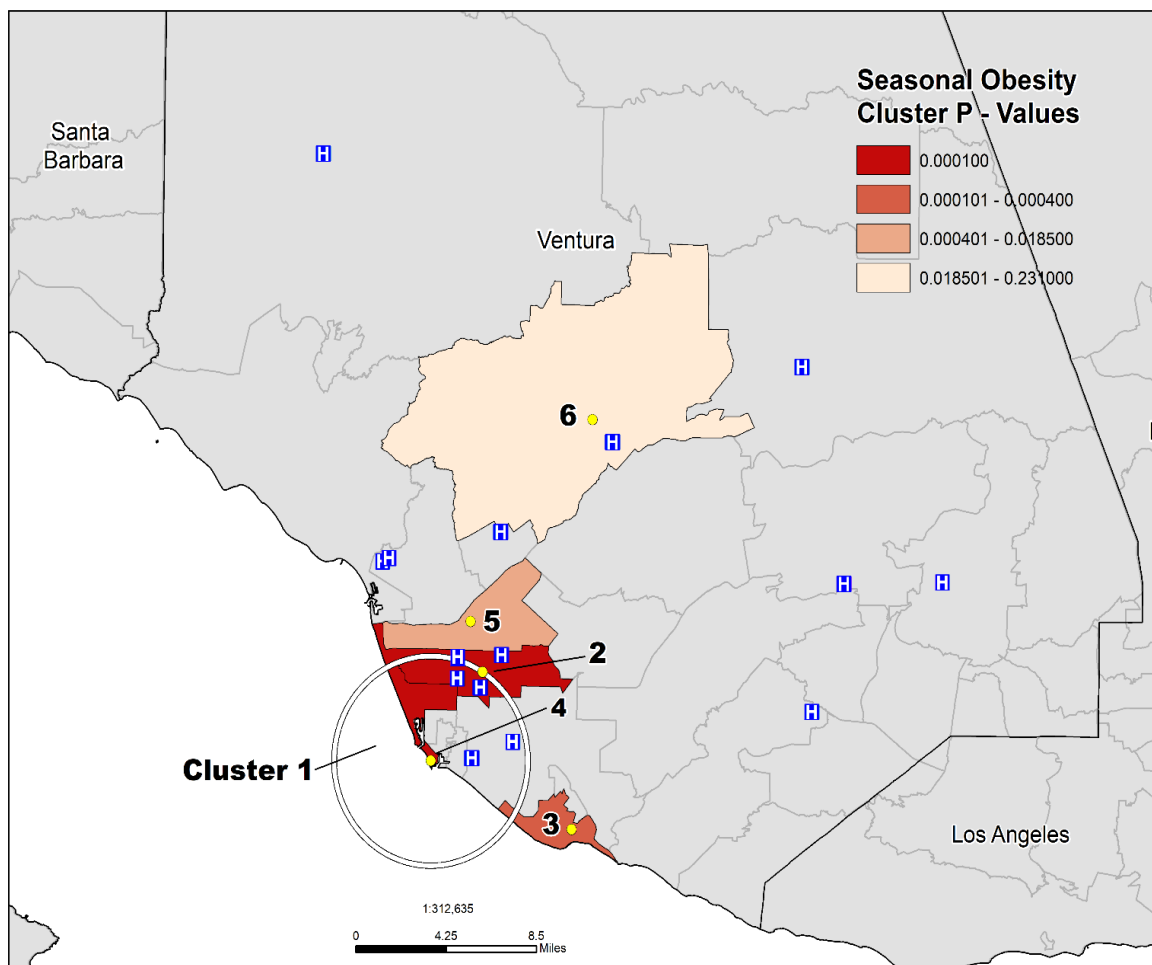


Figure 12.9 – Seasonal obesity (California)

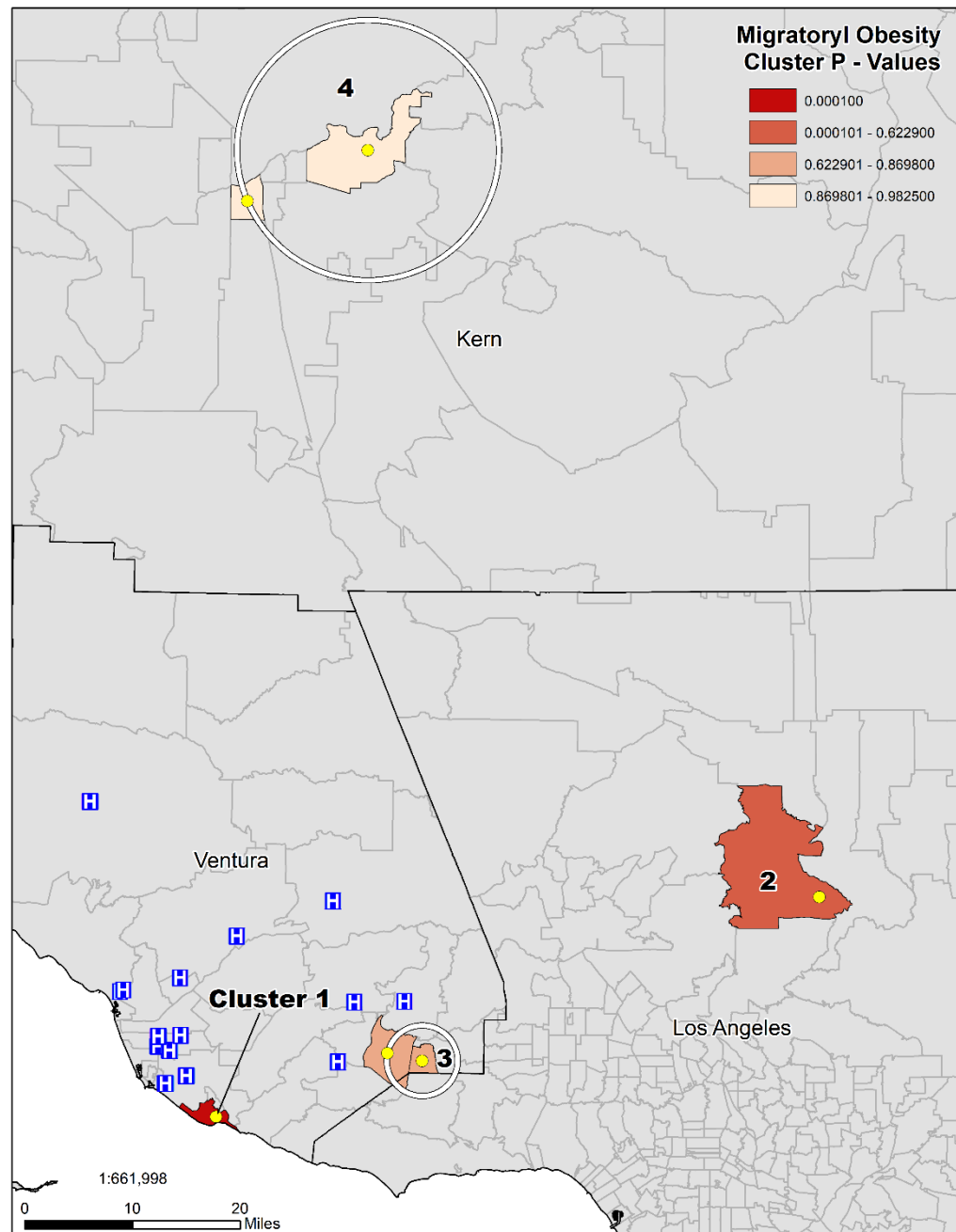


Figure 13 – Migratory obesity (California)

The geographic distribution of risk factor encounters (n = 838) is clustered throughout south-central Ventura and west-north-central Los Angeles County (Figure 13.1). Considerable overlap between these and the chronic disease zip codes is apparent,

especially when comparing the distribution to that of diabetes in Ventura County. Communities in these zip codes include Newbury Park (91320), Sun Valley (91360), Westlake Village (91361), Ventura (93001), Simi Valley (93063), Moorpark (93021), Canyon Country (91387), Fillmore (93015), Thousand Oaks (91360), Somis (93066), and Oak View (93022). Measures of cluster sensitivity for chronic disease risk factors indicate strong performance when an MSWS of 10% (450 observed; 52 expected; Test Statistic – 557.06; RR – 480.17), 20% (416 observed; 58 expected; Test Statistic – 482.30; RR – 96.33), and 30% (379 observed; 78.40 expected; Test Statistic – 339.21; RR – 41.62) of the at-risk-population were employed. This combination of MSWS produced a total of 34 clusters (P – Value: < 0.0001 – 0.0003; Gumbel P-Value: 0 – 0.0004).

The temporal distribution of patient encounters (2011 – 2015) when compared to long-term temperature averages from 1981 – 2010 (NOAA – National Climatic Data Center, 2018), unlike Colorado and Michigan, remains constant throughout the year and displays multiple peak (January, February, July, October) and down periods (March, June, September) (Figure 13.2). These numbers are not surprising for two reasons: first, the heavy concentration of urban and suburban development, coupled with a highly developed transportation system, may give farmworkers in this area better opportunities to access a C/MHC unlike their rural counterparts in Colorado and Michigan. Second, the warm-summer Mediterranean climate of Southern California enables farm owners to employ farmworkers in the fall and winter months from October – February. Cold weather crops in this area include cabbage, carrots, spinach, kale, radishes, garlic, white potatoes, and cauliflower.

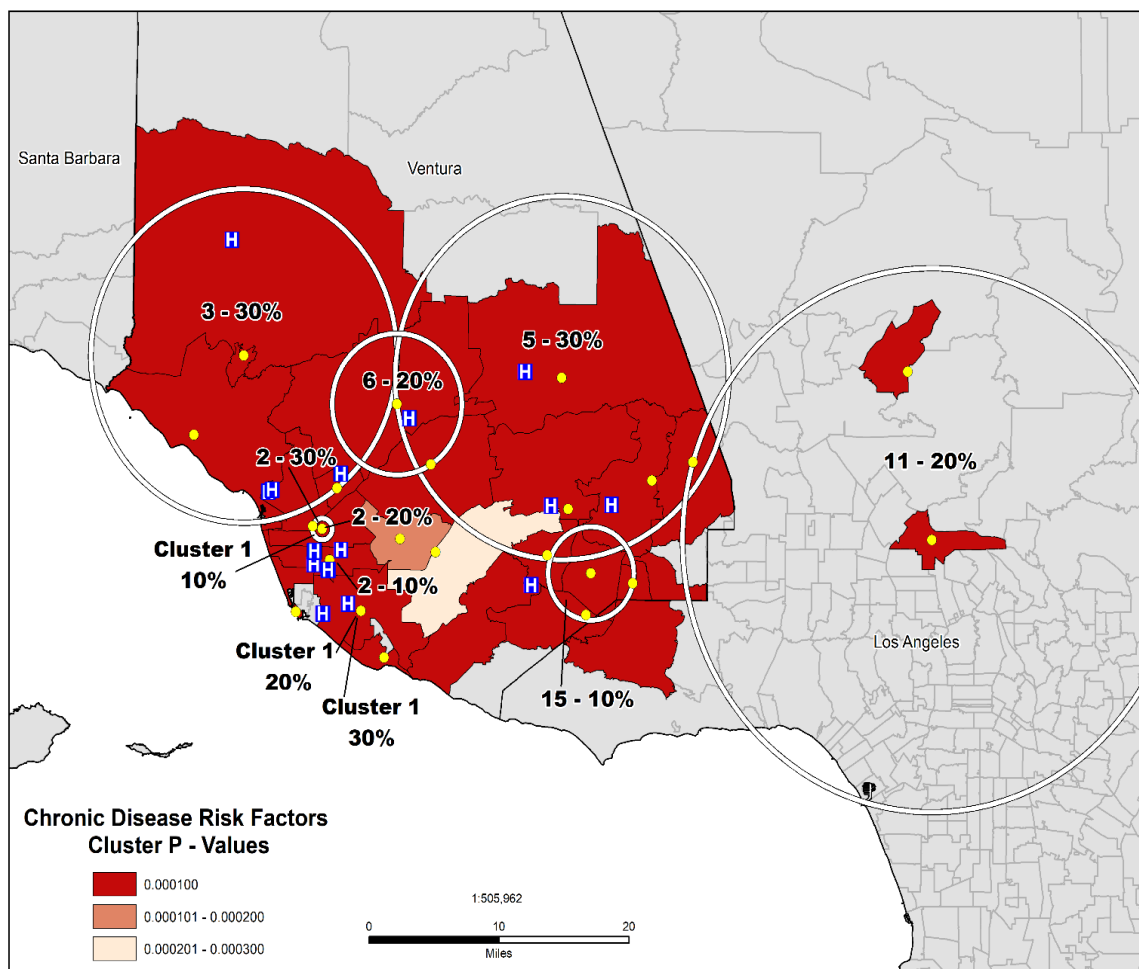


Figure 13.1 – Chronic disease risk factors (California)

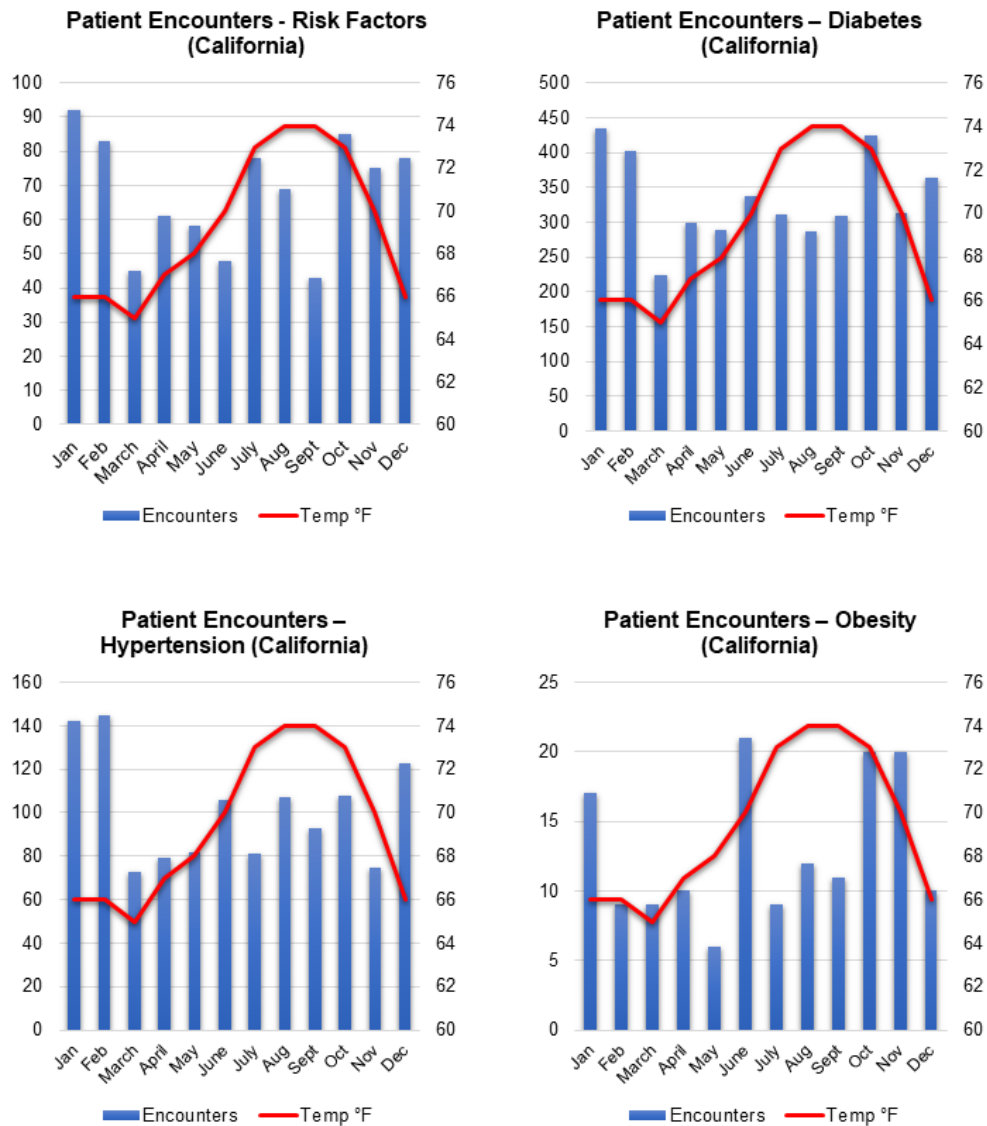


Figure 13.2 – California patient encounters in relation to temperature averages

Demographics

Demographics were analyzed based on patient encounters for the treatment of chronic disease and their associated risk factors at Clinicas del Camino Real (CDCR) affiliated C/MHC's (Figure 13.3). Statistics for diabetes encounters (n = 3,993) revealed that the mean age for seasonal and migratory farmworkers was 57 years of age (max: 97; min: 4) and that the patient population was 60% female and 40% male. The predominant ethnic composition was Hispanic/Latino (53%), followed by unknown/unreported at 37.2% and non-Hispanic/Latino (9.7%). Spanish (76%) and English (20.6%) were the primary spoken languages, as were Punjabi (0.003%) and Arabic (0.002%). Over half of the population is married (53.2%), while 18% classified as 'unknown,' another 14.1% are single, and 8.3% are widowed. The most frequently visited C/MHC's, considering the geographic distribution of diabetes clusters in Ventura County, was not surprising. The brunt of patient encounters was recorded in CDCR Oxnard (27.5%) and CDCR Ventura (9.4%), followed by CDCR Fillmore (6.9%) and CDCR El Rio (6.2%). The city of origin is further reflected when comparing diabetes encounters, over half (55.6%) lived in Oxnard, as did significant numbers in Santa Paula (7.3%), Ventura (7%), Fillmore (4.6%), and Simi Valley (4.1%).

Demographics for hypertension patient encounters (n = 1,215) revealed that ethnically, the population composition was predominately Hispanic/Latino (49%) with 18% non-Hispanic/Latino. Additionally, a sizeable portion of the encounters was classified as unknown/unreported (32%). The sex of patients was again mainly female at

56%, with males making up 44% of all encounters. The mean age of these patients was also slightly older than the diabetes patients in this study, at 58.4 years old (max: 97; Min: 16). Spoken languages again favored Spanish (59.3%) and English (37.1%); however, there were again Punjabi and Arabic speakers, as well as Farsi and two hearing-impaired farmworkers who communicate with sign language. Over half (51%) of all patients were married, 21.3% identifying as single, and another 17.1% again were classified as ‘unknown.’ The bulk of these individuals lived in Oxnard (46%), Ventura (11%), and Santa Paula (8.2%). Patient visits at C/MHC’s were nearly evenly split between CDCR Oxnard (13.4%), and CDCR Ventura (13.1%), however, sizable numbers were documented in CDCR North Oxnard (10.2%) and CDCR Moorpark (7.7%).

Obesity encounter patients (n = 477) had a mean age of 35 years old (Max: 81; Min: 2) and ethnically identified as 50.1% Hispanic/Latino ancestry, while another 40.2% of these farmworkers’ ethnicities were classified as unknown/unreported. Spanish was the predominant spoken language of patients at 66%, followed by English at 32%. Furthermore, a small number of farmworkers in the obesity category in a similar fashion to diabetes and hypertension patients spoke Arabic and Punjabi. Patients were primarily single (46.3%), 29.1% identified as being married, 19.7% were registered as ‘unknown.’ Larger proportions of these patients were female (69%), with males making up only 31.2% of all encounters. Farmworkers in this category were found to live at high numbers in Oxnard (63.1%), Santa Paula (9.4%), and Ventura (7.5%). The most visited C/MHC’s were again CDCR Oxnard (31%) and CDCR North Oxnard (9.8%), as well as CDCR Maravilla (9.4%).

Demographic analysis of the patient encounters (n = 838) for chronic disease risk factors reveals that 40% of the patients were single, 25% married, and the remaining 23% were again 'unknown.' Additionally, 67.3% were female and 32.6% male. The population had a mean age that was higher than the obesity patients at 42.5 years old (Max: 101; Min: 5), but lower than that of patients being treated for diabetes and hypertension. Ethnically, 41.6% were Hispanic/Latino, and 33.4% were again listed as 'unknown/unreported followed by non-Hispanic/Latino at 24.3%. English speakers for the first time represented the majority, at 63% of patients, followed by Spanish speakers at 36%. Languages also included Arabic, Chinese, Farsi, Portuguese, Urdu, and Sign Language. Patients from this group primarily lived in Oxnard (38%), Ventura (12%), and Ojai (7.8%). Chronic disease risk factor encounters were documented in higher numbers in CDCR Ventura (16.7%), CDCR Oxnard (13%), CDCR Newberry Park (9%), and CDCR North Oxnard (7.7%).

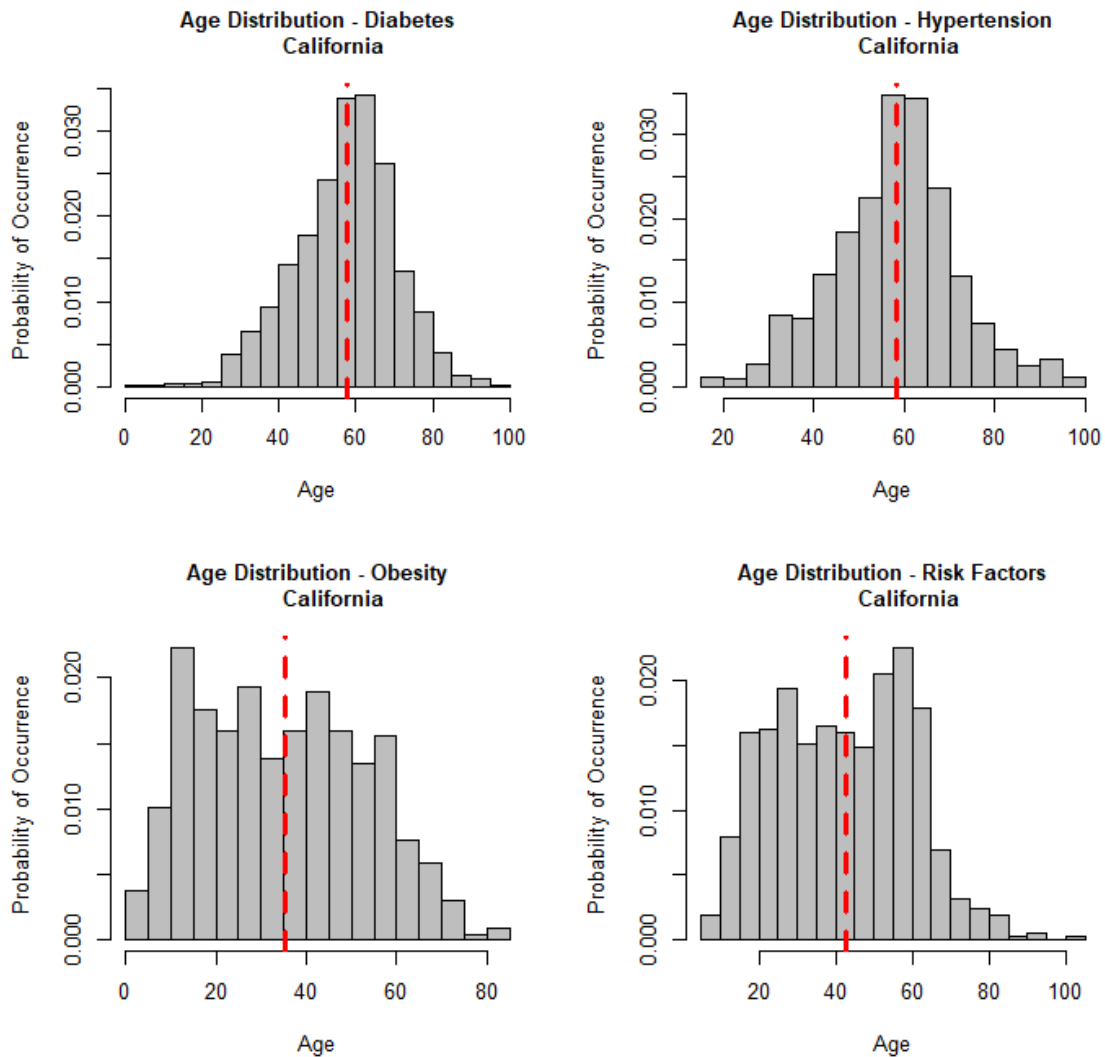


Figure 13.3 - Age distribution for MSFW patient encounters in California. When compared to Colorado and Michigan, patient encounters for diabetes and hypertension display similarities when comparing age groups. The young age of obesity patients is similar to that of farmworkers in Colorado, as is the number of patients under age 20. The distribution for diabetes and hypertension, again displays a bell-shaped normal distribution, while obesity and risk factors again (like Colorado) have a range that is skewed to the right (positive).

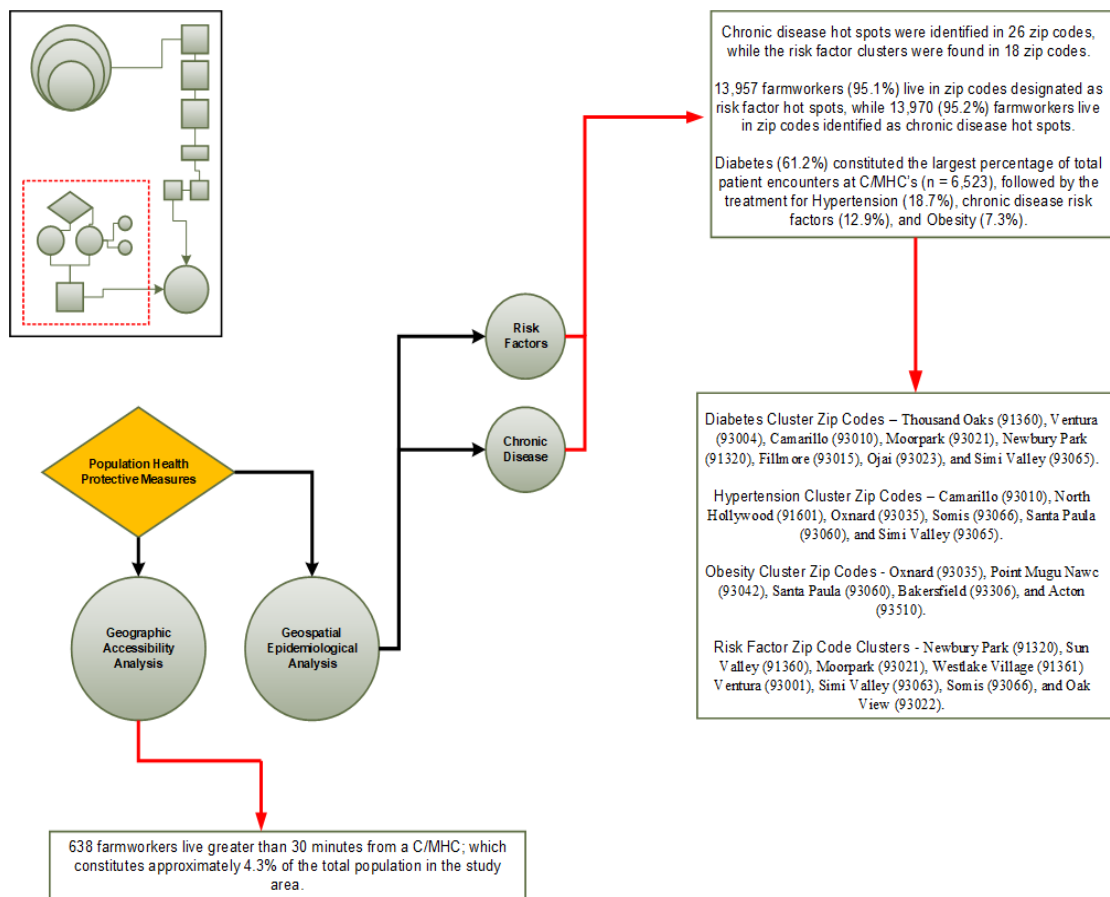


Figure 13.4 - Ecosocial model of farmworker health (quantitative)

CHAPTER X.

CALIFORNIA RESULTS: QUALITATIVE

10.1 Introduction

Fieldwork in California began on August 20, 2018, at the Clinicas del Camino Real in Ventura. The interviews with key informants and farmworkers ended on August 22, 2018. In total, ten interviews were conducted with four key informant and six farmworkers. The key informants involved in the interview process worked as community health workers and enrollment specialists. Combined, these individuals have 51 years of combined experience working directly with farmworker populations in Southern California. The farmworkers interviewed at Clinicas del Camino Real were the youngest farmworkers when comparing study areas and ranged in age between 25 and 33 years old (average 29.3 years).

Demographically, unlike Colorado and Michigan where the population has consistently shifted towards solo male workers, this group of interviewees featured three men, three women, and two-family units. Another dissimilarity when comparing study areas was the classification of these workers. The entirety of farmworkers interviewed were seasonal workers. These workers were not however static in their classification during their years working in agriculture; in the past, they had worked in a migratory capacity at farms in Salinas and Santa Maria, California. These farmworkers originated in the *non-traditional* sending states of Puebla, Oaxaca, Guerrero, and Chiapas; as well as El Salvador and Guatemala. Another dissimilarity between the study areas was that some farms in Ventura County operate medical clinics, as an alternative to relying on the

community and migrant health system. The qualitative portion of the ecosocial model of farmworker health (see Chapter I – Figure 3) is located at the end of this chapter (Figure 13.5).

10.2 The Social Epidemiology of Farmworker Health

Agriculture work in the United States has since the colonial era been distinguished by successive demographic and geographic shifts, with the arrival of indentured servants from Great Britain on the eastern seaboard, freed slaves and plantation agriculture in the American south, Asian immigrants during in the Reconstruction era, and finally the Bracero Program of 1942. The post-Reconstruction era established the foundation for the dominance of California as a major agricultural center in the United States. Today, forty percent of the farmworker population works in the five leading agricultural counties in the state: Fresno, Monterey, Kern, Tulare, and Ventura (Mines 2006). Farmworkers in Ventura County work on the vast coastal Oxnard Plain bounded between the Transverse Ranges of the Santa Monica and Santa Susana Mountains, the Topatopa Mountains to the north, and the Santa Clara River to the northeast.

Ventura County is a principal contributor to the California economy with total annual crop values of more than \$2.1 billion (United States Department of Agriculture, 2012). Since 1971, Clinicas del Camino Real has served the health needs of medically underserved farmworker populations in Ventura County. These health needs are complex and present a considerable challenge for community and rural health organizations. Along with Clinicas del Camino Real, the farmworker social advocacy organization CAUSE (Central Coast Alliance United for a Sustainable Economy) provides an additional level of support in Ventura and Santa Barbara County. Since 2001, CAUSE

has focused on providing farmworkers with resources to improve healthcare access and long-term outcomes through the creation of low-cost health access programs for children in Ventura County, with additionally goals to expanded public transportation options in the region.

Farmworkers are confronted with a variety of barriers to care, including language barriers, pesticide exposure, housing, immigration status, labor exploitation, low educational attainment, and transportation difficulties. Access to transportation for visits to C/MHC's according to the key informants is "plentiful" in the Ventura – Los Angeles County region and many farmworkers with work visas obtain drivers licenses, while others utilize shuttle bus services. Others have the choice of utilizing the public bus system, taxi services, and Uber. This reflects a sharp difference when comparing study areas based on geographic accessibility alone. To recap on the earlier chapters, the barriers to healthcare as it pertains to transportation were described by key informants in Colorado and Michigan were frequently described as "daunting in scope," a "problem too big to solve" and one that has not garnered "too much interest."

Improved access is further made possible by social programs like the Ventura County Women, Infants, and Children Program (WIC), which supplies transportation to appointments for enrollees. Transportation difficulties were further described as affecting older farmworkers. However, programs do exist that cover the transportation costs of older demographic groups in the area. Transportation services are additionally available through the Medi-Cal program, directed by the California Department of Health and Human Services. However, according to the key informants, much of the farmworker community in Ventura County are undocumented, which disqualifies these workers from

such services. Follow-up visits are not only dictated by transportation accessibility but also by the rate of insured versus uninsured. One key informant estimated that less than 20% of farmworkers attend follow-up appointments; however, if insured and provided with transportation, this number would rise drastically.

The burden of chronic disease is high among the farmworker population in all age groups. It is common to encounter pregnant female farmworkers who have developed gestational diabetes, while also being treated for pre-existing conditions like hypertension. During medical visits to local farms with mobile clinical units, farmworkers diagnosed with diabetes and high blood pressure are sometimes treated for symptoms associated with high blood glucose levels, like lethargy and dizziness. An issue brought to my attention by a key informant was the difficulty farmworkers might encounter when accessing fresh fruits and vegetables when they first enter the United States. Often is the case in much of Mexico, produce stands are available even in rural areas, unlike Ventura County where there is a greater reliance on frozen and fast food options.

This reality manifests in diets that combine traditional foods with those of the American diet. These food habits, coupled with a lack of educational attainment and general knowledge of healthy food choices, have a significant effect on farmworkers and their families (inter-generational). Culture plays a critical role in the percentage of farmworkers returning for follow-up appointments, as does male and female gender roles, which in some instances requires a female to get permission from her husband before returning for a follow-up appointment. Cultural practices furthermore dictate how or if any personal health information is shared with medical professionals. Language barriers

in the area significantly delay the delivery of care to the large and ever-growing indigenous population of Zapotec and Mixtec peoples from the southern Mexican states of Oaxaca, Guerrero, Puebla, and Chiapas. Key informants in this study identified farmworkers of indigenous descent as a high-risk population as it related to language and access to healthcare services. The Zapotec language constitutes a significant branch of the Oto-Manguean language family; while Mixtec languages are divided into as many as fifty known dialects belonging to the Otomanguean language family. These languages and their associated regional dialects pose a considerable challenge to community health workers, doctors, and medical professionals in treating this population when translation services are not available. Language resources for indigenous farmworkers are supplemented by regional advocacy organizations like the Mixteco/Indigena Community Organizing Project (MICOP) which supplies language interpretation services and health outreach programs, as well as *Radio Indigena* (Oxnard), an indigenous language radio station.

A comparison between study areas reveals the stark difference in the percentage of Spanish speakers. The Oxnard community health center, located in the Hobson Park East neighborhood (93039), is home to a large Spanish speaking population, which represents 71.6% of the total population (36,287), while in contrast the zip codes in Ft. Lupton, Colorado (80621) and Bangor, Michigan (49013) had Spanish speaking populations that constituted 27.9% and 3.7% of the total population respectively. These data reveal that Spanish speaking farmworker populations in Ventura County may not be faced with the same degree of languages barriers experienced by their fellow agricultural workers in Western Michigan, who are less likely to encounter non-farmworkers who

speak Spanish.

Language is a significant foundational component to the development of social structures, a foundation that is key to the development of social interactions.

Farmworkers in Michigan do not have the opportunity to develop these structural components because of not-only their migratory status, but also the broader social and economic structure of the majority non-Spanish speaking population of Western Michigan. Thus, farmworkers living in Ventura County have increased opportunities to access a significant sociocultural resource unavailable to farmworkers in Michigan. Access to such a resource allows for communication that enables the identification and construction of diverse social environments. Language goes hand in hand with social and cultural development, none of which are static (Clancy, Lee and Zoh 1986).

Educational attainment among the farmworkers in Ventura County, as in Colorado and Michigan, is another obstacle when aiming to improve long-term health outcomes. The average educational attainment according to the key informants was ‘if that’ or ‘maybe’ at the elementary level (4th – 6th grade), with some being completely illiterate and unable to write their names. This unfortunate reality translates into a misunderstanding of health information and the proper usages and dosages of diabetes medications; this is coupled with the use of humoral medicines and home remedies for the treatment of illness. According to one community health worker, several outreach programs exist in the area that addresses these educational deficiencies; these include visits to local farms to education farmworkers using visual aids on healthy dietary habits and the prevention of sexually transmitted infections (STIs).

The immigration status, political representation, and the availability of affordable housing are another series of barriers encountered by farmworkers and their families. As noted earlier in the chapter, the high number of undocumented workers in the county has apparent negative health consequences; the most significant is the disqualification from welfare programs like Medi-Cal. Locally, the political climate in Ventura County favors farmworkers and their families in certain instances. One key informant commented that Ventura and Oxnard were “very sheltered politically” and have not experienced as much push-back from the local, regional populace. The cities of Simi Valley and Newberry Park area, however, were named as locations in which farmworkers had previously experienced difficulties.

Newberry Park features a demographic profile primarily consisting of Central Americans (Guatemala, El Salvador), while those in Ventura and Oxnard are predominately Mexican; the Newberry Park population is also more service-based and less involved in agriculture. Interestingly though, racism internally is cited as a chronic issue in the community, especially among farmworkers from Mexico, El Salvador, and Guatemala. Additionally, staff from Clinicas del Camino Real have encountered push-back from farm management, including denied access to farmworkers for conducting medical screenings. Affordable and quality housing options are limited in Ventura County and the greater Los Angeles area when compared to the average salary of area farmworkers.

As is often reported in agricultural regions of the United States, farmworkers in this area are found to be living in cramped, rundown units, where the spread and amplification of infectious diseases have been documented; the key informants related

this directly to the poor socioeconomic status of the workers. Labor exploitation and unsafe working conditions were documented during the key informant interviews. Farmworkers are often unaware of their legal rights and the California laws governing both the housing and labor markets locally. Farm management policies in some instances feature direct threats to workers who had been absent from work because of medical issues and even requiring pregnant mothers to supply a doctor's excuse for missing work.

Because of restrictions barring me from visiting individual farms, all interviews with local farmworkers were completed at the Clinicas del Camino Real Ventura community clinic. As stated in the introduction section of this chapter, the demographic composition of farmworkers at this location was entirely different than in Colorado and Michigan. These workers were more inclined to speak in detail about their lives as farmworkers, including struggles they have faced as single parents, and by the very nature of working in agriculture; a reality that exposes these individuals to adverse health conditions driven by lack of health insurance, pesticide exposure, and poor working conditions. Pesticide exposure is a topic of concern in the farmworker community and studies of environmental health and regulatory reforms at the state and federal level. In all, three farmworkers shared their experiences with me on this subject. The first two interviews were with two young women (29 and 25); both were the mothers of two small children. Each expressed worry because they had witnessed other farmworkers becoming sick and dying due to pesticide exposure, and they had sustained burns from the freshly sprayed pesticide applications. The first woman also told me that she experienced a miscarriage of her first child as a result of both exposures to these substances and continued work in the cilantro fields even in the late stages of her pregnancy.

This story was followed up by a 28-year-old male from Mexico City, Mexico, who started working in the cilantro, tomato, and strawberry fields at age 18. He expressed again his concern with the number of pesticides being used and the exposure to these chemicals (absorbed through the skin, inhaled). What was most noticeable about this man was the scarring on his left forearm and hand, all the result of dermatological irritation that in the past cause blistering and itching. Along with their exposures to pesticides, these three farmworkers also experienced varying degrees of pain throughout their bodies, in their lower back and shoulder regions. The final interviews came from a Mixteco family from the southern Mexican state of Oaxaca, both husband and wife first came to the U.S. in 1999 and previously worked in Salinas picking strawberries. In their nearly 20 years of agriculture work they were very familiar with the dangers and adverse health effects of constant pesticide exposure. Both commented on seeing co-workers with rashes on their arms and exposed skin, as well as many workers showing symptoms of uncontrolled chronic disease (diabetes, hypertension) like fainting and lethargy.

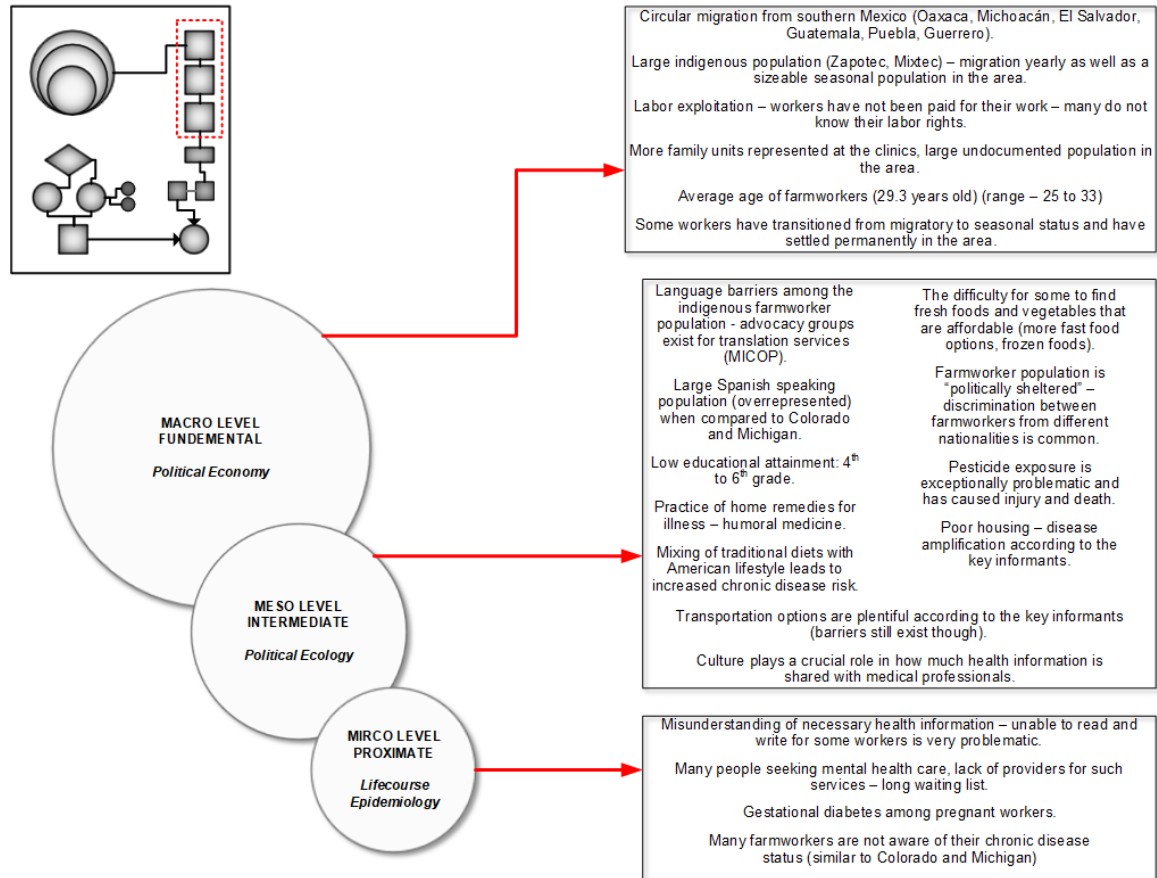


Figure 13.5 - Ecosocial model of farmworker health (qualitative)

CHAPTER XI.

DISCUSSION

Introduction

The results of this study consisted of a two-part mixed-method analysis featuring quantitative (Phase I) and qualitative (Phase II) methods. Phase I described the geographic distribution of chronic disease and risk factor-disease clusters; as well as delineating healthcare service areas. Phase II investigated the barriers to care through interviews with key informants and farmworkers in Colorado, Michigan, and California. Findings from both sections will be discussed in more detail in relation to the study research questions. Finally, policy recommendations and potential improvements to the geographic management of farmworker health will be discussed in further detail; this is then followed by the study limitations and conclusions. By accounting for multiple scales of analysis and theoretical perspectives, a detailed narrative of chronic disease within the farmworker community has been documented. This investigation revealed that the barriers to care for farmworkers are numerous, each directly correlated to individual and population level contextual determinants that govern the geographic distribution of chronic disease, and the accessibility to healthcare services.

Phase I - Question 1: How does the geographic distribution of chronic disease and associated risk factors vary within each of the three study areas?

The examination of migratory and seasonal farmworker disease clusters is a unique geographic study and one that is part of the classic triad in *descriptive epidemiology* (time, person, place). Mapping the distribution of geographic variations in disease risk presents a unique opportunity to examine the environmental and genetic influences of chronic disease. Geospatial sciences and geographic information systems (GIS) allow researchers and health authorities the ability to comprehend disease patterns and the underlying health determinants. In this study, GIS and spatial statistics were combined successfully for the first time to map the distribution of farmworker chronic disease and their associated risk factors. The distribution of chronic disease and risk factor clusters is widespread, especially in Colorado and Michigan, where the natural composition of the landscape affords these types of spatial phenomenon to propagate at multiple scales.

Zip codes are distributed in eastern Larimer, Western Weld, Morgan, Boulder, Broomfield, Adams, Arapahoe, Logan, Phillips, Sedgwick, and Washington County (Figure 13.6). The distribution of zip code clusters in Michigan displays the characteristic north-south orientation, a pattern associated with coastal Lake Michigan agricultural production. These counties include Berrien, Cass, Van Buren, Allegan, Ottawa, Kent, St. Joseph, and Muskegon (Figure 13.7). California, as mentioned previously displays clustering in large portions of southern Ventura County, as well as portions of Los Angeles and central Kern County (Figure 13.8). When compared between study areas,

what is clear is that the distribution of migratory clusters exhibits in some instances more non-spatial dependency when compared to the characteristic pattern observed in the vicinity to C/MHC's. For example, migrant obesity clusters in California (Bakersfield) or migrant diabetes in Michigan (Newaygo County) are outliers found outside of recognizable homogenous patterns. These geographies are also found in regions of low-accessibility; for example, zip codes in St. Joseph County, Michigan and Kern County, California.

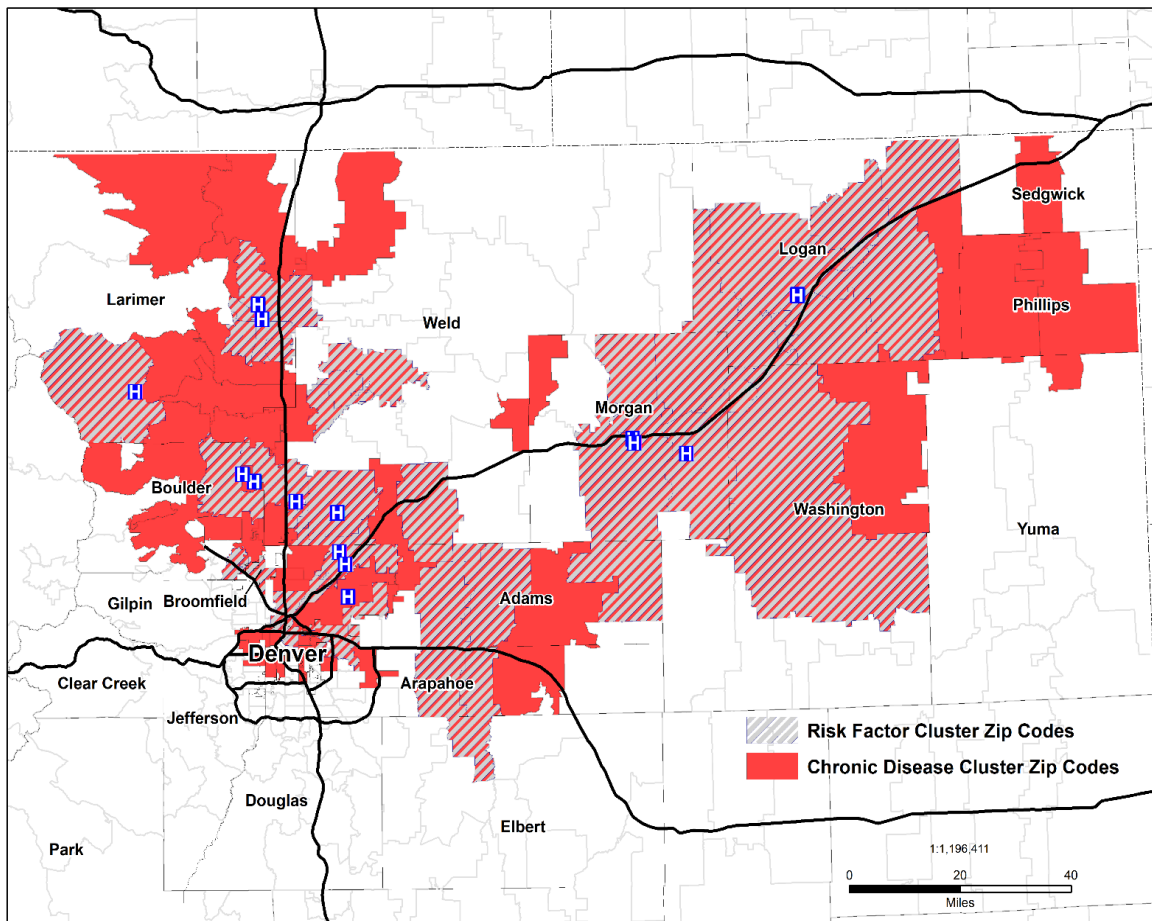


Figure 13.6 – Colorado zip code clusters

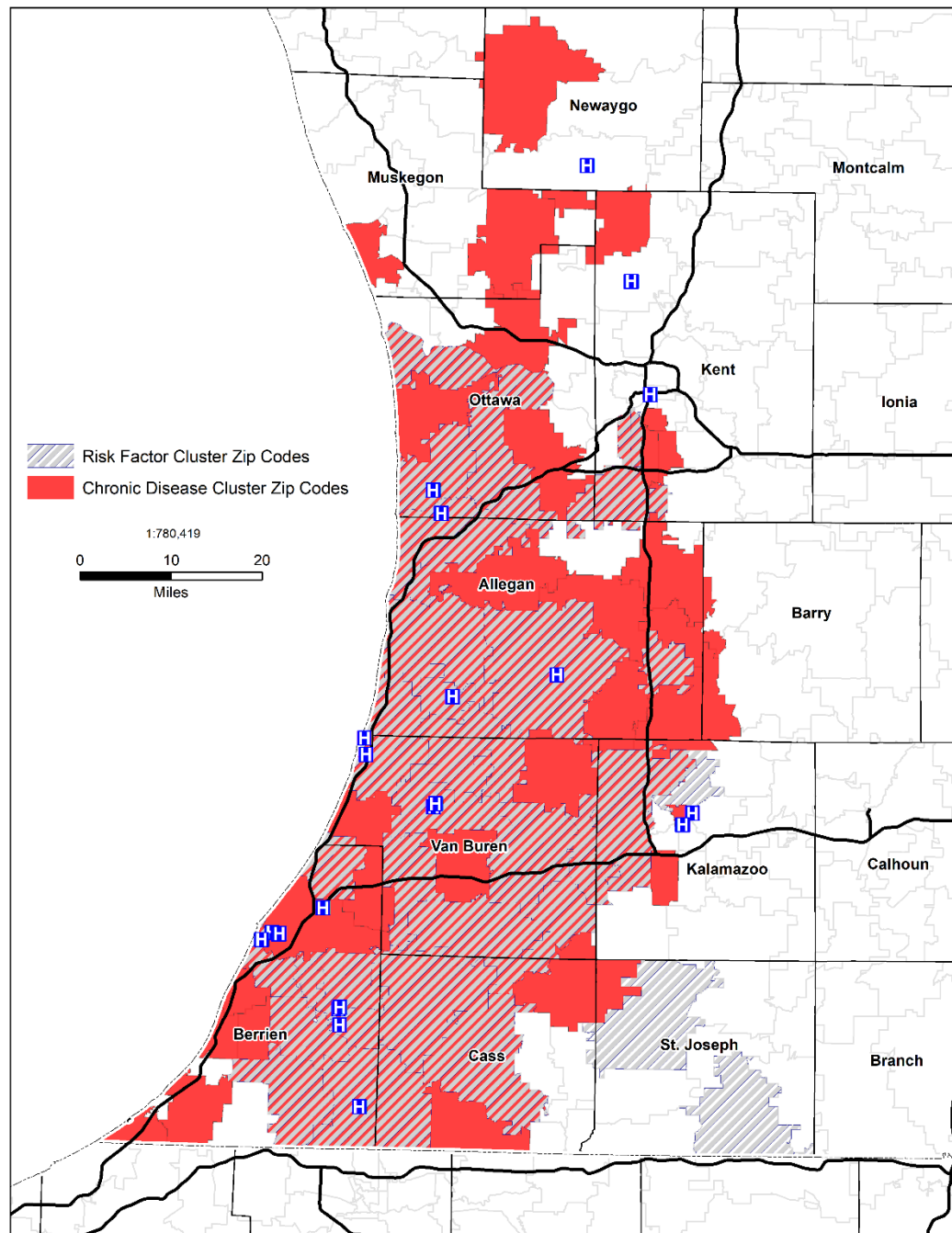


Figure 13.7 – Michigan zip code clusters

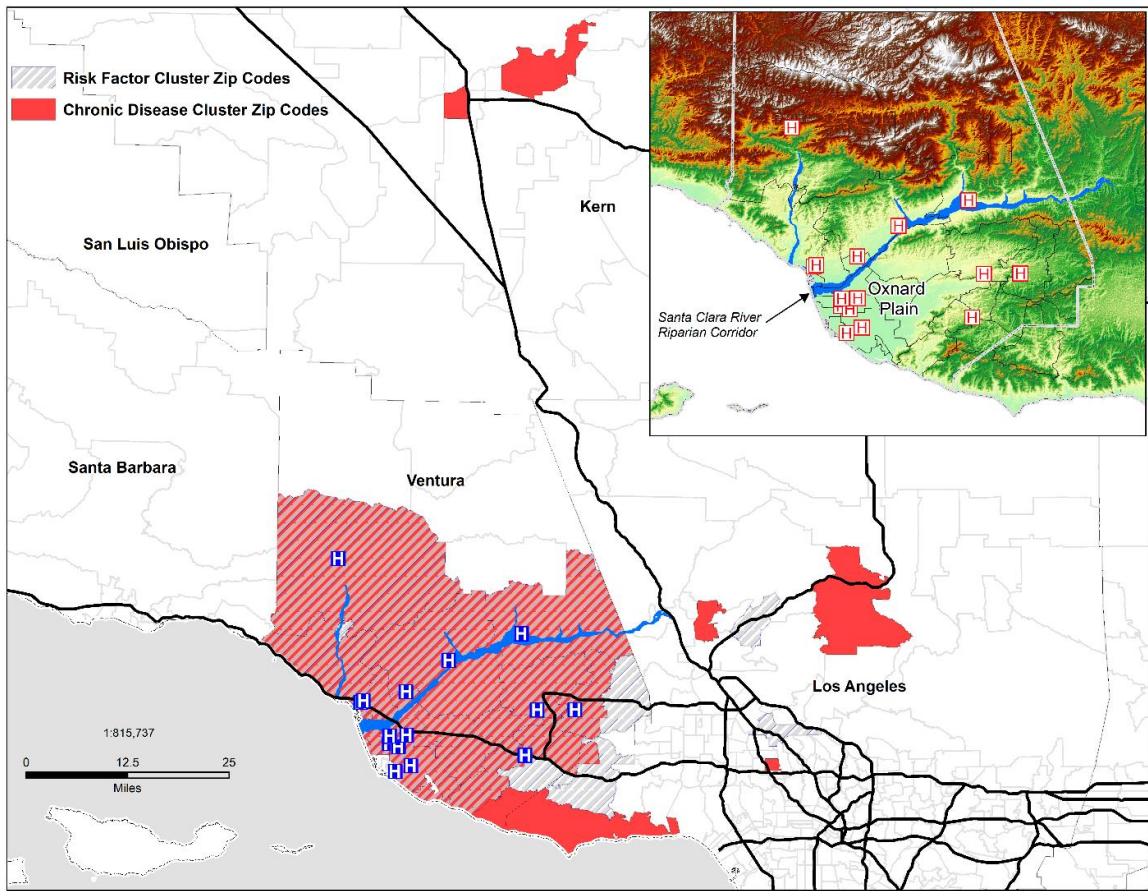


Figure 13.8 – California zip code cluster in comparison to the topographic profile of the region.

The total number of zip codes identified as clusters varied between study areas. In Colorado, 71 zip codes were identified in the chronic disease category, while an additional 44 were those of disease risk factors. Michigan in total featured 64 chronic disease zip codes and 36 zip codes in the risk factor category, while cluster detection in California revealed 26 chronic disease and 18 risk factor zip codes. The total number of zip codes within the extent of these clusters totaled 259 (Colorado – 115; Michigan – 100; California – 44). Patient encounters at C/MHC’s overwhelmingly were for the treatment of diabetes, which represented 56.2% of all encounters in Colorado, 49.3% in Michigan, and 61.2% in California, respectively. In total, when varying the SaTScan

MSWS model parameters to between 10 – 50% of the at-risk population, 209 total clusters were identified. Measures of cluster sensitivity, when using the aforementioned CBRN patient encounter data, were successful when set at 10% and 30% of the at-risk population.

These MSWS settings accounted for the location of 136 clusters (68% of the total) (Figure 13.6). Standard Monte Carlo inference (9999 permutations) testing for cluster validation at all window sizes (10 – 50%) produced a mean p-value of < 0.02 (Figure 13.5). Measures of cluster sensitivity produced meaningful results as it pertains to the on-going debate on the choice of SaTScan MSWS. Much of the literature on this subject is limited, and many scholarly manuscripts employ the default settings when using this technique. It is recommended that before specifying an MSWS that a variety of window sizes be experimented with to find the right combination to maximize the effectiveness of epidemiological investigation at multiple scales of analysis.

Measures of LLR and RR varied between the chosen MSWS. At 50% of the at-risk population, a greater range of high values is seen when plotting the LLR (Figure 13.7). However, this MSWS has fewer outliers than its counterparts. Additionally, the 50% MSWS produced the least total amount of total clusters between study areas, but the highest LLR value (421.92). When the RR for all window sizes are compared, the opposite is, in fact, true: the RR for chronic disease and risk factor clusters has the higher range of values at 10% and the highest total RR outliers. Relative risk is primarily an indicator of ‘excess,’ and this could be either patient encounters or deaths. Hence, RR is a more relevant indicator when attempting to identify and validate cluster locations.

Table 11. SaTScan model performance

	50%	40%	30%	20%	10%
<i>Total Clusters</i>	5	42	62	26	74
<i>Observed Encounters</i>	3,735	4,980	4,609	1,620	1,989
<i>Expected Encounters</i>	2,258	3,071	3,252	1,958	316

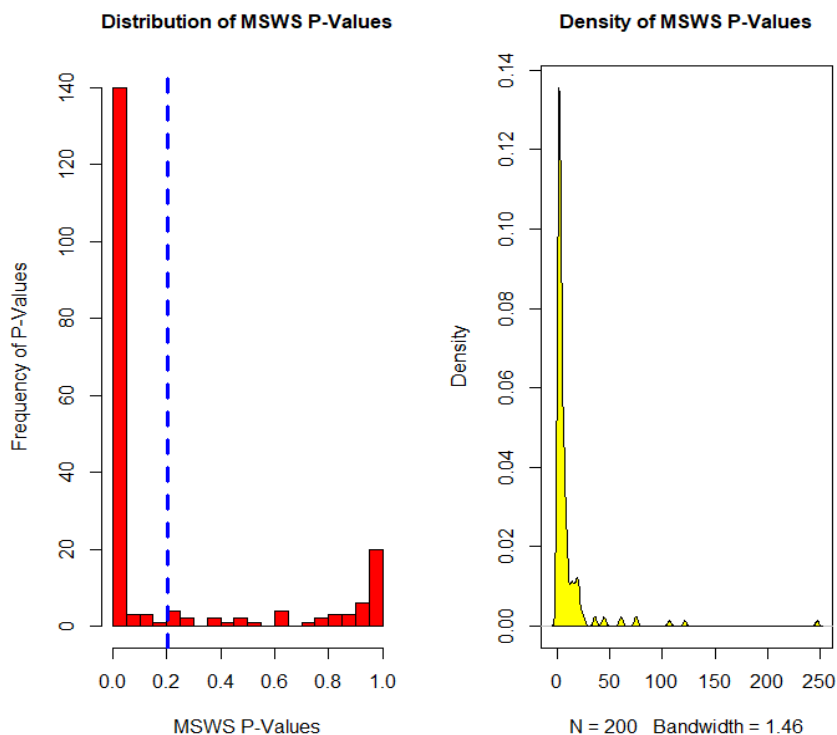


Figure 13.9 – The range and density of cluster p-values for all MSWS.

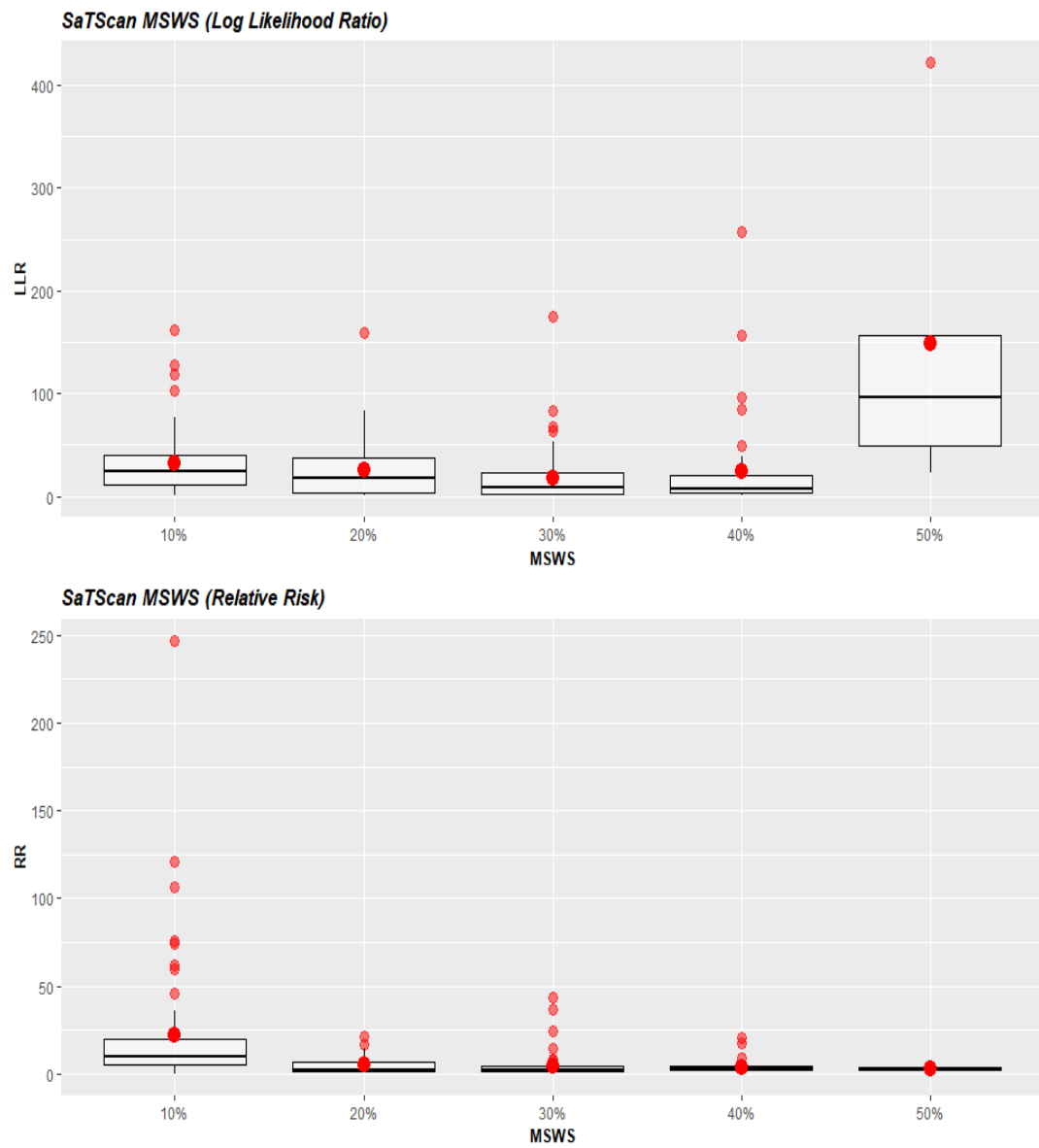


Figure 14 - SaTScan LLR and RR statistics (10 – 50% MSWS).

These results indicate that 10% and 30% of the at-risk population is an excellent approximation to maximize the power of scan statistic in three ways. The first guarantees the investigator the ability to apply the maximum level of total cluster identification; second, these parameters provide a more critical measure of cluster relative risk (RR), which is an essential component in locating high-risk cluster anomalies. Finally, the third advantage of using these MSWS is the inclusion of large proportions of the at-risk population while retaining the above-stated advantages. The 30% MSWS located just over 60 total clusters (2nd highest), a strong result that is further validated by the high overall total observed encounters.

The 10% MSWS produced 74 total clusters between locations and would be a good choice when the data set is relatively small (i.e., risk factors and obesity) or when attempting to balance fluctuation in detection for rare diseases (i.e., Bovine Spongiform Encephalopathy) (Forbes et al. 2013), or in rural areas where the at-risk populations are small. Another positive result associated with the 10% MSWS was the ability to discern many cluster anomalies at large and small scales. These clusters would previously be hidden inside the larger window sizes. Furthermore, the practice of multiple variable cluster window sizes addresses spatial aggregation challenges associated with the modifiable aerial unit problem (MAUP).

Question 2: Are there any geographic variations in healthcare accessibility between study areas?

Comparisons of geographic accessibility to C/MHC's in each study area revealed similarities regarding the sheer number of farmworkers living within 30-minutes of a C/MHC. The delineation of service areas determined that in total 2,732 farmworkers in all three study areas lived greater than 30-minutes from a C/MHC, or 7% of the total population (n = 39,193). In Colorado, much of the population lives in the vicinity of a C/MHC. However, large pockets of inaccessible workers are distinguishable in the southern half of the City of Denver and Arapahoe, Jefferson, Douglas, and Weld County. Counties farther to the east with similar conditions include Washington, Morgan, and Logan. Michigan, which has the highest percentage of farmworkers (10.2%) living greater than 30-minutes from a C/MHC, has a higher number of counties falling outside of the 30-minute excessive threshold. These include Muskegon, Newaygo, Oceana, Branch, Barry, Ionia, Montcalm, Cass, Calhoun, St. Joseph, Elkhart (Indiana), and LaPorte (Indiana).

California provides an interesting alternative to the other two areas, in that the region is predominantly urban and suburban. While there are substantial areas in the greater Los Angeles Area that have desert and semi-arid biomes, much of the agricultural output and farmworkers are localized in coastal areas of Ventura County. The key informants in Colorado and Michigan supplied responses that on the surface imply that transportation issues are endemic in these areas and persistent through generations. The responses in California, on the contrary, implied that much of the population has ample access to multiple modes of transportation, which is further hypothesized as being

directly correlated to Ventura County's location in the Los Angeles Metropolitan Area.

One solution to providing coverage for a higher percentage of the population in Michigan could entail the development of a database that accounts for the migrant camp locations, and not the city or town provided when registering at a C/MHC. Migrant camp locations could provide to farmworker care providers a higher level of intricate detail on accessibility issues. Counties in Colorado and Michigan on the fringes of low-accessibility should also be aware of the benefits of the integration of urban-rural transportation networks. This urban-to-rural spectrum represents a distinct problem in accessibility studies. The urban access issue is characterized by congestion, rather than the rural in which the strategic concern is the cost of access and the travel time over low or intermediate roadways (Lockwood 2004).

Farmworkers in Michigan and Colorado are more likely to encounter the cost of access issue due to the propensity to reside in rural areas, characterized by road operating constraints (i.e., speed limits, road quality) and weather incidents (Lockwood 2004). Earlier studies have investigated how policymakers can bridge the gap between urban-rural networks to create accessible environments for all population groups. For example, Sipus and Abramovic (2017) found that through the integration of urban-rural transportation systems especially public bus services, that rates of emigration decreased, and the quality of life increased for rural residents. Murawski and Church (2009), through the application of a Maximal Covering Network Improvement Problem (MC-NIP), found that access to healthcare services increased in rural areas when the road network was improved through selected targeting of poor-quality segments

Phase II - Question 3: What risk factors are associated with migratory and seasonal farmworker health and do these factors vary geographically (rural, urban, semi-urban) between study areas? How do the health needs of farmworkers and the challenges faced by key informants in treating this population differ geographically?

Phase II of the study consisted of interviews with farmworkers and key informants at C/MHC's in Colorado, Michigan, and California between June and August 2018. In total, 32 interviews were conducted (9 key informants; 23 farmworkers). The average age of farmworker participants was 33.9 years old. Farmworkers in California and Michigan originated in *non-traditional* Mexican sending states (Puebla, Oaxaca, Guerrero, Chiapas, Morelos), while workers in Colorado originated in *traditional* sending states (Guanajuato). Circular migration was common among farmworkers in this study, with many returning to Mexico when their work was completed; however, only farmworkers in Colorado and Michigan migrated annually.

Macro-level (fundamental)

Multiple push-pull dynamics regulate the political economy of health at local and global scales. Macro-level frameworks in this study helped in our understanding of the many economic, political, and socio-cultural forces which shape the health of farmworkers. Traditional labor theory views all workers as competing and being paid according to their marginal productivity. These markets are divided into primary and secondary labor sectors. The primary sector provides to workers the greatest opportunity for advancement, job mobility, and fringe benefits (i.e., health insurance, paid vacation). Secondary markets, in contrast, feature higher levels of instability, little opportunities for

advancement, no fringe benefits, and more discrimination on gender and racial lines (Bernstein, 1998). Workers in the secondary labor market are the main concern for policymakers, especially those who are the primary income source in their households. Farmworkers in these urban enclaves and those on the periphery would be situated in the secondary labor market.

In all three study areas, there is an urban component (as well as rural) to the political economy of health for farmworkers which draws workers from urban centers like Los Angeles, Chicago, and Denver. The key informant interviews in Michigan revealed that the deviations from the traditional farmworker demographic profile (Chinese) were, in fact, a consequence of the proximity to Chicago, which draws low-skilled workers from the city's vast and diverse immigrant community. The key-informant interviews revealed that for instance in Colorado, support for community and migrant health programs have bi-partisan support throughout the state, and since the 1990s funding for these programs have increased exponentially.

These policies are in line with the Migrant Health Act (MHA) and the Migrant Health Program (MHP) of 1962, a federal law which established the guidelines for providing healthcare for agricultural workers with the ending of the Bracero Program. California, similarly, has according to the key informants provided farmworkers in Ventura County with a politically protected environment that allows these workers to access a variety of healthcare services and transportation options. Admittedly, in Michigan, it was difficult to fully judge the local and regional political climate towards farmworkers due to an apparent lack of knowledge from the key informants themselves

on these topics. These individuals seemed more in-tuned with the national narratives and less astute in discussing the local representation of farmworkers.

The characteristics of the farmworkers interviewed in this study varied between study areas. While the average age of workers was in line with the literature on the subject and the temporal trends in demographics, there still existed minor dissimilarities. The first commonality was the young populations represented during the interview process. In Michigan, the migrant camps had two distinct structural components, family units with transportation versus young, single male units with no transportation options. The age range between camps and respondents was 21 to 38 (29.8 average) years old regardless of if these workers were married or had children. Similarities were seen in Colorado; however, the interviewed farmworkers were much older on average (42.5), and featured men as old as 62, and as young as 25. It is estimated that 15 to 20% of farmworkers in Colorado migrate alone. California featured more family units, less single males, and more female agricultural workers. On the contrary, in Colorado, females often worked in a greenhouse setting and were not often found working in the fields.

Migration similarities and dissimilarities exist between study areas (Figure 13.8). For example, agricultural workers in Colorado are predominately from Mexico and the traditional sending states of Chihuahua, Leon, and the city of Valle de Santiago, as are farmworkers in Southern California, who primarily originate from traditional and non-traditional sending states of Michoacán and Oaxaca. On the contrary, interviews in Michigan with key informants and farmworkers revealed that many of the workers originate from the traditional sending states of Morelos and Guerrero, as well as Haiti and Honduras. The economic drivers geographically have also shifted from region to region.

For instance, in Colorado much of the traditional streams of workers have in recent decades shift away from the domestic labor market (Texas, New Mexico) to international sources of labor; the same is true for California, which now imports most of the farm labor from Mexico and Central America. However, in Michigan, there still exists strong domestic bonds of labor from the eastern stream and Mexico and Central America.

California is home to a large and diverse indigenous farmworker population from southern Mexico and Guatemala, much more abundant in total numbers than their counterparts in Colorado and Michigan. Farmworkers from the state of Oaxaca for example, have historically engaged in subsistence farming, but in recent years have met numerous obstacles (push-pull) that have forced these people from their land (economic stagnation, population encroachment) (Kresge 2007). Indigenous Oaxacans are the fastest growing farmworker population in California, with total population estimates numbering between 100,000 to 150,000. The largest communities of indigenous Mexicans from Oaxaca in California are found in the Los Angeles County, Ventura County, Central Valley, and the Central Coast (Kresge 2007).

Migration and the relationship to health were discussed in this research and interwoven into the interview questions with key informants and farmworkers. Responses were broad and ranged considerably. Key informants in all study areas acknowledged the impact of migration on the health of farmworkers from the standpoint of follow-up appointments at C/MHC's. As is often the case, farmworkers do not for several reasons (socio-cultural, migration) continue to follow-up with medical professionals for the treatment of chronic disease, especially diabetes and hypertension, which require consistent monitoring and intervention to lessen the burden of symptoms. Migration,

singularly, is a global phenomenon that influences the health of individuals and populations. These spatial movements of people are not one-dimensional and need to be viewed from a multi-stage context that does not primarily focus on permanent transnational resettlement.

Zimmerman, Kiss, and Hossain (2011) introduced a migratory health process model with five phases: *pre-departure*, *travel*, *destination*, *interception*, and *return*. This study is firmly entrenched in the destination phase, as are most migration and health policy research. According to the authors, from a public policy perspective lacks the focus on the socioeconomic influences of health. To understand if migration leads to adverse health consequences among farmworkers in Colorado, Michigan, and California, the other four stages need to be introduced. The *pre-departure* phase features factors that influence the decision to migrate as previously mentioned (political, economic, and interpersonal circumstances), which may affect these farmworker's physical and psychological health. The *travel* phase (Oaxaca – Ventura) features multiple transit locations where farmworkers will stop for short or extended periods. This stage is often when cases of human trafficking and illegal border crossings are documented (Zimmerman, Kiss, and Hossain 2011).

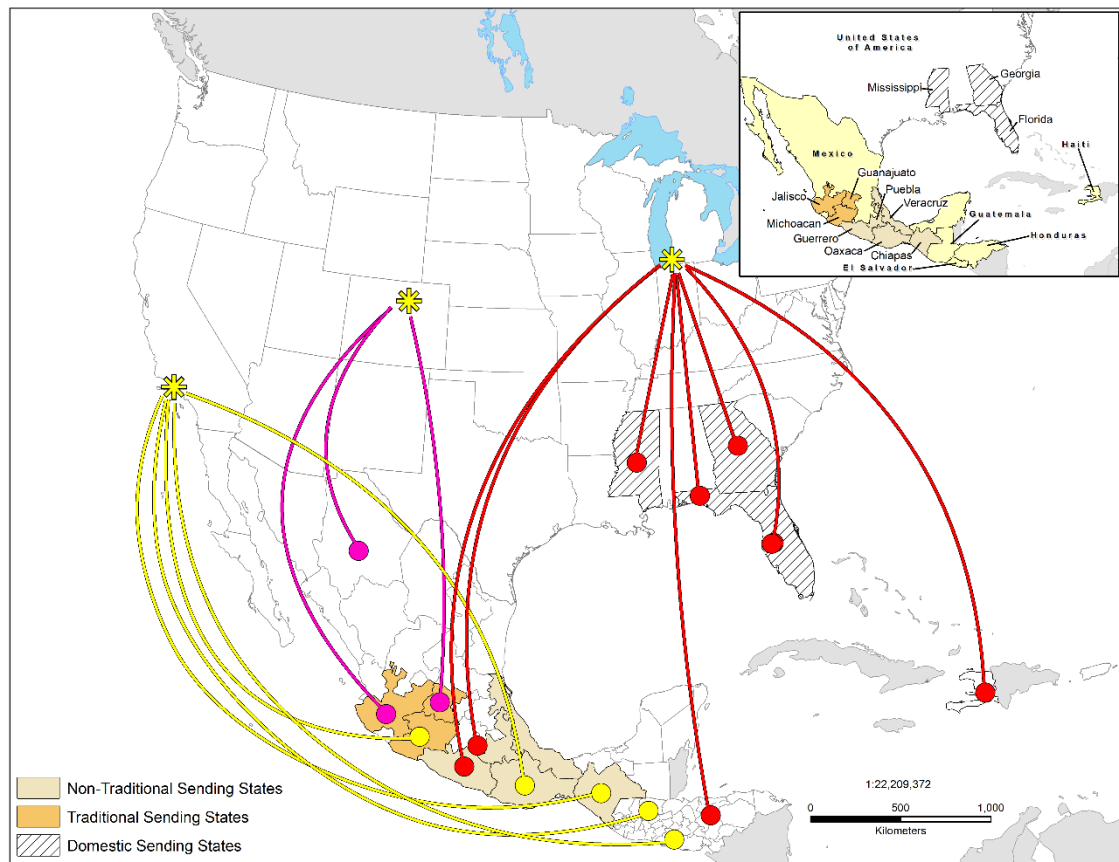


Figure 14.1 – Traditional and non-traditional migration routes to California (yellow), Colorado (purple), and Michigan (red). Location data collected through key informant and farmworker interviews.

The *interception* phase applies to a small portion of migrating populations. This phase applies to studies on forced (asylum-seekers, refugees, displaced populations) or irregular migrants, such as the sizeable undocumented farmworker population in California. This phase contributes to the health of farmworkers by affecting their mental and physical health through immigration control policies. Finally, the return phase is when farmworkers (Colorado, Michigan) go back to their place of origin, whether foreign or domestic. Individuals in this phase, as documented through key informant interviews, will return to low-resource areas (Mexico, Central America, Haiti) that may not be

equipped to treat chronic diseases like diabetes and hypertension. However, farmworkers may, through considerable remittances, be able to support themselves and their families (Holzmann, Koettl, and Chernetsky 2005).

In each of the study areas, labor exploitation is acknowledged as a significant issue by the key informants; however, it was evident that the full extent of these criminal acts is impossible to quantify. Migrant and seasonal farmworkers are the archetypical dependent employees, selling nothing but their labor, whose position within the social divisions of labor in the United States systemically constructs them as an atomized and disempowered stratum (Friedland and Pugliese 1989, 154). Farmworkers in Colorado, Michigan, and California face exploitation on several fronts. One is because of their lack of knowledge on labor laws in the United States, which combined with their legal status can give these workers little to no legal or political representation. Coupled with language barriers, this limits the ability for farmworkers to negotiate with their employers. The unskilled nature of the secondary labor sector is one of the few types of employment in the United States that is systemically compensated at rates below the federal minimum wage.

Migratory and seasonal farmworkers are employed in conditions that guarantee that their employers exercise control over when, where, how, and whether to plant crops, as well as controlling all production and marketing (Friedland and Pugliese 1989; Minuti 2014). In California, in some instances, farmworkers are not paid for their work on local farms. Another aspect of this exploitation is when farm management is resistant to granting their workers the ability to receive medical care from organizations like Clinicas del Camino Real. This was mentioned by key informants in Colorado as well, who

believed that these farms (primarily in the dairy industry) were hiding the true extent of how many illegal workers they were employing. Interviews in Michigan revealed that because of language barriers, migrant crew leaders because of language barriers were the primary contacts between farm management and their workers. Farm owners who operate through crew leaders attempt to heighten the anxiety of the worker who is fearful of not being rehired in the following season, and this anxiety causes farmworkers to work even harder. Farm operators who structure their operations on this premise receive the benefits of mobility, fungibility, and availability without compensation (Friedland and Pugliese 1989).

Meso Level

Meso level relations in social epidemiology and ecosocial theory are defined by transportation barriers, poverty, poor housing conditions, low educational attainment, language barriers, and the natural geography of the study areas. Combined, these contextual factors form the foundation of farmworker health, one that is a culmination of human activity and natural environmental characteristics that regulate the distribution of disease. Transportation in all study areas is a significant determinant of health for farmworkers and their families. However, this need displays considerable homogeneity in Colorado and Michigan, while the situation in California, because of the stable urban-suburban composition, is heterogeneous. Community health workers in Michigan described transportation barriers as “daunting” in scope and that previous effort to combat these issues were unsuccessful because of a combination of the region’s rurality, financial strains, and language barriers between farmworkers and drivers.

The unpredictable schedule of the workers again presents a severe challenge to bus or van drivers, as does accessing rural, secondary roads in poor physical condition. Key informants in Colorado acknowledged these barriers for farmworkers but claimed that interest in improving outcomes had in recent years been pushed aside for increased funding to improve clinical outcomes and mobile response teams. On the contrary, transportation in Ventura County according to anecdotal evidence is plentiful, and multiple options are available for farmworkers, including state-funded welfare programs, shuttle services, and peer-to-peer ridesharing services like Uber and Lyft. Transportation systems are unique in geography because they link people and places by streamlining access and reducing temporal space. While transportation systems in the United States have accelerated the growth of the country, these systems have fundamentally altered the landscape to the point where average Americans must drive to maintain their livelihoods (Waugh 2006). The U.S. interstate highway system has reduced temporal distance; however, physical distance remains constant, and by consequence, those farmworkers without vehicles are at a considerable disadvantage.

Poverty and poor housing conditions are another social determinant of health for farmworkers. Housing conditions in Colorado and Michigan were poor; in fact, during fieldwork on a farm outside of Ft. Lupton, Colorado this reality was on display. The men interviewed in Colorado lived in a two-bedroom farmhouse, which from the road looked dilapidated and abandoned. This farmhouse housed fifteen men for up to six months throughout the year. The conditions in Michigan were identical to those in Colorado. However, these workers lived in cramped, double-wide trailers, with mattresses strewn on the floor, and sometimes up to seven men living in one structure. To make matters

worse, these homes were in some camps occupied by families with small children. The educational attainment of farmworkers in all study areas is poor. Estimates in Colorado from interviews with key informants estimated that 90% of the population in the area has less than high school education. Educational attainment presents a serious barrier to health for farmworkers and is intimately tied to proximate level factors and lifecourse epidemiology. Higher educational attainment can lead to improved health outcomes for individuals through better-informed, health-related decisions for not only themselves but their families as well. Education is just one of the many economic and social conditions that shape the health of communities (Shankar et al. 2013).

Illiteracy is common, and farmworkers in these areas struggle with basic reading and writing comprehension; for example, writing their name or birth date is a considerable challenge which extends to all forms of verbal communication. Farmworkers may have difficulties in identifying themselves to health professionals and legal authorities, all of which can cause considerable increased stress and anxiety. Lack of educational attainment, more importantly, is detrimental when these workers try to understand and comprehend instructions on how to properly take medications for chronic diseases like diabetes and hypertension. To illustrate these challenges, during my interviews in Colorado I was informed that community health workers are tasked with educating adults on how to safely use toiletries like hand lotion, which in the past had been mistaken for toothpaste. In California, community health workers from local clinics make frequent trips to local farms to educate farmworkers on the dangers of sexually transmitted diseases with visual aids, because of the high illiteracy rates within these communities.

Finally, culture and the relationship to the short-term and long-term health outcomes was examined. Farmworkers, who predominantly originate from outside of the United States (Mexico, Central America, Caribbean), are faced with a variety of challenges when they first enter the United States. Even before these individuals' step in the apple orchards of Western Michigan or the greenhouses of Denver, they must navigate a new cultural landscape, unlike anything they have been exposed to previously. In all study areas, this navigation and adoption of new societal and cultural standards have undoubtedly affected the health of these individuals, either through yearly migration for improved economic opportunity or long-term residency. The culture of farmworkers from the traditional, non-traditional, or domestic sending states is diverse. Moreover, often is the case, when these behaviors are intermixed with traditional American principals, like diet, chronic diseases can propagate at macro, meso, and micro scales.

Without question, the key informants at C/MHC's in Colorado, Michigan, and California spoke of culture as one of the defining factors in farmworker chronic disease and their associated risk factors. Key informants in California commented that the cultural practices of some farmworkers are a factor when these individuals visit the doctor: some will not share sensitive information on their health or will not speak to a doctor or community healthcare worker without their spouse being present, which according to key informants in California was common among female farmworkers. Cultural influences are paramount to individual perceptions of emotional and emotional states. For example, Uppaluri, Schumm, and Lauderdale (2011) found that recent Asian immigrants were less likely to report stress over a 2-week period than whites, while Asian immigrants residing in the United States for at least 15 years reported higher levels

of stress.

Culture is even more of a factor when considering dietary habits, such as the traditional consumption of high caloric and fatty foods. This, combined with a lack of education on healthy food choices and the adoption of the negative aspects of the American diet and lifestyle, can increase and exasperate chronic diseases like diabetes, hypertension, obesity. Fast food options in the United States are plentiful, as are frozen foods, and convenience stores stocked with heavily processed items. Farmworkers are no exception to this reality and often bear the brunt of chronic disease, along with low-income and rural population groups of all ethnic groups. Access to fresh food options is a challenge, especially when transportation options are limited, and/or their long working hours do not provide these individuals with the time to prepare daily meals.

Medical professionals and community health workers in Colorado, Michigan, and California are faced with these unique challenges even when bilingual providers and interpreters are readily available. While almost all the key informants in this study spoke Spanish fluently, this does not necessarily correlate to higher patient satisfaction. Earlier research has found that ethnic resemblance alone is not enough for providing culturally appropriate care (Shaw 2005), while, on the contrary, higher satisfaction has been documented among minority group members who share a language and/or ethnic background (Carrasquillo et al. 1999). These studies imply that the relationship between medical provider and patient is complicated, malleable, and contextually based; this combined with frequent farmworker migration, prevents doctors from establishing effective communication with farmworkers which is vital for successful healthcare.

Micro Level

The micro level (*proximate*) progression (lifecourse epidemiology) represents the final stage of progression in the farmworker ecosocial model of health. To review, the lifecourse approach centers on the study of the long-term effects on health from social exposures during gestation, childhood, adolescence, young adulthood, and later adult life (Kuh et al. 2003). Disease risk is therefore in farmworker populations associated with biological, behavioral, and psychosocial processes that operate across micro level (individual) and generational scales. The progression is directly correlated with the determinants of health in the previous macro and meso stages of the ecosocial model. Interviews with farmworkers and key informants revealed that environmental exposures in the farmworker country of origin were a critical antecedent in predicting the long-term effects on adult chronic disease risk. In all three study areas, a broad array of similarities existed when the responses from farmworkers and key informants were compared.

One significant commonality, originating from the meso level (*intermediate*), is the difficulty for farmworkers to understand necessary health information due to their low levels of educational attainment and the potential of experiencing language barriers when trying to seek medical care. Low health literacy is associated with difficulties in not only reading and interpreting information, but also tasks such as interpreting food labels, measuring blood glucose levels, and adhering to medication regimens (Berkman et al. 2011). One consequence of low levels of health literacy in this study were poor dietary habits by farmworkers and their families. Research published by Quandt et al. (2018) highlights the difficulties that farmworkers face as it pertains to diabetes management and following dietary guidelines. Quandt and colleagues discovered that about half of all

lunches and a quarter of all dinners were bought from vendors or other commercial sources. This study further determined that 1 in 5 farmworkers reported issues with food insecurity, and another 2 in 5 reported lack of control of meal content (Quandt et al. 2018).

The first key informant interview in Colorado pinpointed a distinct homogenous region characterized by the proximity to C/MHC's, agricultural fields, and Interstate 25, or the "I-25" diet. Farmworkers living and working in this area often will use the many fast food options along Interstate 25 between Denver and Ft. Collins. In the interest of explaining this apparent correlation, fast food locations along the corridor were geocoded and mapped in comparison to obesity cluster zip codes for both migratory and seasonal farmworkers (Figure 14.1). The results of this simple geospatial analysis supply a wealth of information about the relationship between obesity clusters and the availability of fast food options. Statistically significant obesity cluster zip codes for both groups contained 62.4% of all fast food locations (n = 157) and 34% of the total farmworker population (5,519).

Key informant interviews in California reveal that gestational diabetes mellitus (GDM) is diagnosed among expecting farmworker mothers. Risk factors for GDM in women include obesity, glycosuria, personal history of GDM, or a strong family history of diabetes (American Diabetes Association 2004). GDM occurs in 2 to 9 percent of all pregnancies and is associated with fetal complications (Hoffman et al. 1998). Long term adverse health outcomes for children born to mothers with GDM include glucose tolerance impairment (Silverman, Metzger, Cho, and Loeb 1995), obesity (Petitt et al. 1985), and impaired intellectual achievement (Rizzo, Metzger, Dooley, and Cho 1997).

Female farmworkers with GDM additionally face an increased risk of the development of type 2 diabetes after pregnancy (American Diabetes Association 2004). While a sobering reality, gestational diabetes mellitus is correlated with the lifecourse and exposures of farmworkers long before they become pregnant. These exposures are the culmination of exposures during the fundamental (*macro*) and intermediate (*meso*) portions of the ecosocial model of farmworker health.

Another commonality between all locations was the demand and lack of mental health providers. Because of the problematic living and working conditions experienced by farmworkers, they may be at increased risk for psychiatric disorders. In California, for example, farmworkers visiting C/MHC's seeking treatment for depression, anxiety, stress, often must wait weeks until they can receive a medical evaluation. This fact, coupled with the young farmworkers in Michigan and Colorado who commented that their mental health at times is reduced because of the demands of their jobs, highlight the fact that psychological disorders in farmworker populations are a significant issue in need of additional investigation. Interview responses from farmworkers and key informants were not entirely surprising considering that the literature on the topic is substantiated. Earlier work by Vega et al. (1985) found that middle-aged farmworkers (40 to 59 years) were at the highest risk of psychological distress, while numerous others have highlighted the psychological stressors indicative of the lifestyle of agricultural workers (Barger and Reza 1994; Goldfarb 1981; Rothenberg and Epp 2003).

Melchior et al. (2007) also discovered that young adults (age 32) exposed to high psychological job demands had a two-fold risk of major depression or generalized anxiety disorder. Risk of these disorders was consistent in both male and female

participants; however, only in women was there an association with low socioeconomic status. This holds significant importance for the qualitative portion of this study, considering the relatively young age (average = 33.9 years) of the interviewees and the barriers to health that the majority have experienced firsthand. Another factor in lifecourse health is the relationship between farmworker mothers, depression symptoms and child weight outcomes (Marshall et al. 2018). Marshall et al. (2018, 1) found that child of mothers with severe or chronic depressive symptoms were more likely to be overweight or obese. Depression significantly predicted diet quality, and children of mothers with moderate to severe symptoms were fed less responsively. With these facts being presented, the establishment of prevention and treatment services for farmworkers for all age groups is the first step in lessening the mental health burden of an individual's life course.

Migrant workers in Colorado and Michigan interviewed in this study admitted that migration had contributed negatively to their health. Continual migration is a form of acculturative stress which in previous findings increases the risk of depression and suicidal ideation among farmworkers (Hovey 2000). Culture is again a factor at the *micro level* because of the correlation to an individual's lifecourse and environmental exposures. Migrant workers, especially those of Mexican descent, may feel particularly vulnerable when they lack social support because of an emphasis on collectivist values and affiliation. Social support is crucial for the development of self-esteem; low self-esteem may put an individual at increased risk of anxiety (Alvarez 1987; Hovey and Magana 2002).

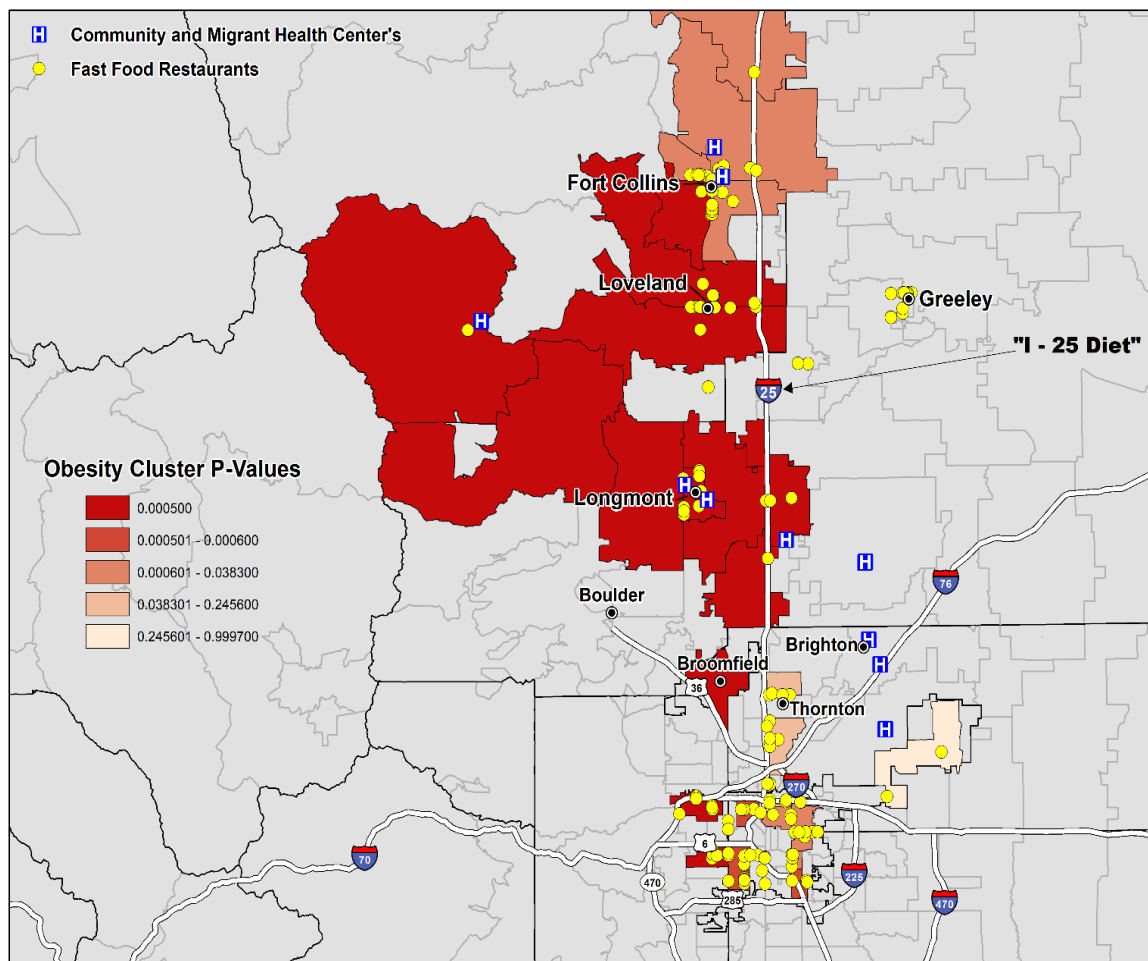


Figure 14.2 – Obesity clusters in Colorado in comparison to the location of fast food restaurants. According to the first key informant interview, farmworkers living in this stretch along I-25 from Denver to Fort Collins practice what is called the “I-25” diet, because of their propensity to choose fast food options.

Phase II - Question 4: What is the demographic, occupational, social, and health characteristics of migratory and seasonal farmworkers in Southern California, Northeastern Colorado, and Western Michigan?

In comparing the study areas, some interesting similarities and dissimilarities were discovered. First, patient encounters in Michigan and Colorado revealed that heavy patient traffic is observed in the first five months of the year with gradual decreases as the year progresses. Farmworker health advocacy organizations and community health workers would benefit from targeting these months with more vigor from a disease surveillance perspective. California's climate and role as a national crop provider especially to cold winter states in the Northeast and Midwest is apparent. The total patient encounters in Southern California are constant throughout the year, a phenomenon intertwined with geography and the year-round demand for low-skilled workers. Frequent migration is another potential factor in the drop-in encounters during the fall and early winter months (October, November, December) in Colorado and Michigan. The burden of chronic disease risk factors is also apparent. The risk factors for chronic disease at some clinics constitute the highest percentage of farmworker patient encounters. In total, six clinics (CDCR Ventura (California), CDCR, Fillmore (California), CDCR EL Rio (California), Bangor (Michigan), Pullman (Pullman), Brighton Salud (Colorado) featured a higher percentage of patient encounters in relation to chronic disease risk factors (Figure 14.3, 14.4, 14.5).

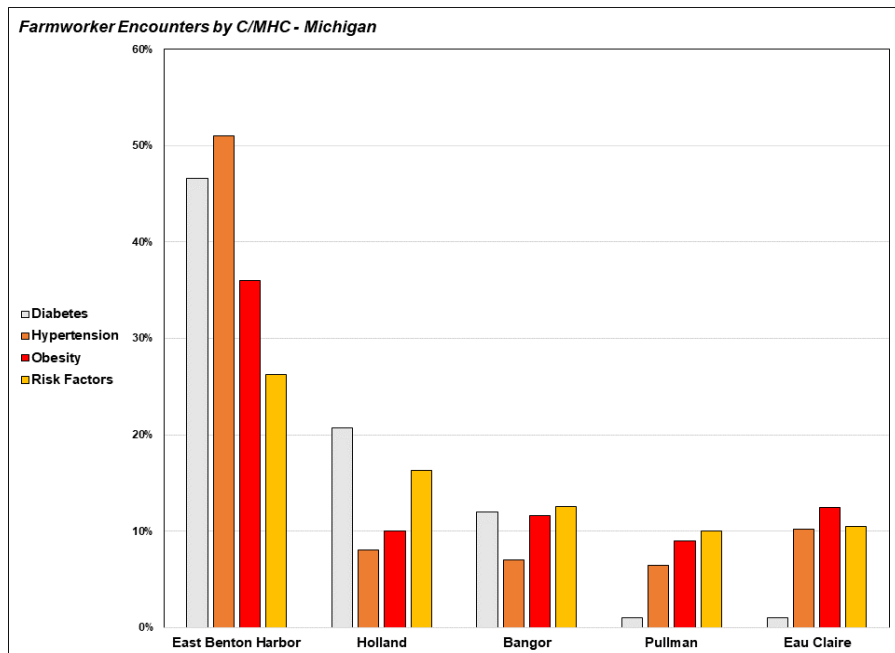
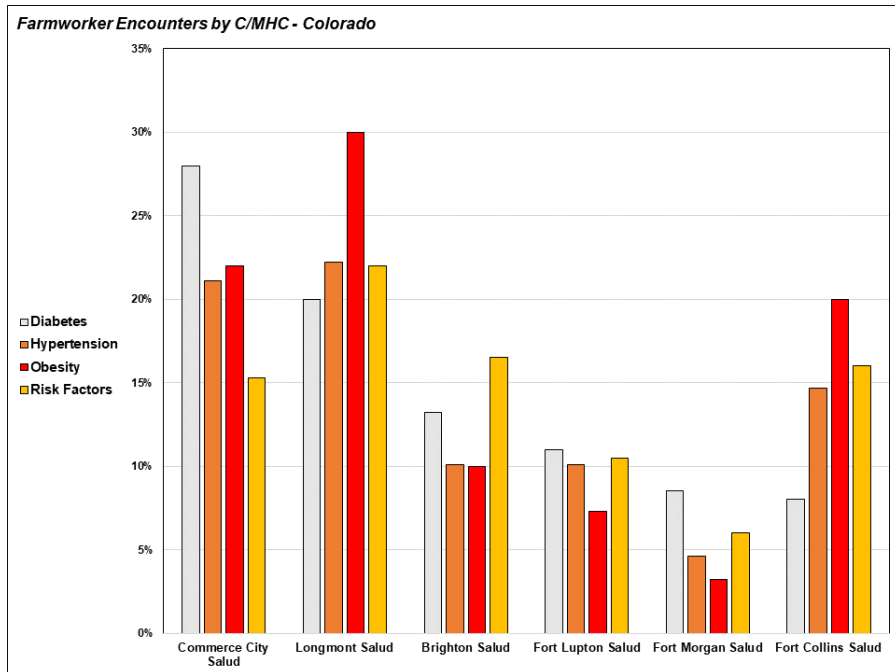


Figure 14.3 & 14.4 – Percentage of farmworker patient encounters in relation to diabetes, hypertension, obesity and their associated risk factors at C/MHC’s in Colorado and Michigan.

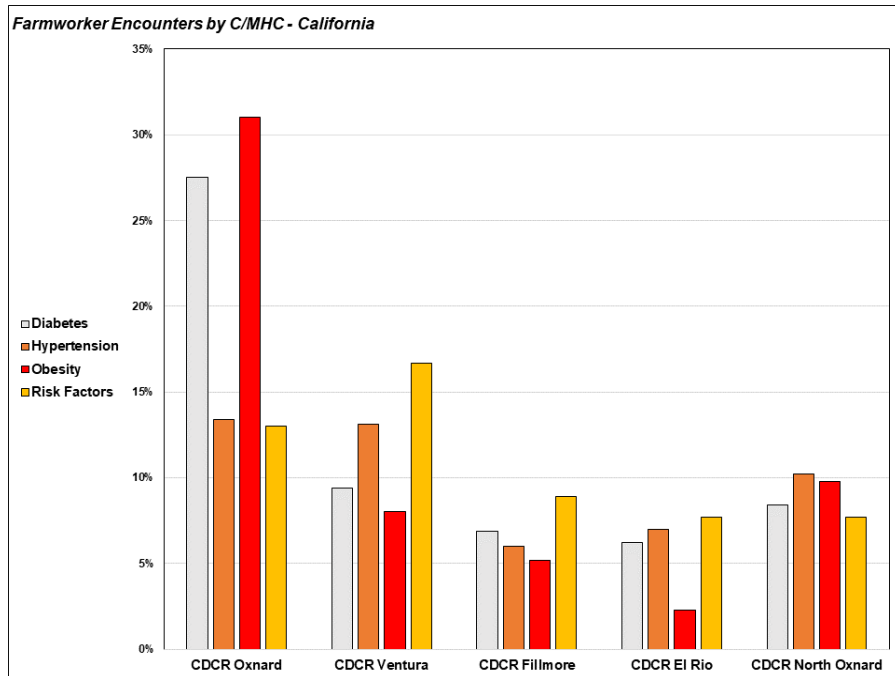


Figure 14.5 – Percentage of farmworker patient encounters in relation to diabetes, hypertension, obesity, and their associated risk factors at C/MHC's in California.

Surprisingly, diabetes made up the highest total of patient encounters at just four clinics: Commerce City Salud (Colorado), Fort Lupton Salud (Colorado), Fort Morgan Salud (Colorado), and Intercare Holland (Michigan). Farmworker encounters for the treatment of obesity were highest at four clinics as well: CDCR Oxnard (California), Intercare Eau Claire (Michigan), Longmont Salud (Colorado), and Fort Collins Salud (Colorado). Hypertension encounters, in a similar fashion to diabetes, surprisingly were only the majority at two clinics: Intercare East Benton Harbor (Michigan) and CDCR Oxnard (Colorado). One glaring dissimilarity between study areas is the lack of social welfare programs for farmworkers and their families. California has in place a variety of social service programs, unlike Colorado and Michigan; these programs support the transportation, health, and language needs of the population in Ventura County.

Farmworkers in Ventura County are supported by advocacy organizations like the Central Coast Alliance United for a Sustainable Economy (CAUSE), Medi-Cal, and the Mixteco/Indigena Community Organization Project (MICOP).

Spoken languages in each study area varied considerably. Geographically different languages spoken by farmworkers encompassed Africa, Europe, southwest and southeast Asia, and the Caribbean. In Colorado, for example, Amharic, Nepali, and Swahili were unique to this area; as were Bulgarian, Haitian, and Polish in Michigan; and Farsi, Russian, Punjabi, Urdu, Zapotec, and German in California. Languages spoken by farmworkers in all areas were Arabic, Chinese, French, Hindi, and Portuguese (Table 12). Similar languages spoken in more than two study areas include Japanese, Somali, Cambodian, Korean, and Vietnamese. The variety of languages spoken by farmworkers in this study highlights again just how diverse this population is today.

Farmworkers are not a monolithic group, and while most farmworkers speak Spanish as a first language, a sizeable amount are bilingual and originate from a variety of educational backgrounds. For example, languages like Amharic and Tigrinya originate in the Afro-Asiatic language family and are found in Ethiopia, Eritrea, and the Horn of Africa. Tigrinya is spoken by ethnic Tigrayans from the highlands of Eritrea and northern Ethiopia. Tigrinya and Amharic alone pose a challenge for community healthcare workers, especially considering that the financial resources for language translation services are scarce. Community health workers also need to be aware of the presence of hearing-impaired farmworkers, as discovered in California and Colorado. Comparisons of demographics between study areas determined that diabetes and hypertension patients are considerably older than farmworker encounters for obesity and chronic disease risk

factors.

The average age for diabetes encounters is 57.6 years old, while the average age of hypertension patients was 52.1 years old, and obesity patients were on average 36.7 years old, followed by farmworkers being treated for risk factors at 44.5 years old. The younger farmworker patient profile for obesity is apparent: 56.4% of all obesity encounters at C/MHC's were for persons under the age of 40, and another 29.2% were under the age of 25. Analysis of spoken language between study areas, specifically Spanish and English, found that California farmworkers spoke the highest percentage of Spanish for diabetes (76%), hypertension (59.3%), obesity (66%), and risk factors (36%). Additionally, California also had the most sizeable number of farmworkers identifying as speaking an 'unknown' language (also see marital status). California farmworkers had the highest percentage of workers in diabetes (53.2%) and hypertension (51%) category that was married; however, this was not the case when examining farmworkers who identified as single. Single workers were predominantly located in Michigan and Colorado, a finding that corroborates the qualitative data validation portion of this study. Diabetes encounters in Michigan among single workers constituted 38.3% of total patient encounters; 51% in Colorado for hypertension; 62.2% for obesity in Colorado; and 51% of all risk factor encounters in Michigan.

Table 12. Farmworker Languages - Purple = unique geographically; Red = similar for all study areas; Blue = similar for at least two study areas.

<u>Colorado</u>	<u>Michigan</u>	<u>California</u>
Amharic	Arabic	Arabic
Arabic	Bulgarian	Cambodian
Chinese	Cambodian	Chinese
French	Chinese	Farsi
Hindi	French	French
Japanese	Haitian	German
Nepali	Hindi	Hindi
Portuguese	Korean	Japanese
Russian	Polish	Korean
Sign Language	Portuguese	Portuguese
Somali	Russian	Punjabi
Swahili	Somali	Russian
Vietnamese	Thai	Sign Language
Tigrinya		Urdu
		Vietnamese
		Zapotec

Table 13. Farmworker Demographics I

Diabetes	Mean	%	%	%	% Non-
	Age	Male	Female	Hispanic	Hispanic
Colorado	59	42	58	69	31
Michigan	57	39	59	26	72.5
California	57	40	60	53	9.7
Hypertension					
Colorado	42	42	58	59.6	39.9
Michigan	56	45.4	54.5	18	82
California	58.4	44	56	49	18
Obesity					
Colorado	34.0	39.0	61.3	66.2	32.0
Michigan	44.0	28.5	71.4	39.7	63.2
California	35.0	31.2	69.0	50.1	*
Risk Factors					
Colorado	47	40.3	59.6	35	62.4
Michigan	44	30	70	15.7	83
California	42.5	32.6	67.3	41.6	24.3

Table 14. Farmworker Demographics II

Diabetes	%	%	%
	Spanish	English	Unknown
Colorado	46	51.2	*
Michigan	18	80.4	*
California	76	20.6	32.2
Hypertension			
Colorado	40	57.3	*
Michigan	12	87	*
California	59.3	37.1	32
Obesity			
Colorado	41.0	57.2	*
Michigan	25.4	74.5	*
California	66.0	32.0	40.2
Risk Factors			
Colorado	19.4	79	*
Michigan	8.6	90	*
California	36	63	33.4

Table 15. Farmworker Demographics III

Diabetes	%	%	%	%	%
	Married	Single	Divorced	Widowed	Unknown
Colorado	53	32.5	0.08	0.03	*
Michigan	40	38.3	0.09	*	*
California	53.2	14.1	*	8.3	18
Hypertension					
Colorado	35	51	9	*	*
Michigan	36	39	15	*	*
California	51	21.3	*	*	17.1
Obesity					
Colorado	29	62.2	*	*	*
Michigan	38	48	11	*	*
California	29.1	46.3	*	*	19.7
Risk Factors					
Colorado	31.2	49	11.2	*	*
Michigan	27.3	51	14	*	*
California	25	40	*	*	23

Policy Recommendations and Implications

Additional meetings at C/MHCs are needed to communicate these results to clinical management and community healthcare workers. This collaboration has the potential to precipitate dialogue on future data collection efforts. Three policy recommendations are outlined below; each will significantly improve farmworker population health through an information management approach that prioritizes the incorporation of geographic information systems, associative environmental analysis, and disease ecology. The first policy recommendation is the *development of farmworker health districts*. Geographers naturally study a variety of human and physical issues from multiple geospatial perspectives. The organization of such phenomenon historically has been left to the development of regions to organize and simplify vast amounts of information. Because of the complex interaction between natural and cultural geofactors, it would be helpful for farmworker healthcare service providers to adopt geographic management of farmworker health through the development of health districts.

The adoption of geographic management for health information is quite useful when aiming to improve population health, the experience of care, and the reduction of per capita healthcare costs (Miranda et al. 2013). To expedite the development process, health district maps for locations in California (Figure 14.5), Colorado (Figure 14.6), and Michigan (Figure 14.7) are included below. These maps will provide for regional care providers geographic information about their patient population, which will subsequently translate to increased regional collaboration. These collaborations can increase organizational knowledge of disease pattern recognition, resource allocation, and current

gaps in healthcare accessibility. The merging of geospatial data management and visualization provides to policymakers a high degree of evidence-based decision making. Geographic management and health have previously been adopted in a variety of disciplines and topical, including the identification of suitable locations for primary care facilities (Dudko, Robey, Kruger and Tennant, 2018), the improvement of maternal and newborn health (Molla et al. 2017), and the assessment of the risk of urban vulnerability in San Juan, Puerto Rico (Mendez-Lazaro et al. 2018). These maps feature intermixing (*point of interface*) of the results from Phase I and II (Figure 14.6, 14.7, 14.8).

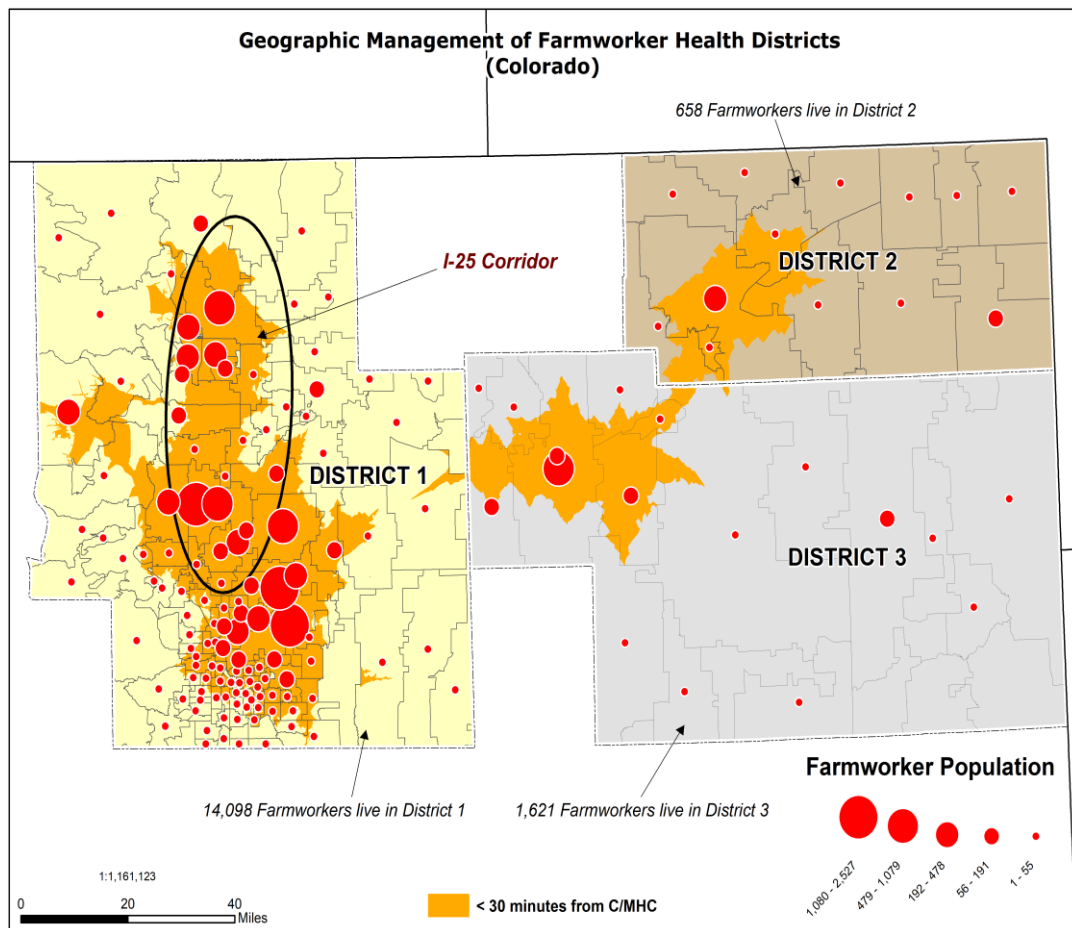


Figure 14.6 – Farmworker health district map (Colorado) with the inclusion of the I-25 corridor.

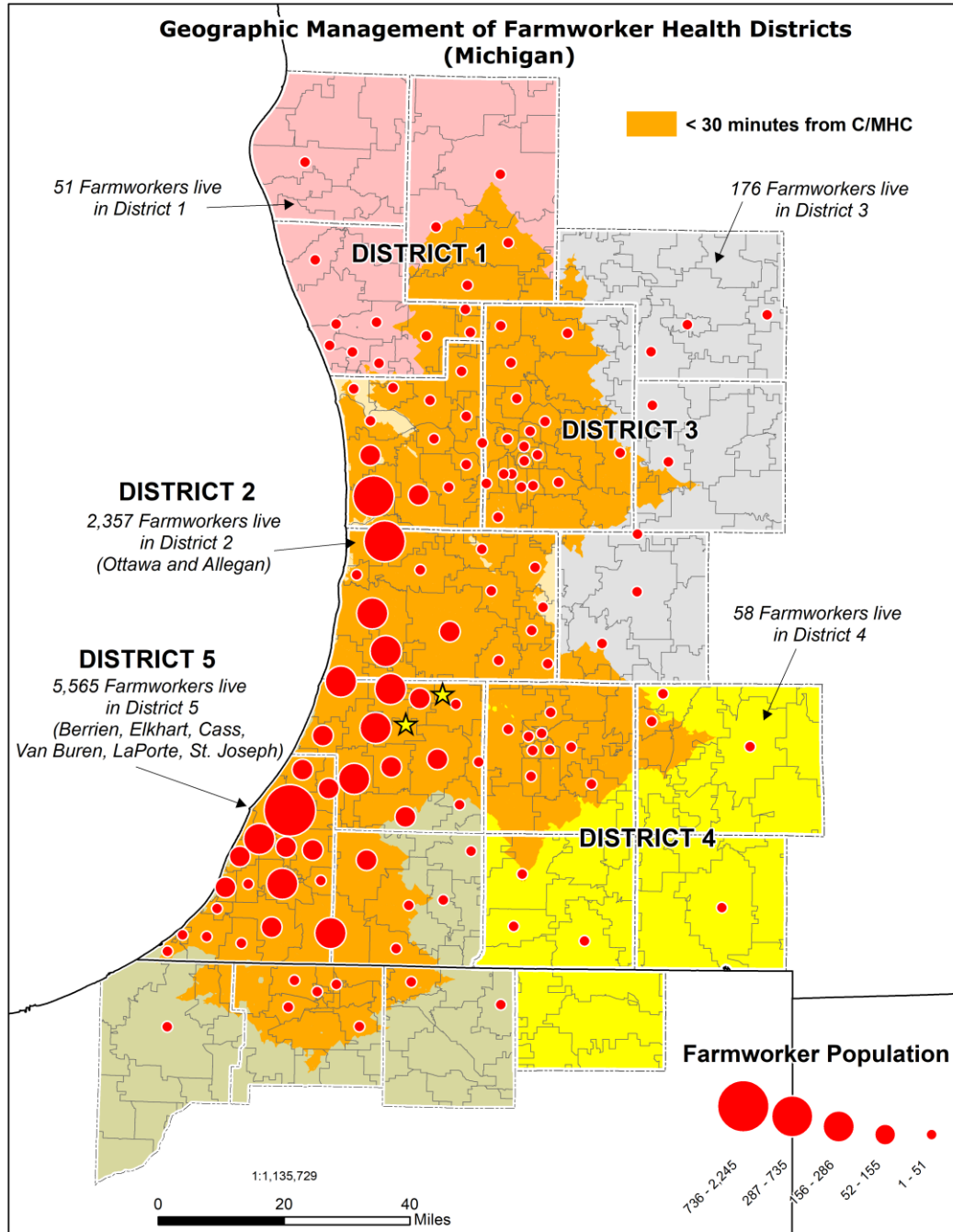


Figure 14.7 – Farmworker health district map (Michigan), yellow stars represent interview locations with farmworkers (August 2018).

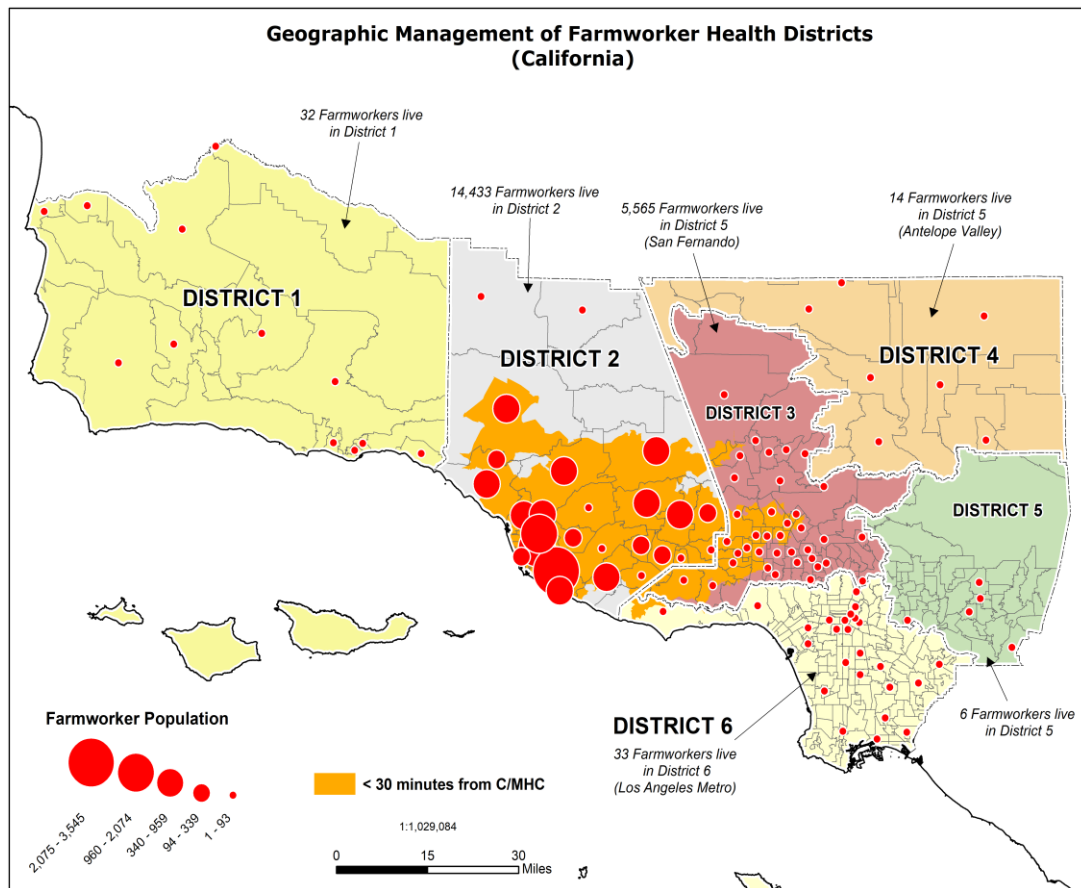


Figure 14.8 – Farmworker health district map (California)

The second policy recommendation is the *development of new healthcare service areas* with added proposed C/MHC locations. Based on the geographic accessibility analysis, the next obvious question is, how do we improve on the presented simulations? Although geographic accessibility is not the only determinant to health, where coverage is sparse, especially in rural areas, accessibility is vital in regulating the number of options for care. In a similar fashion as the previous section, some changes have been applied to the current accessibility models, through the incorporation of newly proposed clinics where gaps in coverage are apparent. It needs to be acknowledged that these clinics were not chosen with any prior financial consultation or site selection criteria. Regardless of this fact, the new locations significantly improve access for farmworkers

based on their city or town of origin alone.

The first of the proposed locations in Michigan should be placed in Muskegon and Centreville, two geographic locations in Western Michigan that have in the case of Muskegon sizeable farmworker populations and little service coverage. This scenario would lower the total number of farmworkers living greater than 30 minutes from a C/MHC to 140 (1.7% of the population), or an 83% decrease in the total number of farmworkers living excessively distant from a care provider (Figure 14.9). Second, the identical rational was applied to the Colorado service area, in which proposed clinics were placed in western Arapahoe County (Centennial) and eastern Jefferson County (Wheat Ridge), areas with current large farmworker populations and low accessibility.

In this situation, the total number of farmworkers living greater than 30 minutes from a C/MHC would drop to 729 (4.4% of the total population), or a 42.8% decrease (Figure 15). Access to healthcare would increase, and these workers would not have to drive to Commerce City to receive treatment. Finally, the California service area was redefined with proposed clinic locations in North Hollywood, Long Beach, and Santa Barbara. Even though most farmworkers live in Ventura County, it is plausible to hypothesize that the total number of excessively distant farmworkers is underreported; case in point, the city of Los Angeles and its diverse immigrant communities that account for 39.7% of the total city population (U.S. Census Bureau 2010). While most farmworkers in the CBRN Ventura dataset spoke Spanish, there were also individuals representing communities that spoke Arabic, Farsi, Chinese, Portuguese, Urdu, and Punjabi.

It is estimated that at least 9% of the total Arab population in the United States lives in Los Angeles, with most immigrating from Egypt and Lebanon (Waldinger and Bozorgmehr 1996). Los Angeles is also home to the largest Salvadoran population outside of the United States, and the largest Salvadoran diaspora living abroad and overseas (U.S. Census Bureau 2010; Migration Policy Institute 2015). The addition of three new C/MHC's in Southern California would improve accessibility for agricultural workers in urban (District 6) and suburban environments (District 2, 3, 5). These new centers would drop the total number of workers living greater than 30 minutes away from 638 to 105, or an 83.7% decrease (Figure 15.1).

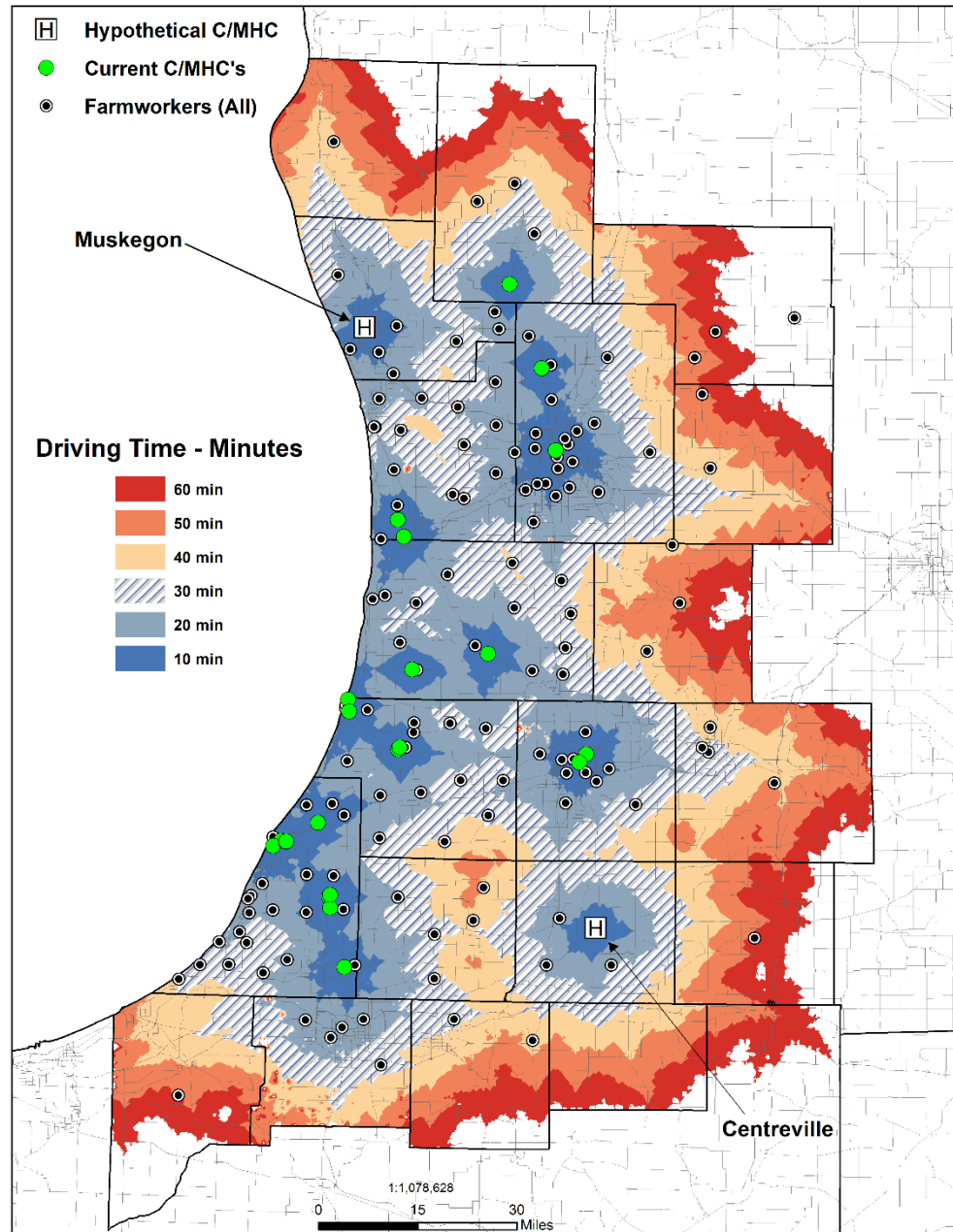


Figure 14.9 – Proposed service area produces an 83% drop in the population considered as “excessively distant” in Western Michigan.

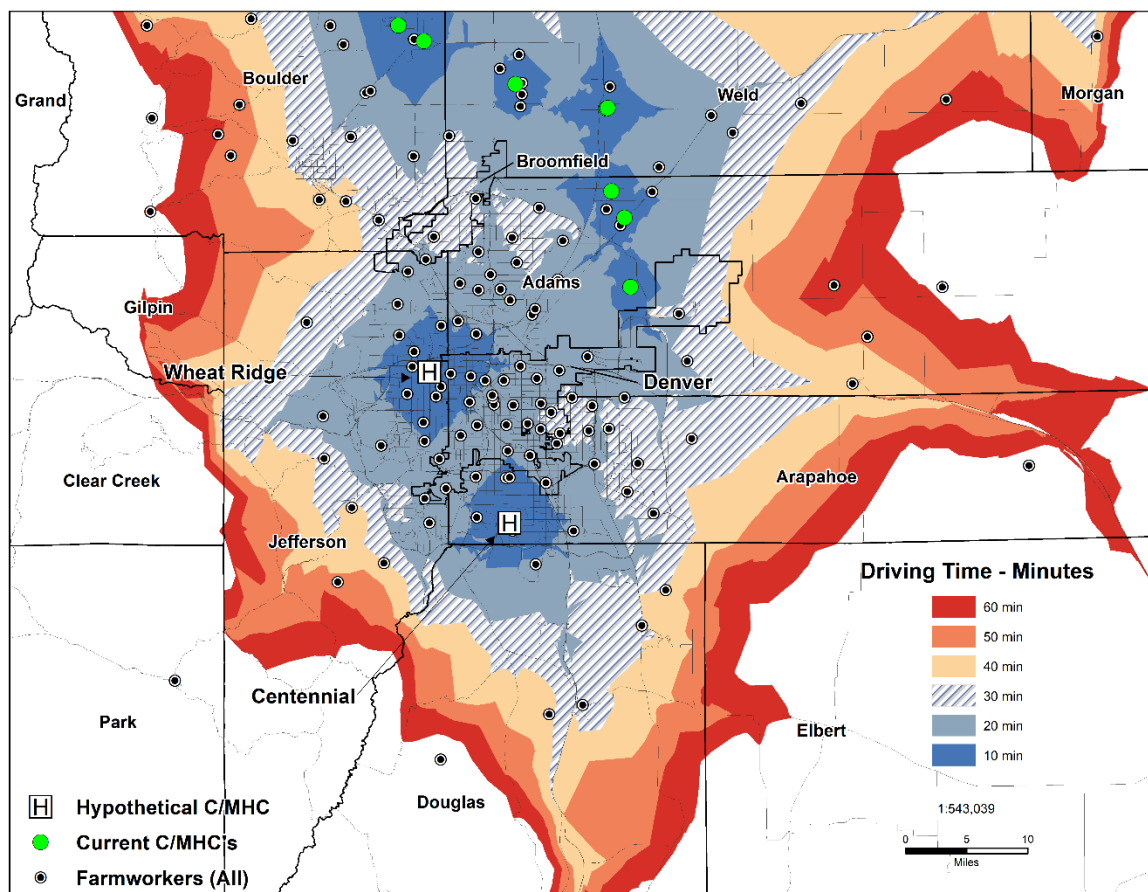


Figure 15 – Proposed service area produces a 43.7% drop in the population considered as “excessively distant” in Colorado. The placement of a C/MHC in western Arapahoe and eastern Jefferson County would significantly increase patient access to healthcare services.

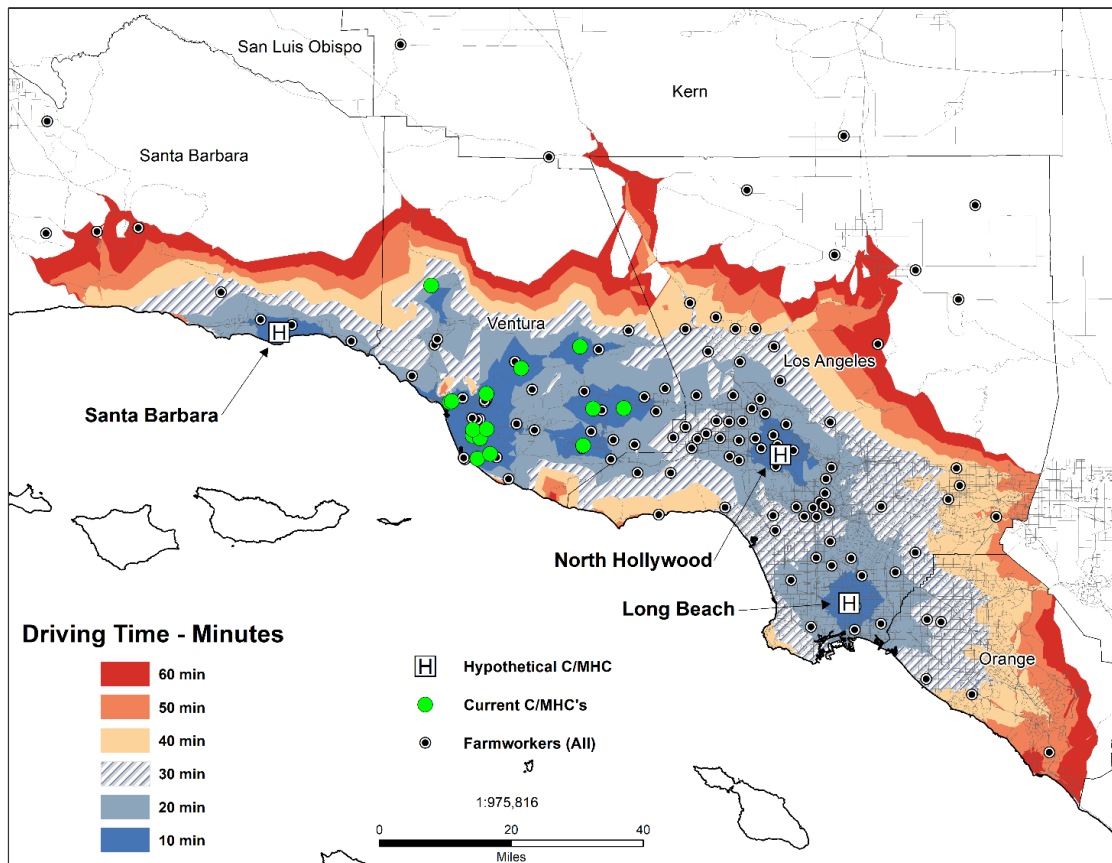


Figure 15.1 – Proposed service area produces an 83.7% drop in the population considered as “excessively distant” in Southern California. These three new clinics would serve Long Beach, North Hollywood, and Santa Barbara; and additionally, supply coverage for Orange County.

Finally, the third policy recommendation is the incorporation of migrant camp locations in future geospatial research endeavors. Farmworker outreach work in Colorado, Michigan, and California would benefit from not just the city or town of origin of farmworker populations, but also the location of temporary migrant housing. This final recommendation (see below) features migrant housing locations (n = 84) for Van Buren County, Michigan, courtesy of the Michigan Department of Agriculture and Rural Development (MDARD). These locations were superimposed with raster data from the United States Department of Agriculture (USDA) CropScape (<https://nassgeodata.gmu.edu/>) and display the prominent agricultural commodities of Van Buren County (Figure 15.2).

The towns of Breedsville and Bloomingdale, Michigan are highlighted in red, and represent the location of farmworker interviews during fieldwork in August 2018. Major crops in the county were clipped with a spatial extent of 2-miles for local scale analysis of the geographic distribution of farmworker populations and to provide care providers with information about potential pesticide vulnerability. Preliminary analysis indicates that 33 (39.2%) migrant housing units are located greater than 30 minutes from a C/MHC in Van Buren County (Figure 15.3, 15.4). As documented in California, the repeated exposure to pesticides causes significant suffering to farmworkers both psychologically and physically. In occupations such as those held by agricultural workers, exposures in the spraying and application of nonarsenical insecticides are classified as carcinogenic (Alavanja, Hoppin, and Kamel 2004). Nervous system damage is documented extensively.

Exposure is associated with a wide range of symptoms related to nerve function and neurobehavioral performance (Keifer and Mahurin 1997). Previous studies have shown that these chemical compounds put humans at high risk for a variety of diseases, including Non-Hodgkin's lymphoma (Blair and Hayes 1982), Leukemia (Blair, Alavanja, Dosemeci and Tarone 2002), Lung cancer (Barthel 1981), Ovarian cancer (Alavanja et al. 2004), pesticide-related skin diseases (Spiewak 2001), and Parkinson's disease (PD) (Kamel et al. 2006), among others. The strength of incorporating GIS-based analysis will allow community healthcare workers and migrant care providers to derive exposure information for farmworkers who work or live near pesticide applications. Geospatial analysis can provide farmworker care providers with the ability to discern, map, and explain the spatial correlation between pesticide exposures and epidemiological data related to the temporal and spatial aspects of local populations.

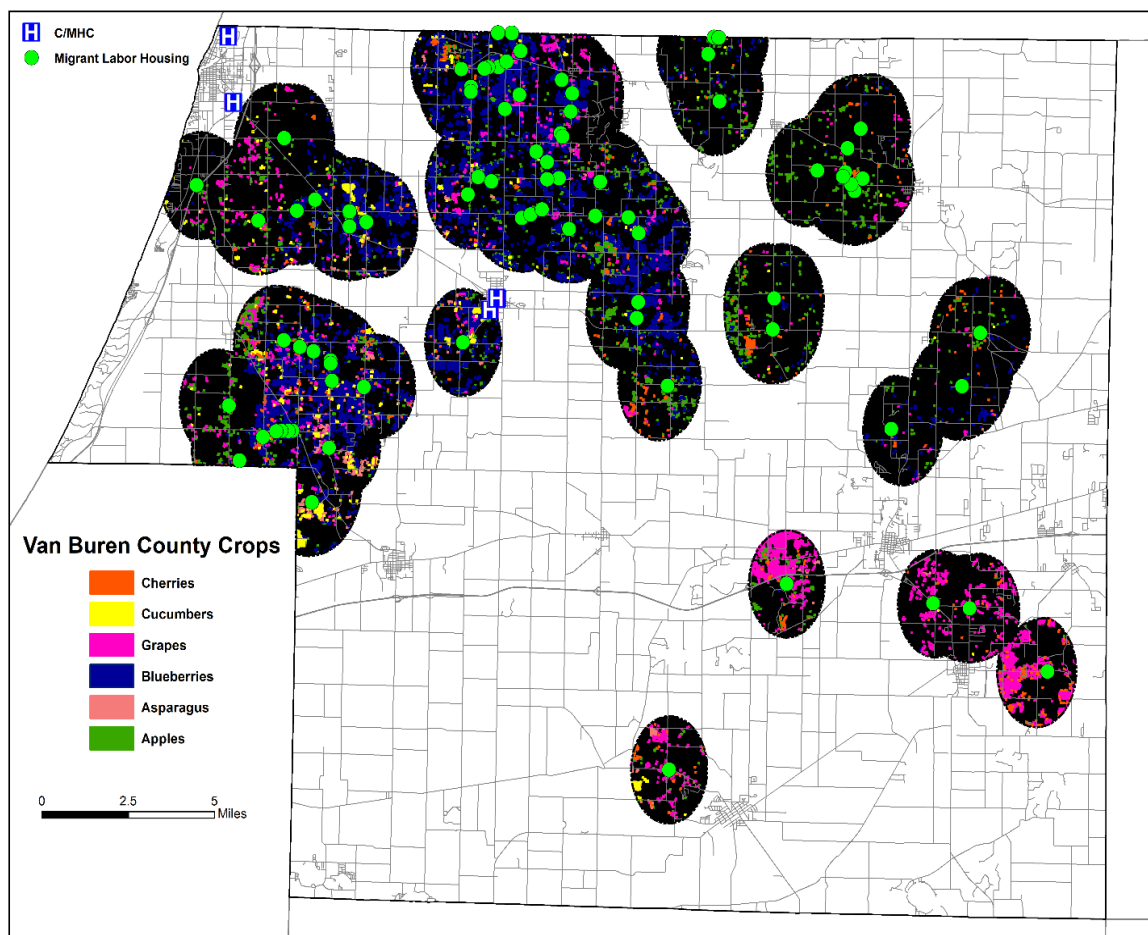


Figure 15.2 – Van Buren County, Michigan, migrant labor housing locations in relation to the major crops of the area.

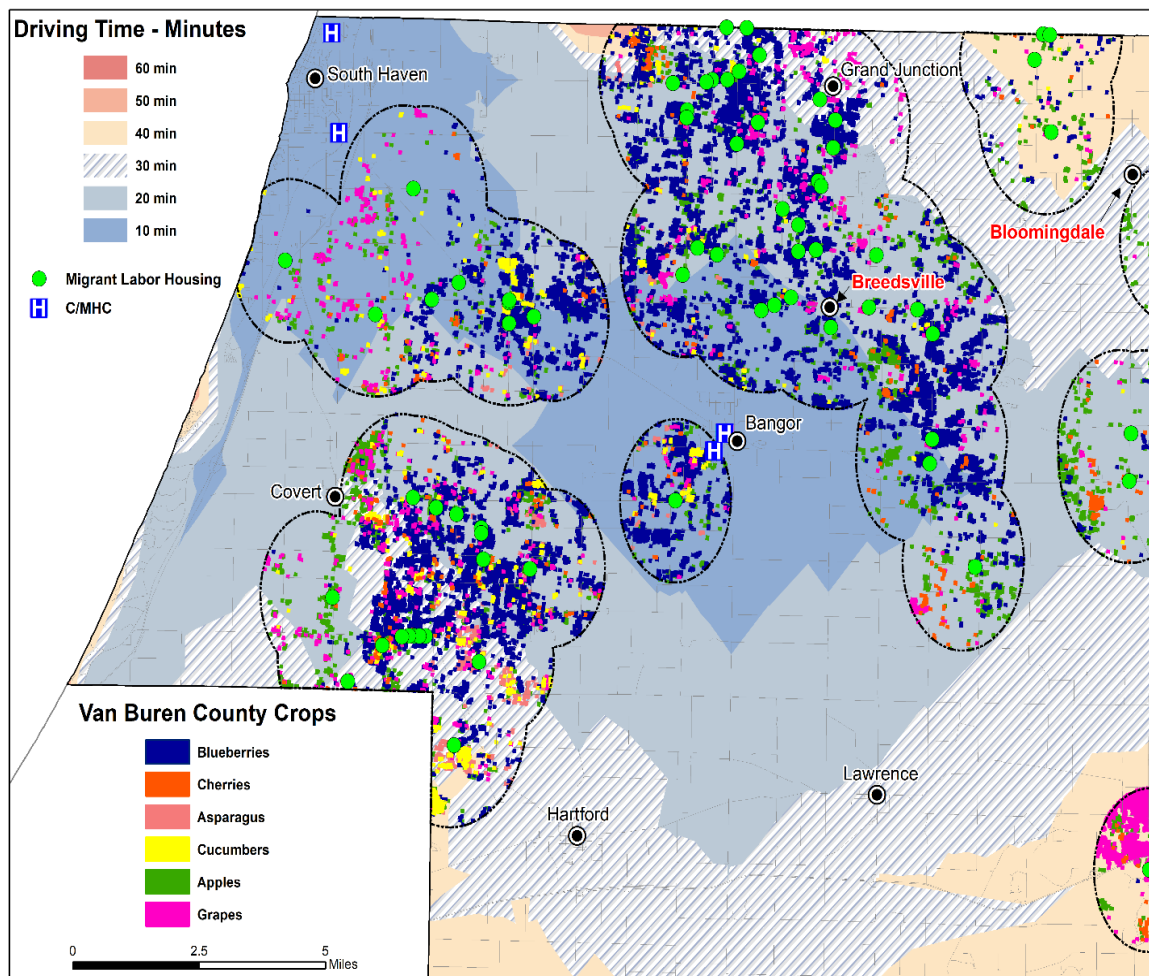


Figure 15.3 – Western Van Buren County, Michigan, migrant labor housing locations in relation to the major crops and the geographic accessibility to C/MHC's. Names in red (Breedsville and Bloomingdale) are the sites of interviews with farmworkers in August 2018. In total, 33 migrant labor housing units are located greater than 30-minutes from C/MHC's in Van Buren County.

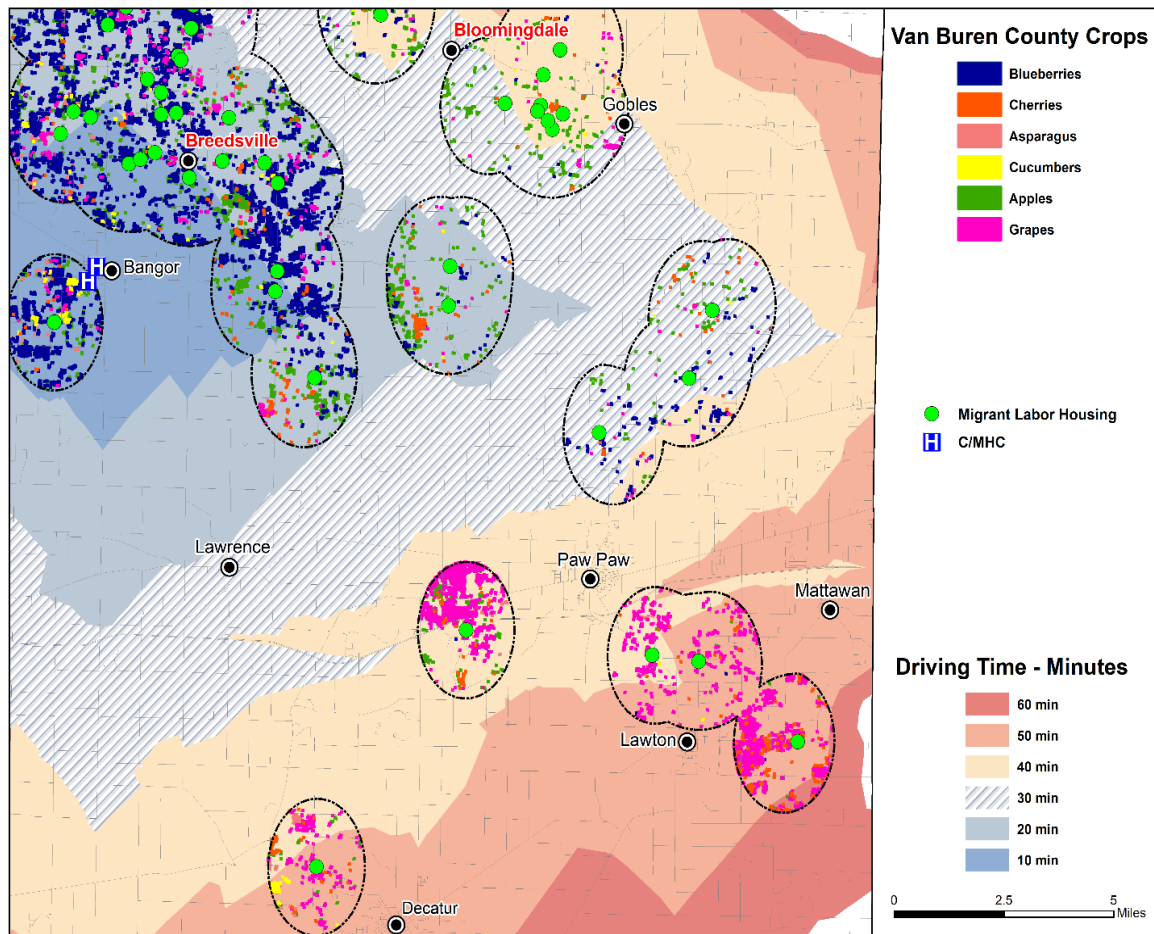


Figure 15.4 – Eastern Van Buren County, Michigan, migrant labor housing locations in relation to the principal crops and geographic accessibility to C/MHC's. Names in red (Breedsville and Bloomingdale) are the sites of interviews with farmworkers in August 2018.

Limitations

Several study limitations must be acknowledged. First, the quantitative data for the SaTScan cluster detection analysis only represented five years of reported encounters at community and migrant health centers (2011 – 2015). Expanding on the temporal range of encounters through collaboration with the CBRN and ICC would give policymakers a more in-depth view of population health patterns and highlight the existence of consistent hotspots, cold spots, and significant outliers. Additionally, two previously identified risk factors (Body Mass Index (BMI), nutritional deficiencies) were dropped entirely from this research due to insufficient records and inconsistencies when comparing study areas.

Second, an inherent limitation needs to be discussed as it relates to false positives and the testing of multiple window sizes. In an earlier publication by Van Meter and colleagues (2008) on the detection of rare diseases, tests for comparisons of RR and areal units size determined that false positives can occur. False positives according to Van Meter et al. (2008) can not only raise false alarms but further divert research and funding efforts. Van Meter et al. (2008) recommends that in order to lessen the prevalence of false positives, the p-values in inference testing should be limited to 0.05. This study serves as a subtle warning for investigators employing methods with variable window sizes to be cautious when interpreting their results, even when all means are taken to minimize these interactions. However, in the end, different situations call for different procedures, and there is not a one-size fit all solution for correct model parameters.

Third, the need for a comprehensive CBRN database that includes the location of

migrant housing in Michigan, Colorado, California would unquestionably improve the presented accessibility models as demonstrated in the policy recommendation section. Fourth, the total number of interviews with farmworkers and key informants was limited due to time and financial constraints. Options for improving this study should include spending a greater duration of time at each study location. This limitation was significant in the qualitative portion of the California interviews and consequently attributed to the inability, because of scheduling issues, to visit migrant housing and farm operation facilities. Fourth, this study relied on self-reported data at the qualitative stage, which is inherently biased. Farmworkers in this study in certain instances had difficulty in recalling specific situations in responses to the interview questionnaire. Earlier research has documented several cultural practices among Latinos such as respect (*respeto*) and the focus on having an interpersonal relationship with another person (*personalismo*) based on exchanging pleasantries (Benson, Garrison, Dropkin, and Jenkins 2016; Ramos 2017). Because of low levels of educational attainment, some workers may not have fully understood the questions, even with translation services.

Investigators need to be aware of these cultural practices because they are, in the interview process, examples of acquiescence response bias, a phenomenon that has been documented in previous studies of farmworkers (Benson, Garrison, Dropkin, and Jenkins 2016). Finally, data discrepancies were evident when comparing study areas. The large numbers of records in the California dataset classified as ‘unknown’ imply that these workers are undocumented, which comes as no surprise after interviewing key informants in Oxnard. These data gaps presented a challenge when comparing demographic profiles for farmworker populations. Additionally, there were examples of the quantitative

analysis of demographic characteristics not matching the qualitative fieldwork in the summer of 2018. Case in point Michigan, which is according to the CBRN database is populated by large farmworker populations that overwhelmingly speak English. However, this was not the conclusion reached when processing interview responses with farmworkers.

Key informants stated explicitly that language barriers were significant determinants to health for farmworkers and their families in Western Michigan. Another discrepancy is apparent when comparing the percentage of male and female farmworkers: although females and children are more common in a clinical setting, male farmworkers makeup nearly 80% of all labor nationwide and are less likely to visit the doctor for medical attention. Therefore, demographic profiles for all locations should be viewed with caution. However, the impact of females in agricultural work should not be understated. The lack of female participants in all interviews was another limiting factor in this study. Female farmworkers in California elaborated with a higher degree of detail than their male counterparts to the interview questions; improving this research in the future will involve including more female participants.

CHAPTER XII.

CONCLUSION

This study described the geography of farmworker chronic disease, from multiple geographic perspectives. The results from this study provide for the first time, a set of abstract, geographic solutions to address not only the *where*, but the *why*. This study is unique because no previous research has studied the geography of farmworker health through an evidence-based mixed-method approach. Migrant and seasonal farmworkers are a vulnerable population that is faced with a myriad of geographic and socioeconomic barriers to healthcare. Geospatial techniques coupled with a qualitative approach emphasizing the inclusion of interviews with farmworkers and key informants supplied a wealth of information on the barriers to care at multiple scales and theoretical perspectives.

This study has several contributions. First, this study exemplifies how GIS and spatial analysis techniques can be used in farmworker health research endeavors. Traditionally, studies on farmworker health have focused primarily on improving clinical outcomes and facilitating the acquisition of healthcare. In contrast, GIS and spatial analysis could be used in an exploratory manner to improve and expand upon prospective and retrospective studies of population health. These techniques for the first time examined the geographic distribution of farmworker chronic disease and their associated risk factors. Additionally, this study is the first to model geographic accessibility to Community and Migrant Health Centers (C/MHC) in Southern California, Northeastern Colorado, and Western Michigan. Results from this study could provide to farmworker

healthcare providers information to identify areas in need of additional outreach, disease surveillance, and gaps in service coverage.

Second, this research contributes to the literature on farmworker health and geography through the development and implementation of the *farmworker ecosocial model of health*, a multi-level conceptual framework that incorporates theoretical foundations of medical, health geography, geospatial science, and social epidemiology. This study is the first to attempt to examine the health of farmworkers with the utilization of such a theoretical model which guided the data collection, analysis, and intermixing phases. Therefore, it is recommended that future studies on farmworker health incorporate the *farmworker ecosocial model of health* as a means of developing effective disease surveillance programs. Because of the complex and non-static nature of human health, it is essential to examine and account for interactions between macro, meso, and microsocial scales.

This framework enhanced knowledge about farmworker health barriers from multiple scales of analysis and methodological perspectives. The results of this study have important implications for reducing healthcare disparities in farmworker communities. Farmworker health is a multi-faceted issue that could be improved through the merging of policy initiatives and geographic perspectives. Although past decades have seen marked decreases in farmworker health disparities, the persistence of socioeconomic and geographic barriers to healthcare remain. This study found that a mixed-method approach to farmworker health is advantageous because of the variety of geographic and socioeconomic determinates that govern contextual level health outcomes.

As the broader American society becomes more disengaged with the realities of food production, so does their conscientiousness of where these food products originate, and the labor force involved in the multiple stages of production and processing. “A society that is concerned primarily with profits and cheap goods is a society that can overlook agricultural practices that are harmful to the natural environment and to human beings” (Pfeifer 2016, 184). It is hoped that these results will prove to be a positive force in increasing awareness of the health needs and barriers to care for farmworkers and their families. Therefore, farmworker health advocacy organizations must view the health of migratory and seasonal farmworkers from a multifaceted lens, one that incorporates perspectives from geospatial sciences, social epidemiology, and ecosocial theory.

APPENDIX SECTION

APPENDIX A

SaTScan Cluster Statistics (Colorado, Michigan, California)

Seasonal Diabetes – Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	0	42.11	0.0001	0	16	0.43	36.91
2	33.02	33.84	0.0001	0	769	595.02	1.46
3	36.90	31.64	0.0001	0	472	332.33	1.54
4	0	24.74	0.0001	0	80	32.75	2.50
5	6.22	8.90	0.0029	0.0025	51	26.63	1.93
6	0	6.92	0.0192	0.0180	77	49.13	1.58
7	0	5.61	0.0665	0.0637	11	3.27	3.37
8	9.77	5.18	0.0967	0.0955	453	394.35	1.19
9	7.92	5.04	0.1088	0.1090	37	20.96	1.77
10	0	4.06	0.2519	0.2624	13	5.240	2.48
11	0	2.65	0.7174	0.7048	10	4.367	2.29
12	0	1.25	0.9963	0.9923	16	10.48	1.53

Migratory Diabetes – Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	7.18	39.03	0.0001	0	60	14.96	4.15
2	3.09	17.71	0.0001	0	81	39.14	2.14
3	9.77	15.86	0.0001	0.00003	49	19.57	2.56
4	0	10.62	0.0008	0.0005	281	216.41	1.37
5	10.93	7.90	0.0064	0.0072	15	4.37	3.46
6	33.51	6.29	0.0371	0.0346	20	8.06	2.50
7	14.66	6.06	0.0456	0.0432	19	7.60	2.52
8	10.89	2.31	0.8189	0.8246	456	419.00	1.13
9	0	2.10	0.8879	0.8813	3	0.69	4.35
10	0	1.42	0.9906	0.9840	6	2.76	2.18

Seasonal Hypertension - Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	25.82	22.39	0.0001	0.0000	79	33.87	2.40
2	3.35	22.22	0.0001	0.0000	44	13.30	3.37
3	0	15.48	0.0001	0.0000	17	3.01	5.69
4	0	11.30	0.0004	0.0003	9	1.06	8.50
5	0	11.06	0.0005	0.0003	54	26.60	2.06
6	0	5.92	0.0538	0.0512	10	2.66	3.78
7	19.58	3.45	0.4579	0.4508	42	27.31	1.55
8	0	2.36	0.8313	0.8270	4	1.06	3.77
9	0	2.04	0.9111	0.9113	3	0.71	4.23
10	12.70	1.72	0.9693	0.9635	72	57.64	1.26
11	6.82	1.59	0.9813	0.9769	173	151.64	1.16
12	0	1.15	0.9992	0.9971	6	3.01	1.99
13	50.13	1.14	0.9992	0.9971	7	3.72	1.88
14	0	1.01	0.9997	0.9988	24	17.74	1.36
15	10.44	0.98	0.9999	0.9989	14	9.40	1.49

Migratory Hypertension - Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	23.30	6.59	0.0086	0.0081	25	11.18	2.33
2	0	3.75	0.1565	0.1561	2	0.12	16.73
3	0	3.40	0.2154	0.2188	20	10.64	1.93
4	0	3.24	0.2552	0.2540	17	8.66	2.01
5	6.68	2.13	0.6101	0.6119	14	7.70	1.85
6	0	1.54	0.8416	0.8316	8	4.03	2.01
7	13.15	1.24	0.925	0.9139	11	6.61	1.69
8	22.88	0.78	0.9922	0.9814	11	7.39	1.50
9	0	0.33	0.9999	0.9984	3	1.80	1.67

Seasonal Obesity - Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	13.91	10.87	0.0005	0.0002	139	96.12	1.63
2	9.49	10.22	0.0006	0.0004	9	1.23	7.45
3	17.10	5.74	0.0383	0.0349	69	45.73	1.59
4	0	4.06	0.1724	0.1807	5	1.00	5.04
5	0	3.67	0.2456	0.2568	16	7.53	2.16
6	50.13	2.65	0.5731	0.5699	4	0.97	4.15
7	0	0.67	0.9997	0.9983	2	0.78	2.59

Migratory Obesity - Colorado

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	7.48	19.62	0.0001	0.0000	7	0.16	44.39
2	48.98	12.79	0.0001	0.0000	122	81.97	1.86
3	6.51	2.65	0.5164	0.5352	4	0.97	4.17
4	47.19	0.49	0.9999	0.9990	2	0.91	2.21

Chronic Disease Risk Factors – Colorado

Cluster	Cluster Radius (km)	Start Date	End Date	Test Statistic	P-Value	GBL P-Value	Observed	Expected	RR
1	0	6/1/2014	6/30/2014	162.01	0.0001	0	115	11.94	9.63
2	0	4/1/2013	4/30/2013	128.28	0.0001	0	69	4.32	15.97
3	0	1/1/2013	1/31/2013	118.51	0.0001	0	73	5.89	12.39
4	12.02	4/1/2014	4/30/2014	103.51	0.0001	0	84	10.49	8.00
5	26.86	11/1/2014	11/30/2014	77.18	0.0001	0	51	4.60	11.08
6	39.75	12/1/2013	2/28/2014	62.70	0.0001	0	71	13.28	5.35
7	0	7/1/2013	7/31/2013	57.46	0.0001	0	22	0.62	35.71
8	10.52	1/1/2013	7/31/2014	55.44	0.0001	0	0	54.19	0.00
9	0	4/1/2014	4/30/2014	46.34	0.0001	0	36	4.15	8.67
10	22.50	8/1/2014	8/31/2014	45.71	0.0001	0	62	13.86	4.47
11	0	10/1/2013	10/31/2013	41.35	0.0001	0	18	0.70	25.83
12	0	5/1/2014	5/31/2014	34.30	0.0001	0	9	0.07	121.40
13	0	7/1/2014	7/31/2014	30.11	0.0001	0	9	0.12	75.88
14	0	1/1/2013	1/31/2013	28.87	0.0001	0	18	1.45	12.39
15	9.72	12/1/2014	12/31/2014	28.04	0.0001	0	9	0.15	60.03
16	7.25	9/1/2013	10/31/2013	24.27	0.0001	0	12	0.62	19.42
17	7.56	1/1/2014	1/31/2014	19.95	0.0001	0	6	0.08	74.33
18	2.88	6/1/2014	6/30/2014	9.60	0.0161	0.0163	7	0.73	9.63

Seasonal Diabetes – Michigan

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	17.80	15.38	0.0001	0.0000	86	48.72	2.18
2	0	12.00	0.0002	0.0001	18	4.45	4.29
3	36.50	8.00	0.005	0.0043	21	7.79	2.86
4	28.02	7.15	0.0101	0.0099	20	7.68	2.75
5	14.40	3.89	0.2191	0.2192	4	0.66	6.15
6	0	1.63	0.9128	0.9010	4	1.39	2.90
7	19.56	1.38	0.9629	0.9482	5	2.16	2.34
8	0	1.20	0.9812	0.9702	6	2.97	2.04
9	13.29	0.97	0.9955	0.9880	7	3.96	1.79

Migratory Diabetes – Michigan

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	15.04	44.15	0.0001	0.0000	74	23.66	4.82
2	0	35.79	0.0001	0.0000	55	15.51	4.80
3	38.15	9.13	0.0015	0.0010	27	10.98	2.74
4	27.23	5.59	0.0376	0.0334	2	0.05	43.82
5	19.51	3.71	0.1824	0.2019	8	2.59	3.20
6	33.68	3.69	0.1855	0.2054	7	2.06	3.50
7	15.57	3.48	0.231	0.2476	6	1.64	3.76
8	0	2.90	0.4037	0.3974	4	0.90	4.54
9	0	0.98	0.985	0.9702	7	3.96	1.80
10	13.92	0.76	0.9951	0.9871	4	2.02	2.00
11	0	0.64	0.9975	0.9927	10	6.90	1.48
12	23.23	0.54	0.9997	0.9958	2	0.87	2.31

Seasonal Hypertension - Michigan

Cluster	Cluster Radius (km)	LLR	P-Values	GBL P-Values	Observed	Expected	RR
1	123.57	174.58	0.0001	0	209	49.14	6.53
2	16.46	44.41	0.0001	0	20	0.85	24.48
3	22.83	22.98	0.0001	0	39	10.69	3.87
4	16.46	8.92	0.0024	0.0019	13	3.07	4.32

Migratory Hypertension - Michigan

Cluster	Cluster Radius (km)	LLR	P-Values	GBL P-Values	Observed	Expected	RR
1	11.46	159.39	0.0001	0	159	31.55	8.38
2	18.31	6.93	0.0108	0.0094	31	14.96	2.18
3	0	4.20	0.1406	0.1408	2	0.09	21.21
4	9.01	3.03	0.3856	0.3915	15	7.45	2.06
5	10.02	2.86	0.4259	0.4455	17	9.05	1.92
6	0	1.43	0.9265	0.9197	2	0.45	4.45

Seasonal Obesity - Michigan

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	19.26	27.82	0.0001	0	22	2.70	9.01
2	43.81	20.69	0.0001	0	29	6.93	4.70
3	9.16	8.60	0.0017	0.0012	8	1.18	7.01
4	18.09	7.38	0.0045	0.0044	93	66.47	1.72
5	0	2.78	0.3891	0.3950	3	0.52	5.80
6	12.50	1.79	0.7542	0.7524	5	1.89	2.69

Migratory Obesity - Michigan

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	23.85	23.69	0.0001	0	86	45.50	3.14
2	0	8.49	0.0017	0.0015	10	1.96	5.41
3	23.98	5.71	0.0291	0.0253	3	0.18	17.36
4	9.33	4.17	0.1119	0.1144	2	0.10	20.97
5	5.77	0.42	0.9998	0.9953	2	0.97	2.08

Chronic Disease Risk Factors – Michigan

Cluster	Cluster Radius (km)	Start Date	End Date	Test Statistic	P-Value	GBL P-Value	Observed	Expected	RR
1	8.47	7/1/2013	8/31/2013	35.28	0.0001	0	18	1.01	17.78
2	0	12/31/2011	12/31/2011	33.10	0.0001	0	16	0.80	20.00
3	0	1/1/2013	1/31/2013	32.84	0.0001	0	27	3.46	7.80
4	62.32	10/1/2013	1/31/2014	24.94	0.0001	0	20	2.45	8.16
5	12.45	5/1/2014	5/31/2014	22.68	0.0001	0	11	0.55	20.00
6	12.05	4/1/2014	6/30/2014	22.33	0.0001	0	16	1.65	9.70
7	0	4/1/2013	4/30/2013	21.87	0.0001	0	10	0.44	22.86
8	0	1/1/2012	1/31/2012	19.98	0.0001	0	7	0.15	45.71
9	13.14	12/1/2012	2/28/2013	18.56	0.0001	0	21	3.94	5.33
10	0	2/1/2013	2/28/2013	18.53	0.0001	0	9	0.45	20.00
11	33.24	3/1/2013	3/31/2013	15.78	0.0001	0.0000	8	0.44	18.29
12	0	9/1/2012	9/30/2012	11.05	0.0004	0.0002	3	0.03	106.67

Seasonal Diabetes – California (40 – 50%)

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	6.91	257.93	0.0001	0	1315	778.07	2.57
2	16.55	155.95	0.0001	0	1025	626.97	2.13
3	6.01	96.01	0.0001	0	760	473.82	1.89
4	8	83.91	0.0001	0	173	54.74	3.33
5	0	49.22	0.0001	0	92	26.79	3.53
6	0	23.21	0.0001	0	62	22.77	2.77
7	9.99	0.71	0.987	0.9738	102	90.69	1.13

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	17.39	421.93	0.0001	0	1796	1107.64	3.65
2	16.55	155.95	0.0001	0	1025	626.97	2.13
3	6.01	96.01	0.0001	0	760	473.82	1.89
4	0	49.22	0.0001	0	92	26.79	3.53
5	0	23.21	0.0001	0	62	22.77	2.77

Migratory Diabetes - California

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	14.86	87.97	0.0001	0	313	141.00	2.51
2	1.22	56.22	0.0001	0	235	112.06	2.28
3	0	31.92	0.0001	0	89	33.81	2.73
4	0	11.10	0.0001	0.0000	83	47.66	1.78
5	0	1.56	0.6303	0.6331	8	3.99	2.01

Seasonal Hypertension - California

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	15.26	18.407593	0.0001	0	484	378.94	1.41
2	0	13.52624	0.0001	0.0000	85	46.22	1.89
3	4.60	10.895171	0.0001	0.0001	251	188.45	1.40
4	0	8.737286	0.0012	0.0008	84	51.84	1.66
5	21.34	7.4522	0.0043	0.0031	42	21.83	1.95
6	0	6.910109	0.0071	0.0055	50	28.31	1.79
7	0	2.233396	0.5132	0.5365	47	34.11	1.39
8	32.44	1.239001	0.8977	0.8884	2	0.51	3.91

Migratory Hypertension – California

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	34.13	28.95	0.0001	0	62	28.90	6.32
2	8	10.66	0.0001	0.0000	23	8.17	3.56
3	0	8.95	0.0004	0.0001	19	6.54	3.51
4	19.08	6.43	0.0027	0.0012	26	12.97	2.50

Seasonal Obesity – California

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	7.33	22.03	0.0001	0	506	382.68	1.41
2	0	14.68	0.0001	0.0000	425	330.43	1.35
3	0	9.76	0.0004	0.0002	121	79.41	1.55
4	0	6.95	0.0057	0.0047	81	52.24	1.57
5	0	5.86	0.0185	0.0147	256	207.40	1.26
6	0	3.04	0.231	0.2477	182	151.76	1.22

Migratory Obesity - California

Cluster	Cluster Radius (km)	LLR	P-Value	GBL P-Value	Observed	Expected	RR
1	0	16.76	0.0001	0	88	44.91	2.02
2	0	1.76	0.6229	0.6089	3	0.80	3.75
3	5.28	1.08	0.8698	0.8651	30	22.72	1.33
4	19.50	0.63	0.9825	0.9624	2	0.80	2.50

Chronic Disease Risk Factors – California (10, 20, 30%)

Cluster	Cluster Radius (km)	Start Date	End Date	Test Statistic	P-Value	GBL P-Value	Observed	Expected	RR
1	0	4/1/2014	4/30/2014	55.96	0.0001	0	33	2.47	13.35
2	0	10/1/2014	10/31/2014	53.21	0.0001	0	46	6.33	7.26
3	0	8/1/2013	8/31/2013	52.85	0.0001	0	28	1.70	16.47
4	0	7/1/2014	7/31/2014	40.28	0.0001	0	39	6.16	6.33
5	0	7/1/2014	7/31/2014	40.28	0.0001	0	39	6.16	6.33
6	8	4/1/2013	7/31/2013	40.06	0.0001	0	38	5.85	6.50
7	0	4/1/2013	4/30/2013	39.82	0.0001	0	37	5.54	6.68
8	0	8/1/2014	8/31/2014	36.28	0.0001	0	26	2.68	9.69
9	0	8/1/2014	8/31/2014	34.87	0.0001	0	25	2.58	9.69
10	0	5/1/2014	5/31/2014	28.66	0.0001	0	14	0.71	19.76
11	0	6/1/2014	6/30/2014	25.97	0.0001	0	15	1.06	14.11
12	0	6/1/2014	6/30/2014	24.23	0.0001	0	14	0.99	14.11
13	0	10/1/2014	10/31/2014	23.87	0.0001	0	21	2.89	7.26
14	0	5/1/2014	5/31/2014	22.49	0.0001	0	11	0.56	19.76
15	5.28	10/1/2013	12/31/2013	18.87	0.0001	0	6	0.10	61.75
16	0	6/1/2014	6/30/2014	10.34	0.0002	0.0000	6	0.43	14.11
17	0	2/1/2015	2/28/2015	9.03	0.0003	0.0003	2	0.01	247.00

Cluster	Cluster Radius (km)	Start Date	End Date	Test Statistic	P-Value	GBL P-Value	Observed	Expected	RR
1	0	11/1/2014	11/30/2014	83.25	0.0001	0	79	12.63	6.25
2	1.22	8/1/2013	4/30/2014	67.54	0.0001	0	61	9.01	6.77
3	18.87	7/1/2014	8/31/2014	64.26	0.0001	0	104	28.99	3.59
4	0	10/1/2014	10/31/2014	53.21	0.0001	0	46	6.33	7.26
5	20.55	4/1/2013	4/30/2013	44.98	0.0001	0	74	20.37	3.63
6	0	6/1/2014	6/30/2014	25.97	0.0001	0	15	1.06	14.11

Cluster	Radius	Start Date	End Date	Test Statistic	P-Value	GBL P-Value	Observed	Expected	RR
1	0	11/1/2014	11/30/2014	83.25	0.0001	0	79	12.63	6.25
2	1.22	8/1/2013	4/30/2014	67.54	0.0001	0	61	9.01	6.77
3	0	10/1/2014	10/31/2014	53.21	0.0001	0	46	6.33	7.26
4	0	7/1/2014	7/31/2014	40.28	0.0001	0	39	6.16	6.33
5	0	7/1/2014	7/31/2014	40.28	0.0001	0	39	6.16	6.33
6	8.00	4/1/2013	7/31/2013	40.06	0.0001	0	38	5.85	6.50
7	0	4/1/2013	4/30/2013	39.82	0.0001	0	37	5.54	6.68
8	0	8/1/2014	8/31/2014	36.28	0.0001	0	26	2.68	9.69
9	0	8/1/2014	8/31/2014	34.87	0.0001	0	25	2.58	9.69
10	0	6/1/2014	6/30/2014	25.97	0.0001	0	15	1.06	14.11
11	30.76	5/1/2014	5/31/2014	20.75	0.0001	0	11	0.66	16.72

APPENDIX B

Key Informant and Farmworker Informed Consent Form (English)

VERBAL CONSENT

Study Title: Farmworker Health: Geospatial and Mixed Method Analysis of Selected Diseases

Principal Investigator: Mark A. Deka **Co-Investigator/Faculty Advisor:** Alberto Giordano

Sponsor: N/A

Part 1: Questions for Migratory and Seasonal Farmworkers

What is this study about: My name is Mark Deka, and I am a graduate student at Texas State University. I am doing this study because I am attempting to understand the lived human experience of migratory and seasonal farmworkers living with chronic disease. I am asking you to take part in this study because I am interested in furthering our understanding of the unique health needs of farmworkers and their families.

What will I ask you to do: If you are interested in taking part in this study, you will be asked 16 questions about your current and past health experiences living with chronic disease. Participation is voluntary. You can, of course, decline to answer, as well as to stop participating at any time. I will not link your name to anything you say, either in the transcript of this interview or the text of my dissertation or any other publications. The interview will take about 30 minutes to complete. With your permission, I would also like to audio-record the interview for future transcription.

Risks and Benefits:

I do not anticipate any risks to you participating in this study other than that you may find some questions about your current health status to be sensitive. There are no specific benefits to you for participating in this study.

Before I proceed:

Do you have any questions for me?

Do you understand what was said to you?

Do you want to be in the study?

If you have any questions: The researchers conducting this study are Mark Deka and Prof. Alberto Giordano. Please ask any questions you have now. If you have questions later, you may contact Mark Deka at mad214@txstate.edu or at 512-557-5647. You can reach Prof. Alberto Giordano at a.giordano@txstate.edu or at 512-245-6581. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Texas State University Institutional Review Board (IRB) at 512-245-2314 or access their website at <http://www.txstate.edu/research/orc/IRB-Resources.html>.

You will be given a copy of this form to keep for your records.

APPENDIX C

Farmworker Informed Consent Form (Spanish)

CONSENTIMIENTO VERBAL

Título del Estudio: Salud de Trabajadores Agrícolas: Análisis Geoespacial y de Metodología Mixta de Enfermedades Seleccionadas

Investigador Principal: Mark A. Deka **Coinvestigador/Consejero de Facultad:**

Alberto Giordano

Sponsor: N/A

Parte 1: Preguntas para Trabajadores Agrícolas Temporales y Migratorios

¿De qué se trata este estudio?: Mi nombre es Mark Deka, y soy un estudiante graduado de la Universidad Estatal de Texas (Texas State University). Estoy haciendo este estudio porque intento comprender la experiencia vivida por los trabajadores agrícolas temporales y migratorios que viven con enfermedades crónicas. Les pido que por favor participen en este estudio porque estoy interesado en ampliar nuestra entendimiento de las necesidades de salud únicas de los trabajadores agrícolas y sus familias.

¿Qué te pediré que hagas?: Si usted está interesado(a) en participar en este estudio, se le harán 16 preguntas sobre sus experiencias de salud actuales y pasadas viviendo con una enfermedad crónica. Su participación es voluntaria. Por supuesto, usted puede negarse a responder, así como a dejar de participar en cualquier momento. Yo no vincularé su nombre a nada de lo que se diga, ni en la transcripción de esta entrevista ni en el texto de mi disertación, ni en ninguna otra publicación. La entrevista tardará unos 30 minutos en completarse. Con su permiso, también me gustaría grabar la entrevista para su transcripción en el futuro.

Riesgos y Beneficios:

Yo no anticipo ningún riesgo hacia usted por participar en este estudio. A pesar de que es posible de que usted encuentre algunas de las preguntas sobre su salud un poco sensibles. Tampoco hay beneficios específicos hacia usted por participar en este estudio.

Antes de proceder:

¿Tienes alguna pregunta para mí?

¿Entiendes lo que te he dicho?

¿Quieres participar en el estudio?

Si tiene alguna pregunta: Los investigadores que realizan este estudio son Mark Deka y

el Prof. Alberto Giordano. Por favor, haga las preguntas que tenga ahora. Si tiene preguntas más adelante, puede comunicarse con Mark Deka por mad214@txstate.edu o al 512-557-5647 y puede contactar al Prof. Alberto Giordano por a.giordano@txstate.edu o al 512-245-6581. Si tiene alguna pregunta o inquietud con respecto a sus derechos como sujeto de este estudio, puede comunicarse con la Junta de Revisión Institucional (IRB) de Texas State University al 512-245-2314 o acceder a su sitio web <http://www.txstate.edu/research/orc/IRB-Resources.html>.

Se le entregará una copia de este formulario para mantenerlo en sus registros.

APPENDIX D

Key Informant Interview Questions (English)

Introduction:

1. How long have you worked at this center?
2. What are the barriers to improved health outcomes experienced by farmworkers in this area?
3. How can we better address the health needs of farmworkers? What are the social determinants of health that detract from farmworkers' health status?
4. What are the social determinants of health that support good health among farmworkers?
5. Do you believe that this or any nearby counties would benefit from an increase in healthcare surveillance? If so, which counties? Monitoring of what conditions?
6. What is the primary demographic composition of farmworkers in this area?

Political Economy (*Fundamental*):

8. How has politics at the local, national level impacted farmworkers?
9. Have push-pull/migration patterns fluctuated in recent years, decades?
10. How many farmworkers here travel alone?
11. Does migration contribute to anxiety, depression, and stress among farmworkers?
12. Have you witnessed or know of labor exploitation?
13. How do social class affect farmworkers and their health outcomes?
14. How would you describe the migration patterns of the farmworkers in this area?
 - a. *Restricted Circuit* (Following traditional migration streams in one geographic area)
 - b. *Point-to-Point* (Travel to the same location for work year after year)
 - c. *Nomadic* (Those who travel seasonally to employment from abroad, non-restrictive geography from either inside or outside the United States)

Political Ecology (*Intermediate*):

12. How long have farmworkers been working in this area?
13. What is the history of farmworkers in this area?
14. When did this clinic open and start serving farmworkers?
15. How do language barriers, cultural practices delay the delivery of healthcare to farmworkers?
16. Where do farmworkers in this area live, where are they from?
17. What is the educational attainment for workers?
18. In general, does a lack of transportation contribute to adverse health outcomes among farmworkers?
19. How can healthcare utilization be improved?
20. Do you believe that a lack of transportation is a prevailing issue among workers utilizing this facility?
21. What solutions exist to overcome transportation barriers?

22. What fresh food options accessible to farmworkers? Are nutritional deficiencies common?

Spatiotemporal scale and Lifecourse epidemiology (*Proximate*):

7. The burden of chronic disease is heavy for patients, family, and community, what is the status of chronic disease among farmworkers in this area?
8. What are the genetic implications of chronic disease; do you see a generational trend in your years on the job?
9. Do you see families not just individuals inflicted with chronic disease?
10. Have you witnessed progression in chronic disease from adolescent to adulthood?
11. Describe the nutritional practices of farmworkers treated here?
12. How many attend follow-up appointments and health screenings?
13. How would you describe the health literacy of farmworkers you have worked with directly?

APPENDIX E

Farmworker Interview Questions (English)

Farmworker Questions-

Where do you consider 'home'? or "Where is your home base"?

1. What year were you born?
2. Do you consider agriculture your primary employment?
 - If yes, what types of agricultural jobs do you perform and in what types of crops or products?
3. Do you migrate to find work in agriculture?
 - If yes, does your family migrate to you?
 - Did migration cause you any negative health symptoms?
 - Where did you migrate from?
4. What year did you first start working in agriculture?
5. Do you consider yourself to be in poor or good health?
6. On a scale of 1-10 with 1 being poor and 10 being excellent, please rate your overall physical health
 - I experience symptoms daily that interfere with my ability to perform daily functions.
 - I have mild to moderate symptoms.
 - I experience symptoms occasionally throughout the day.
 - I very rarely experience health issues that interfere with my daily living.
 - I consider myself to be in excellent health and have no medical problems.
7. Do you have a medical condition that needs ongoing attention such as a chronic disease? At what age did you first start experiencing symptoms related to this problem? What type of chronic disease?
8. How would you describe your access to fresh fruits and vegetables?
 - Limited access
 - Moderate access
 - Full access
9. How would you describe your access to essential (primary) healthcare services?
 - Limited access
 - Moderate access
 - Full access
10. Do you utilize either a community or migrant health center in this area?
 - Yes
 - No, Why?
11. Do you utilize either a community or migrant health center in any other area of the country?
 - Yes. If yes, where?
12. What other types of medical care do you use when you need medical assistance?
 - Private Medical Office
 - Free Clinic

- School-based health center
 - Free clinic
 - Hospital or hospital ER
 - Urgent care center
 - Other (please specify)
13. How many times a year do you see a physician?
14. How would you best describe your current emotional or mental health? (Rank from worst: 1 – 5: best)
15. Do you experience any symptoms of depression, anxiety, or stress?
16. If applicable, please describe briefly how diabetes, hypertension, or obesity has negatively affected you and your family?

APPENDIX F

Farmworker Interview Questions (Spanish)

Preguntas para agricultores-

¿Dónde consideras que es “tu casa”? o ¿Dónde es tu residencia habitual?

1. ¿En qué año naciste?
2. ¿Consideras que la agricultura es tu trabajo principal?
 - Si la respuesta es sí, ¿Qué tipo de trabajos agrícolas realizas y en qué tipo de cultivos o productos?
3. ¿Migras para encontrar trabajo en la agricultura?
 - Si la respuesta es sí, ¿Tu familia migra contigo?
4. ¿En qué año empezaste a trabajar en la agricultura?
5. ¿Te consideras una persona con buena o mala salud?
6. Selecciona la opción que mejor describa tu salud:
 - Todos los días presento síntomas que interfieren con mi habilidad para realizar funciones diarias.
 - Mi salud es de leve a moderada.
 - Presento síntomas ocasionalmente durante el día.
 - Muy rara vez presento problemas de salud que interfieren con mi vida diaria.
 - Considero que tengo excelente salud, no tengo problemas médicos.
7. ¿Tienes una condición médica que necesite atención regular como una enfermedad crónica? ¿A qué edad empezaste a presentar los síntomas relacionados con este problema?
8. ¿Cómo describiría su acceso a frutas y verduras frescas?
 - Limitado
 - Moderado
 - Total
9. ¿Cómo describirías tu acceso a atención médica esencial (primaria)?
 - Limitado
 - Moderado
 - Total
10. ¿Utilizas un centro de salud comunitario o para migrantes en esta área?
 - Si
 - No
11. ¿Utilizas un centro de salud comunitario o para migrantes en alguna otra área del país?
 - Si la respuesta es sí, ¿Dónde?
12. ¿Qué otros tipos de servicios médicos usas cuando necesitas asistencia médica?
 - Oficina médica privada (Private medical office)
 - Clínica gratis (Free clinic)
 - Centro de salud escolar (School-based health center)
 - Hospital o una sala de emergencias (Hospital or hospital ER)

- Centro de atención urgente (Urgent care center)
 - Otro (por favor especifica)
13. ¿Cuántas veces al año vez a un médico?
14. En una escala del 1 al 5, donde 1 es pésima y 5 excelente, ¿Cómo describirías tu salud emocional o mental actual?
15. Si es tu caso, por favor describe brevemente la forma en que la diabetes, hipertensión, o la obesidad han afectado negativamente a ti y a tu familia

APPENDIX G

Texas State University Institution Review Board (IRB)

In future correspondence, please refer to 2018407

April 3, 2018

Mark Deka
Texas State University
601 University Drive.
San Marcos, TX 78666

Dear Mr. Deka:

Your IRB application 2018407 titled “Farmworker Health: Geospatial and Mixed Method Analysis of Selected Diseases” was reviewed and approved by the Texas State University IRB. It has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects’ welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is not required as participation implies consent; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data; (3) Appropriate safeguards are included to protect the rights and welfare of the subjects. (4) Compensation will not be provided for participation.

This project is therefore approved at the Exempt Review Level

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments, please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Research Integrity and Compliance.

Report any changes to this approved protocol to this office. All unanticipated events and adverse events are to be reported to the IRB within 3 days.

Sincerely,

Monica Gonzales
IRB Regulatory Manager
Office of Research Integrity and Compliance

APPENDIX H

United States Library of Congress Pictures of Farmworkers (California, Colorado, Michigan)



Boy Picking Strawberries, Berrien County, Michigan – July 1940 (Library of Congress
Prints and Photographs Division Washington, DC 20540 USA,
<http://hdl.loc.gov/loc.pnp/pp.print>).



Migrant fruit worker camp along railroad tracks. Berrien County, Michigan – July 1940
(Library of Congress Prints and Photographs Division Washington, DC 20540 USA,
<http://hdl.loc.gov/loc.pnp/pp.print>).



Cherry pickers. Berrien County, Michigan – July 1940 (Library of Congress Prints and Photographs Division Washington, DC 20540 USA, <http://hdl.loc.gov/loc.pnp/pp.print>).



Beet workers, ten years, twelve years, fourteen years, and eighteen years, hoeing for father, Jacob Dill, in Sugar City, Colorado. They moved here ten years ago from Southern Russia, work all summer, and after the topping is over in the fall, they go to school. See Hine Report, Colorado Beet Workers, July 1915. Location: Sugar City, Colorado (Library of Congress Prints and Photographs Division Washington, DC 20540 USA, <http://hdl.loc.gov/loc.pnp/pp.print>).



Mexican workers recruited and brought to the Arkansas Valley, Colorado, Nebraska, and Minnesota by the FSA (Farm Security Administration), to harvest and process sugar beets under contract with the Inter-mountain Agricultural Improvement Association. May 1943 (Library of Congress Prints and Photographs Division Washington, DC 20540 USA, <http://hdl.loc.gov/loc.pnp/pp.print>).



Mexican migrant woman harvesting tomatoes. Santa Clara Valley, California 1938
(Library of Congress Prints and Photographs Division Washington, DC 20540 USA,
<http://hdl.loc.gov/loc.pnp/pp.print>).



Pea pickers at work. San Luis Obispo County, California Spring 1938 (Library of Congress Prints and Photographs Division Washington, D.C. 20540 USA, <http://hdl.loc.gov/loc.pnp/pp.print>).



Near Brentwood, California. Winter quarters of migrants. Agricultural laborers Nov 1938
(Library of Congress Prints and Photographs Division Washington, D.C. 20540 USA,
<http://hdl.loc.gov/loc.pnp/pp.print>)

LITERATURE CITED

- Abrams, A. M., Kleinman, K., & Kulldorff, M. (2010). Gumbel based p-value approximations for spatial scan statistics. *International Journal of Health Geographics*, 9(1), 61.
- Abrams, S. E. (2004). From function to competency in public health nursing, 1931 to 2003. *Public Health Nursing*, 21(5), 507-510.
- Acevedo-Garcia, D., & Bates, L. M. (2008). Latino health paradoxes: empirical evidence, explanations, future research, and implications. In *Latinas/os in the United States: Changing the face of America* (pp. 101-113). Springer, Boston, MA.
- Acevedo-Garcia, D., Sanchez-Vaznaugh, E. V., Viruell-Fuentes, E. A., & Almeida, J. (2012). Integrating social epidemiology into immigrant health research: a cross-national framework. *Social science & medicine*, 75(12), 2060-2068.
- Adams, A. M., & Fenton, M. B. (2017). Identifying peaks in bat activity: a new application of SaTScan's space-time scan statistic. *Wildlife Research*, 44(5), 392-399.
- Aday, L. A., & Andersen, R. (1974). *Development of indices of access to medical care*. Health Administration Press.
- Ahamat, A., & Chong, S. C. (2015). Multi-methodological approaches in qualitative entrepreneurship research. *International Business Management*, 9(4), 601-612.
- Alavanja, M. C., Hoppin, J. A., & Kamel, F. (2004). Health effects of chronic pesticide exposure: cancer and neurotoxicity. *Annu. Rev. Public Health*, 25, 155-197.
- Alavanja, M. C., Sandler, D. P., Lynch, C. F., Knott, C., Lubin, J. H., Tarone, R., ... & Blair, A. (2005). Cancer incidence in the agricultural health study. *Scandinavian journal of work, environment & health*, 39-45.
- Alderete, E., Vega, W. A., Kolody, B., & Aguilar-Gaxiola, S. (1999). Depressive symptomatology: Prevalence and psychosocial risk factors among Mexican migrant farmworkers in California. *Journal of Community Psychology*, 27(4), 457-471.
- Aleuy, O., Pitesky, M., & Gallardo, R. A. (2018). Utilizing Multinomial and Space-Time Permutation Models to Understand the Epidemiology of Infectious Bronchitis in California Between 2008-2012. *Avian Diseases*.
- Alstadt, J., Chen, D. M., & Getis, A. (1998). Point pattern analysis. Available: <http://ceadserv1.nku.edu/longa/cgi-bin/cgi-tcl-examples/generic/ppa/ppa.cgi>. Last accessed: 7 May 2018.

- Alvarez, R. R. (1987). *Familia*. Berkeley: University of California Press.
- American Diabetes Association (2015). <http://www.diabetes.org/diabetes-basics/statistics/>. Last accessed: 1/21/18.
- American Diabetes Association. (2013). Diagnosis and classification of diabetes mellitus. *Diabetes care*, 36(Supplement 1), S67-S74.
- American Diabetes Association. (2013). Economic costs of diabetes in the US in 2012. *Diabetes care*, 36(4), 1033-1046.
- American Diabetes Association. (2004). Gestational diabetes mellitus. *Diabetes care*, 27, S88.
- Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *Journal of health and social behavior*, 1-10.
- Anselin L. (2003). GeoDa. Available: <https://spatial.uchicago.edu/geoda>. Last accessed: 7 May 2018.
- Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical analysis*, 27(2), 93-115.
- Arcury, T. A., & Marín, A. J. (2009). Latino/Hispanic farmworkers and farm work in the eastern United States: the context for health, safety, and justice. In *Latino farmworkers in the eastern United States* (pp. 15-36). Springer New York.
- Arcury, T. A., & Quandt, S. A. (2007). Delivery of health services to migrant and seasonal farmworkers. *Annu. Rev. Public Health*, 28, 345-363.
- Arcury, T. A., Estrada, J. M., & Quandt, S. A. (2010). Overcoming language and literacy barriers in safety and health training of agricultural workers. *Journal of agromedicine*, 15(3), 236-248.
- Arcury, T. A., Gesler, W. M., Preisser, J. S., Sherman, J., Spencer, J., & Perin, J. (2005). The effects of geography and spatial behavior on health care utilization among the residents of a rural region. *Health services research*, 40(1), 135-156.
- Arcury, T. A., Grzywacz, J. G., Chen, H., Vallejos, Q. M., Galvan, L., Whalley, L. E., & Quandt, S. A. (2009). Variation across the agricultural season in organophosphorus pesticide urinary metabolite levels for Latino farmworkers in eastern North Carolina: project design and descriptive results. *American journal of industrial medicine*, 52(7), 539-550.

- Arcury, T. A., Weir, M., Chen, H., Summers, P., Pelletier, L. E., Galván, L., & Quandt, S. A. (2012). Migrant farmworker housing regulation violations in North Carolina. *American journal of industrial medicine*, 55(3), 191-204.
- Arifin, S. (2011). *Location allocation problem using genetic algorithm and simulated annealing. A case study based on school in Enschede* (Doctoral dissertation, Master's thesis, the University of Twente, Enschede, the Netherlands, 92p).
- Ashcraft, N., & Schefflen, A. E. (1976). *People space: The making and breaking of human boundaries*. Anchor Books.
- Athas, W. F., Adams-Cameron, M., Hunt, W. C., Amir-Fazli, A., & Key, C. R. (2000). Travel distance to radiation therapy and receipt of radiotherapy following breast-conserving surgery. *Journal of the National Cancer Institute*, 92(3), 269-271.
- Balán, J., Browning, H. L., & Jelin, E. (1973). *Men in a developing society: Geographic and social mobility in Monterrey, Mexico* (Vol. 30). University of Texas Press.
- Barger, W. K., & Reza, E. M. (1994). *The farm labor movement in the Midwest: Social change and adaptation among migrant farmworkers*. University of Texas Press.
- Barker, R. G. (1968). Ecological psychology; concepts and methods for studying the environment of human behavior. Midwest Psychological Field Station.
- Barrett, F. A. (2000). Disease and Geography. The History of an Idea. *Toronto: Becker Associates*.
- Barthel, E. (1981). Increased risk of lung cancer in pesticide-exposed male agricultural workers. *Journal of Toxicology and Environmental Health, Part A Current Issues*, 8(5-6), 1027-1040.
- Benson, J., Garrison, E., Dropkin, J., & Jenkins, P. L. (2016). Methodological concerns related to response bias in migrant and seasonal farmworkers. *American journal of industrial medicine*, 59(12), 1112-1119.
- Berenson G.S., MacMahan C.A., Voors A.W. (1980). Cardiovascular Risk Factors in Children: The Early Natural History of Atherosclerosis and Essential Hypertension. New York: Oxford University Press.
- Berke, O. (2004). Exploratory disease mapping: kriging the spatial risk function from regional count data. *International Journal of Health Geographics*, 3(1), 18.
- Bernard, H. R., & Bernard, H. R. (2012). *Social research methods: Qualitative and quantitative approaches*. Sage.

- Bernstein, J. (1997). *Low-Wage Labor Market Indicators by City and State: The Constraints Facing Welfare Reform*. Diane Publishing Company.
- Besag, J., & Newell, J. (1991). The detection of clusters in rare diseases. *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, 143-155.
- Bickett, A., & Tapp, H. (2016). Anxiety and diabetes: Innovative approaches to management in primary care. *Experimental Biology and Medicine*, 241(15), 1724-1731.
- Bidin, C. Moni, R. de La Fuente Marcos, C. de La Fuente Marcos, and Giovanni Carraro. "Not an open cluster after all: the NGC 6863 asterism in Aquila." *Astronomy & Astrophysics* 510 (2010): A44.
- Björntorp, P., Holm, G., & Rosmond, R. (1999). Hypothalamic arousal, insulin resistance, and type 2 diabetes mellitus. *Diabetic medicine*, 16(5), 373-383.
- Black, S. A., Markides, K. S., & Ray, L. A. (2003). Depression predicts increased incidence of adverse health outcomes in older Mexican Americans with type 2 diabetes. *Diabetes care*, 26(10), 2822-2828.
- Blair, A. (1982). Cancer risks associated with agriculture: epidemiologic evidence. In *Genetic Toxicology* (pp. 93-111). Springer, Boston, MA.
- Blair, A., & Zahm, S. H. (1991). Cancer among farmers *Occup Med*, 6 (3): 335–354.
- Boggess, B., & Ochoa Bogue, H. (2014). The health of U.S. agricultural workers: An ecological analysis of over 790,000 agricultural worker patients of Migrant Health Centers. Buda, TX: The National Center for Farmworker Health.
- Bohle, H. G., & Fünfgeld, H. (2007). The political ecology of violence in eastern Sri Lanka. *Development and change*, 38(4), 665-687.
- Boscoe, F. P., McLaughlin, C., Schymura, M. J., & Kielb, C. L. (2003). Visualization of the spatial scan statistic using nested circles. *Health & Place*, 9(3), 273-277.
- Bostock, L. (2001). Pathways of disadvantage? Walking as a mode of transport among low-income mothers. *Health & social care in the community*, 9(1), 11-18.
- Brannen, J. (2017). *Mixing methods: Qualitative and quantitative research*. Routledge.
- Braun, A., Musse, S. R., de Oliveira, L. P. L., & Bodmann, B. E. (2003). Modeling individual behaviors in crowd simulation. In *Computer Animation and Social Agents, 2003. 16th International Conference on* (pp. 143-148). IEEE.
- Braveman, P., Egerter, S., & Williams, D. R. (2012). The social determinants of health: coming of age. *Annual review of public health*, 32, 381-398.

- Britt, H., & Britt, H. (2001). *General practice activity in Australia 2000-01*. Canberra: Australian Institute of Health and Welfare, p. 8.
- Bronfenbrenner, U. (1979). Contexts of child rearing: Problems and prospects. *American psychologist*, 34(10), 844.
- Brunner, E. (1997). Stress and the biology of inequality. *BMJ: British medical journal*, 314(7092), 1472.
- Brunner, E. J., & Marmot, M. G. (2005). *Social organisation, stress, and health*. Oxford University Press.
- Burkitt, D. (1962). A “tumour safari” in East and Central Africa. *British journal of cancer*, 16(3), 379.
- Cai, Q., Rushton, G., & Bhaduri, B. (2012). Validation tests of an improved kernel density estimation method for identifying disease clusters. *Journal of geographical systems*, 14(3), 243-264.
- Calavita, Kitty (2010). *Inside the State: The Bracero Program, Immigration, and the I. N. S.* New York: Quid Pro, LLC. p. 1.
- California Department of Agriculture, Employment Development Department. California’s Agricultural Employment, 2008. EDD; 2008.
- Carrasquillo, O., Orav, E. J., Brennan, T. A., & Burstin, H. R. (1999). Impact of language barriers on patient satisfaction in an emergency department. *Journal of general internal medicine*, 14(2), 82-87.
- Carey, J. W. (1993). Linking qualitative and quantitative methods: Integrating cultural factors into public health. *Qualitative Health Research*, 3(3), 298-318.
- Carroll, Daniel, Georges, Annie and Saltz, Russell. (2011). Changing Characteristics of U.S. Farm Workers: 21 Years of Findings from the National Agricultural Workers Survey (presentation, Immigration Reform and Agriculture Conference: Implications for Farmers, Farm Workers, and Communities, Washington D.C., May 12, 2011).
- Cason, K. L., Nieto-Montenegro, S., Chavez-Martinez, A., Lee, N., & Snyder, A. (2004). *Dietary intake and food security among migrant farm workers in Pennsylvania*. Irving B. Harris Graduate School of Public Policy Studies, University of Chicago.
- Castañeda, H., Holmes, S. M., Madrigal, D. S., Young, M. E. D., Beyeler, N., & Quesada, J. (2015). Immigration as a social determinant of health. *Annual review of public health*, 36, 375-392.

- Castañeda, S. F., Rosenbaum, R. P., Holscher, J. T., Madanat, H., & Talavera, G. A. (2015). Cardiovascular Disease Risk Factors among Latino Migrant and Seasonal Farmworkers. *Journal of agromedicine*, 20(2), 95-104.
- Ceci, S. J. (1991). How much does schooling influence general intelligence and its cognitive components? A reassessment of the evidence. *Developmental psychology*, 27(5), 703.
- Centers for Disease Control and Prevention. (1990). Guidelines for investigating clusters of health events. *MMWR*, 39, (RR-11), pp. 1-23.
- Chapman, I. M. (2006). Nutritional disorders in the elderly. *Medical Clinics*, 90(5), 887-907.
- Chaput, E. K., Meek, J. I., & Heimer, R. (2002). Spatial analysis of human granulocytic ehrlichiosis near Lyme, Connecticut. *Emerging infectious diseases*, 8(9), 943.
- Chaput, Emma K., James I. Meek, and Robert Heimer. "Spatial analysis of human granulocytic ehrlichiosis near Lyme, Connecticut." *Emerging infectious diseases* 8, no. 9, pp. 943-8 (2002).
- Charlton, M. (2008). Geographical analysis machine (gam). In K. K. Kemp (Ed.), *Encyclopedia of geographic information science* (pp. 179-179). Thousand Oaks, CA: SAGE Publications Ltd. doi: 10.4135/9781412953962.n80.
- Chen, J., Roth, R. E., Naito, A. T., Lengerich, E. J., & MacEachren, A. M. (2008). Geovisual analytics to enhance spatial scan statistic interpretation: an analysis of US cervical cancer mortality. *International journal of health geographics*, 7(1), 57.
- Chowdhury, A., Helman, C., & Greenhalgh, T. (2000). Food beliefs and practices among British Bangladeshis with diabetes: implications for health education. *Anthropology & Medicine*, 7(2), 209-226.
- Church, R. L., & Murray, A. T. (2009). *Business site selection, location analysis, and GIS*. Hoboken, NJ: John Wiley & Sons.
- Cialdini, R. B. (1993). *Influence: The Psychology of Persuasion*. New York: William Morrow and Company.
- Clancy, P. M., Lee, H., & Zoh, M. H. (1986). Processing strategies in the acquisition of relative clauses: Universal principles and language-specific realizations. *Cognition*, 24(3), 225-262.
- Clark L, Hofsess L. (1998). Acculturation. In: Loue S, ed. *Handbook of Immigrant Health*. New York, NY: Plenum Press; 37–59.
- Cletus, F., & Daniel, B. H. (1981). *A History of California Farmworkers 1870–1941*. Ithaca: Cornell University Press.

- Clingerman, E. (2008). Type 2 diabetes among migrant and seasonal farmworkers. *Hispanic Health Care International*, 6(2), 97-106.
- Cohen, D. A., Scribner, R. A., & Farley, T. A. (2000). A structural model of health behavior: a pragmatic approach to explain and influence health behaviors at the population level. *Preventive medicine*, 30(2), 146-154.
- Collischonn, W., & Pilar, J. V. (2000). A direction dependent least-cost-path algorithm for roads and canals. *International Journal of Geographical Information Science*, 14(4), 397-406.
- Colorado Climate Center. (2012). "Climate of Colorado".
<https://web.archive.org/web/20120703034302/http://climate.colostate.edu/climateofcolorado.php>. Last accessed: 11/7/2018.
- Comber, A. J., Brunsdon, C., & Radburn, R. (2011). A spatial analysis of variations in health access: linking geography, socio-economic status, and access perceptions. *International journal of health geographics*, 10(1), 44.
- Connor, A., Layne, L., & Thomisee, K. (2010). Providing care for migrant farm worker families in their unique sociocultural context and environment. *Journal of Transcultural Nursing*, 21(2), 159-166.
- Cooper, S. P., Heyer, N., Shipp, E. M., Ryder, E. R., Hendrikson, E., Socias, C. M., ... & Partida, S. (2014). Community based research network: opportunities for coordination of care, public health surveillance, and farmworker research. *Online journal of public health informatics*, 6(2).
- Costa, M. A., Kulldorff, M., & Assuncao, R. M. (2007). A space time permutation scan statistic with irregular shape for disease outbreak detection. *Advances in Disease Surveillance*, 4, 243.
- Cousens, S., Smith, P. G., Ward, H., Everington, D., Knight, R. S. G., Zeidler, M., ... & Will, R. G. (2001). Geographical distribution of variant Creutzfeldt-Jakob disease in Great Britain, 1994–2000. *The Lancet*, 357(9261), 1002-1007.
- Cowie, C. C., Rust, K. F., Ford, E. S., Eberhardt, M. S., Byrd-Holt, D. D., Li, C., ... & Geiss, L. S. (2009). Full accounting of diabetes and pre-diabetes in the US population in 1988–1994 and 2005–2006. *Diabetes care*, 32(2), 287-294.
- Creswell, J. W. (1994). Research design: Qualitative & quantitative approaches. Sage Publications, Inc. Thousand Oaks, CA.
- Creswell, J. W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. Sage Publications, Inc. Thousand Oaks, CA.

- Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. *Handbook of mixed methods in social and behavioral research*, 209-240.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Cromley, E. K., & McLafferty, S. L. (2011). *GIS and public health*. Guilford Press.
- Cummins, S., & Macintyre, S. (2006). Food environments and obesity—neighbourhood or nation? *International journal of epidemiology*, 35(1), 100-104.
- Curtis, A., Duval-Diop, D., & Novak, J. (2010). Identifying spatial patterns of recovery and abandonment in the post-Katrina Holy Cross neighborhood of New Orleans. *Cartography and Geographic Information Science*, 37(1), 45-56.
- Cuzick, J., & Edwards, R. (1990). Spatial clustering for inhomogeneous populations. *Journal of the Royal Statistical Society. Series B (Methodological)*, 73-104.
- D'alonzo, K. T., Johnson, S., & Fanfan, D. (2012). A biobehavioral approach to understanding obesity and the development of obesogenic illnesses among Latino immigrants in the United States. *Biological research for nursing*, 14(4), 364-374.
- Dede-Bamfo, N. (2017). *Improving Spatial Accessibility to Agricultural Markets in the Afram Plains, Ghana* (Doctoral dissertation). Texas State University.
- Degazon, C. E. (2004). Cultural diversity and community-oriented nursing practice. P. Stanhope & J. Lancaster. (Eds.), *Community and Public Health Nursing*, 148-169.
- Delamater, P. L., Messina, J. P., Shortridge, A. M., & Grady, S. C. (2012). Measuring geographic access to health care: raster and network-based methods. *International journal of health geographics*, 11(1), 15.
- Denham, T. (2008). *The Agricultural Revolution in Prehistory: Why did Foragers become Farmers?* Oxford University Press on Demand.
- Devillanova, C. (2008). Social networks, information, and health care utilization: evidence from undocumented immigrants in Milan. *Journal of Health Economics*, 27(2), 265-286.
- Diez Roux, A. V. (2001). Investigating neighborhood and area effects on health. *American journal of public health*, 91(11), 1783-1789.

- Diggle, P. J. (1990). A point process modelling approach to raised incidence of a rare phenomenon in the vicinity of a prespecified point. *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, 349-362.
- Doak, C. C., Doak, L. G., & Root, J. H. (1985). Teaching patients with low literacy skills. Philadelphia, Pennsylvania, xix, p. 171.
- Doyal, L., & Pennell, I. (1979). *The political economy of health*. Pluto Press. London, England.
- Dudko, Y., Robey, D. E., Kruger, E., & Tennant, M. (2018). Selecting a location for a primary healthcare facility: combining a mathematical approach with a Geographic Information System to rank areas of relative need. *Australian Journal of Primary Health*, 24(2), 130-134.
- Elwood, S. (2006). Negotiating knowledge production: The everyday inclusions, exclusions, and contradictions of participatory GIS research. *The Professional Geographer*, 58(2), 197-208.
- Engels, F. (1845/1987). *The Condition of the working class in England*. New York: Penguin Classics.
- Engum, A. (2007). The role of depression and anxiety in onset of diabetes in a large population-based study. *Journal of psychosomatic research*, 62(1), 31-38.
- Environmental Systems Research Institute. (2008). Algorithms used by Network Analyst. http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?id=3899&pid=3884&to picname=Algorithms_used_by_Network_Analyst. Last accessed: October 12, 2017.
- Fan, M., Gabbard, S., Pena, A. A., & Perloff, J. M. (2014). Institute for Research on Labor and Employment (IRLE). University of California Berkeley.
- Farquhar, S., Samples, J., Ventura, S., Davis, S., Abernathy, M., McCauley, L., ... & Shadbeh, N. (2008). Promoting the occupational health of indigenous farmworkers. *Journal of Immigrant and Minority Health*, 10(3), 269-280.
- Fernström, M., Fernberg, U., Eliason, G., & Hurtig-Wennlöf, A. (2017). Aerobic fitness is associated with low cardiovascular disease risk: the impact of lifestyle on early risk factors for atherosclerosis in young healthy Swedish individuals—the Lifestyle, Biomarker, and Atherosclerosis study. *Vascular health and risk management*, 13, 91.
- Field, K. S., & Briggs, D. J. (2001). Socio-economic and locational determinants of accessibility and utilization of primary health-care. *Health & social care in the community*, 9(5), 294-308.

- Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Jama*, 307(5), 491-497.
- Forbes, F., Charras-Garrido, M., Azizi, L., Doyle, S., & Abrial, D. (2013). Spatial risk mapping for rare disease with hidden Markov fields and variational EM. *The Annals of Applied Statistics*, 7(2), 1192-1216.
- Fortney, J. C., Booth, B. M., Blow, F. C., Bunn, J. Y., & Loveland Cook, C. A. (1995). The effects of travel barriers and age on the utilization of alcoholism treatment aftercare. *The American Journal of Drug and Alcohol Abuse*, 21(3), 391-406.
- Fortney, J. C., Burgess, J. F., Bosworth, H. B., Booth, B. M., & Kaboli, P. J. (2011). A re-conceptualization of access for 21st century healthcare. *Journal of general internal medicine*, 26(2), 639.
- Fortney, J., Rost, K., Zhang, M., & Warren, J. (1999). The impact of geographic accessibility on the intensity and quality of depression treatment. *Medical care*, 37(9), 884-893.
- Fotheringham, A. S., & Zhan, F. B. (1996). A comparison of three exploratory methods for cluster detection in spatial point patterns. *Geographical analysis*, 28(3), 200-218.
- Friedland, W. H., & Pugliese, E. (1989). Class formation and decomposition in modern capitalist agriculture: comparative perspectives. *Sociologia Ruralis*, 29(2), 149-165.
- Frizzelle, B. G., Evenson, K. R., Rodriguez, D. A., & Laraia, B. A. (2009). The importance of accurate road data for spatial applications in public health: customizing a road network. *International journal of health geographics*, 8(1), 24.
- Fukuda, Y., Umezaki, M., Nakamura, K., & Takano, T. (2005). Variations in societal characteristics of spatial disease clusters: examples of colon, lung, and breast cancer in Japan. *International Journal of Health Geographics*, 4(1), 16.
- Furtado, C. (1976). *Economic development of Latin America: historical background and contemporary problems* (Vol. 8). Cambridge University Press.
- Furuset, O. J. (2010). Geographic information systems (GIS) demonstrating primary care needs for a transitioning Hispanic community. *The Journal of the American Board of Family Medicine*, 23(1), 109-120.
- Gami, A. S., Witt, B. J., Howard, D. E., Erwin, P. J., Gami, L. A., Somers, V. K., & Montori, V. M. (2007). Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. *Journal of the American College of Cardiology*, 49(4), 403-414.

- Gesler, W. M., & Meade, M. S. (1988). Locational and population factors in health care-seeking behavior in Savannah, Georgia. *Health Services Research*, 23(3), 443.
- Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport geography*, 12(2), 127-140.
- Gibson, J., Deng, X., Boe-Gibson, G., Rozelle, S., & Huang, J. (2011). Which households are most distant from health centers in rural China? Evidence from a GIS network analysis. *GeoJournal*, 76(3), 245-255.
- Giele, J. Z., & Elder, G. H. (Eds.). (1998). *Methods of life course research: Qualitative and quantitative approaches*. Sage Publishers, Inc. Thousand Oaks, CA.
- Glader, J. M. (1990). A harvest of shame: the imposition of independent contractor status on migrant farmworkers and its ramifications for migrant children. *Hastings LJ*, 42, 1455.
- Glass, T. A., & McAtee, M. J. (2006). Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Social science & medicine*, 62(7), 1650-1671.
- Goldfarb, R. L. (1981). *Migrant farm workers: A caste of despair*. Iowa State Press.
- Goldsmith, D. F., & Sisneros, G. C. (1996). Cancer prevention strategies among California farmworkers: preliminary findings. *The Journal of Rural Health*, 12(S4), 343-348.
- Golledge, R. G. (1996). Geographical theories. *International Social Science Journal*, 48(150), 461-476.
- Goodman D, Fraga MA, Brodine S, et al. (2013). Prevalence of diabetes and metabolic syndrome in a migrant Mixtec population, Baja California, Mexico. *J Immigr Minor Health*. 2013 Feb;15(1), 93-100. doi:10.1007/s10903-012-9717-0
- Goodman, D. C., Fisher, E. S., Gittelsohn, A., Chang, C. H., & Fleming, C. (1994). Why are children hospitalized? The role of non-clinical factors in pediatric hospitalizations. *Pediatrics*, 93(6), 896-902.
- Goodman, D. C., Fisher, E., Stukel, T. A., & Chang, C. H. (1997). The distance to community medical care and the likelihood of hospitalization: is closer always better? *American Journal of Public Health*, 87(7), 1144-1150.
- Graham, S. (1963). Social factors in relation to chronic illness. *Handbook of medical sociology*, 65-98.
- Green, C., Hoppa, R. D., Young, T. K., & Blanchard, J. F. (2003). Geographic analysis of diabetes prevalence in an urban area. *Social science & medicine*, 57(3), 551-560.

- Greene, J. C., & Caracelli, V. J. (1997). *Advances in mixed-method evaluation: The challenges and benefits of integrating diverse paradigms* (No. 658.4032 A244). Jossey-Bass Publishers.
- Gregory, P. M., Malka, E. S., Kostis, J. B., Wilson, A. C., Arora, J. K., & Rhoads, G. G. (2000). Impact of geographic proximity to cardiac revascularization services on service utilization. *Medical care*, 38(1), 45-57.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, 2(163-194), 105.
- Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods*, 18(1), 59-82.
- Guptill, S. C. (1975). The spatial availability of physicians. In *Proceedings of the association of American Geographers* (Vol. 7, pp. 80-84).
- Hahamovitch, C. (2010). *The fruits of their labor: Atlantic coast farmworkers and the making of migrant poverty, 1870-1945*. Univ of North Carolina Press; p. 14.
- Hales, C. N., & Barker, D. J. (1992). Type 2 (non-insulin-dependent) diabetes mellitus: the thrifty phenotype hypothesis. *Diabetologia*, 35(7), 595-601.
- Hanchette, C. L. (2008). The political ecology of lead poisoning in eastern North Carolina. *Health & place*, 14(2), 209-216.
- Hansen, E., & Donohoe, M. (2003). Health issues of migrant and seasonal farmworkers. *Journal of Health care for the Poor and Underserved*, 14(2), 153-164.
- Harper, J. (2004). Breathless in Houston: a political ecology of health approach to understanding environmental health concerns. *Medical Anthropology*, 23(4), 295-326.
- Hartshorne, R. (1958). The concept of geography as a science of space, from Kant and Humboldt to Hettner. *Annals of the Association of American Geographers*, 48(2), 97-108.
- Haynes, R. (1991). Inequalities in health and health service use: evidence from the General Household Survey. *Social science & medicine*, 33(4), 361-368.
- Heraclides, A. M., Chandola, T., Witte, D. R., & Brunner, E. J. (2012). Work Stress, Obesity, and the Risk of Type 2 Diabetes: Gender-Specific Bidirectional Effect in the Whitehall II Study. *Obesity*, 20(2), 428-433.
- Heres, Lourens, Dick J. Brus, and Thomas J. Hagenaars. (2008). "Spatial analysis of BSE cases in the Netherlands." *BMC Veterinary Research* 4, no. 1, 21.

- Hernandez, D. J., & National Research Council. (1999). Children In Immigrant And Nonimmigrant Farmworker Families: Findings From The National Agricultural Workers Survey, 1.
- Herzog, I. (2010). Theory and practice of cost functions. Abstracts of the XXXVII Conference on Computer Applications and Quantitative Methods in Archaeology, p. 431-34.
- Hiott, A. E., Grzywacz, J. G., Davis, S. W., Quandt, S. A., & Arcury, T. A. (2008). Migrant farmworker stress: mental health implications. *The Journal of Rural Health*, 24(1), 32-39.
- Hjalmars, U. L. F., M. Kulldorff, G. Gustafson, and N. Nagarwalla. (1996). "Childhood leukaemia in Sweden: using GIS and a spatial scan statistic for cluster detection." *Statistics in medicine* 15, no. 7-9, pp. 707-715.
- Hoerster, K. D., Mayer, J. A., Gabbard, S., Kronick, R. G., Roesch, S. C., Malcarne, V. L., & Zuniga, M. L. (2011). Impact of individual-, environmental-, and policy-level factors on health care utilization among US farmworkers. *American journal of public health*, 101(4), 685-692.
- Hoffman, L., Nolan, C., Wilson, J. D., Oats, J. J., & Simmons, D. (1998). Gestational diabetes mellitus-management guidelines-The Australasian Diabetes in Pregnancy Society. *Medical Journal of Australia*, 169(2), 93-97.
- Holzmann, R., Koettl, J., & Chernetsky, T. (2005). *Portability regimes of pension and health care benefits for international migrants: an analysis of issues and good practices* (Vol. 23). Geneva, Switzerland: Global Commission on International Migration.
- Horwitt, M. K. (1965). Nutrition in mental health. *Nutrition reviews*, 23(10), 289-291.
- Hovey, J. D., & Magaña, C. (2000). Acculturative stress, anxiety, and depression among Mexican immigrant farmworkers in the Midwest United States. *Journal of Immigrant health*, 2(3), 119-131.
- Hovey, J. D., & Magaña, C. G. (2002). Exploring the mental health of Mexican migrant farm workers in the Midwest: psychosocial predictors of psychological distress and suggestions for prevention and treatment. *The Journal of Psychology*, 136(5), 493-513.
- Hovey, J. D. (2000). Acculturative stress, depression, and suicidal ideation among Central American immigrants. *Suicide and Life-Threatening Behavior*, 30(2), 125-139.

- Howe, G. M. (1989). Historical evolution of disease mapping in general and specifically of cancer mapping. In *Cancer mapping* (pp. 1-21). Springer, Berlin, Heidelberg.
- Hsu, C. E., Jacobson, H., & Mas, F. S. (2004). Evaluating the disparity of female breast cancer mortality among racial groups-a spatiotemporal analysis. *International Journal of Health Geographics*, 3(1), 4.
- Hudson, J. C. (1969). A location theory for rural settlement. *Annals of the Association of American Geographers*, 59(2), 365-381.
- Hunter, J. M. (1974). The challenge of medical geography. *The Geography of Health and Disease. Chapel Hill, North Carolina: Studies in Geography*, (6).
- Hussein, A. (2015). The use of triangulation in social sciences research: Can qualitative and quantitative methods be combined? *Journal of comparative social work*, 4(1).
- Institute of Medicine. (2004). Health Literacy: A Prescription to End Confusion. <http://www.iom.edu/CMS/3775/3827/19723.aspx>. Last accessed: 1/21/2018.
- Ivory, V. (2008). Neighbourhood social fragmentation and health: Bringing social epidemiology and social theory together. *Doctor of Philosophy, University of Otago, Dunedin, Dunedin*.
- Jackson, M. C., Huang, L., Luo, J., Hachey, M., & Feuer, E. (2009). Comparison of tests for spatial heterogeneity on data with global clustering patterns and outliers. *International journal of health geographics*, 8(1), 55.
- Jaco, E. G. (1960). Social epidemiology of mental disorders. New York, New York, Russell Sage Foundation.
- Jacquez, G. M. (1996). Statistical software for the clustering of health events. *Statistics in medicine*, 15(7-9), 951-952.
- Janz, N. K., Zimmerman, M. A., Wren, P. A., Israel, B. A., Freudenberg, N., & Carter, R. J. (1996). Evaluation of 37 AIDS prevention projects: Successful approaches and barriers to program effectiveness. *Health Education & Behavior*, 23(1), 80-97.
- Johnson, J. H., Parnell, A., Joyner, A. M., Christman, C. J., & Marsh, B. (2004). Racial apartheid in a small North Carolina town. *The Review of Black Political Economy*, 31(4), 89-107.
- Joseph, A. E., & Phillips, D. R. (1984). *Accessibility and utilization: geographical perspectives on health care delivery*. Sage Publishers Inc. Thousand Oaks, CA.
- Jung, I., & Park, G. (2015). p-value approximations for spatial scan statistics using extreme value distributions. *Statistics in medicine*, 34(3), 504-514.

- Kamel, F., Tanner, C. M., Umbach, D. M., Hoppin, J. A., Alavanja, M. C. R., Blair, A., ... & Ross, G. W. (2006). Pesticide exposure and self-reported Parkinson's disease in the agricultural health study. *American journal of epidemiology*, 165(4), 364-374.
- Kandel, W. (2008). Profile of hired farmworkers, a 2008 update. Economic Research Report Number 60. Washington, DC: Economic Research Service, United States Department of Agriculture.
- Katona, P., & Katona-Apte, J. (2008). The interaction between nutrition and infection. *Clinical Infectious Diseases*, 46(10), 1582-1588.
- Kearns, R. A. (1993). Place and health: towards a reformed medical geography. *The Professional Geographer*, 45(2), 139-147.
- Keifer, M. C., & Mahurin, R. K. (1997). Chronic neurologic effects of pesticide overexposure. *Occupational medicine (Philadelphia, Pa.)*, 12(2), 291-304.
- Khan, A. A. (1992). An integrated approach to measuring potential spatial access to health care services. *Socio-economic planning sciences*, 26(4), 275-287.
- Kim, D. A. (2015). *Social networks and health: From epidemiology to intervention*. Doctoral Dissertation, Harvard University, Graduate School of Arts & Sciences.
- Kimes, D., Ullah, A., Levine, E., Nelson, R., Timmins, S., Weiss, S., ... & Blaisdell, C. (2004). Relationships between pediatric asthma and socioeconomic/urban variables in Baltimore, Maryland. *Health & place*, 10(2), 141-152.
- Kinnick, M. K., & Kempner, K. (1988). Beyond “front door” access: attaining the bachelor's degree. *Research in Higher Education*, 29(4), 299-318.
- Kirby, R. S., Delmelle, E., & Eberth, J. M. (2017). Advances in spatial epidemiology and geographic information systems. *Annals of epidemiology*, 27(1), 1-9.
- Knox, E. G. (1989). Detection of clusters. *Methodology of enquiries into disease clustering*. London: Small Area Health Statistics Unit, 17, 20.
- Knox, P. L. (1978). The intraurban ecology of primary medical care: patterns of accessibility and their policy implications. *Environment and planning A*, 10(4), 415-435.
- Kohli, S., Sahlen, K., Sivertun, Å., Löfman, O., Trell, E., & Wigertz, O. (1995). Distance from the primary health center: a GIS method to study geographical access to health care. *Journal of medical systems*, 19(6), 425-436.

- Kosteniuk, J. G., & Dickinson, H. D. (2003). Tracing the social gradient in the health of Canadians: primary and secondary determinants. *Social science & medicine*, 57(2), 263-276.
- Kresge, L. (2007). Indigenous Oaxacan Communities in California: An Overview. *California Institute for Rural Studies*, 1107.
- Krieger, N. (2001). Theories for social epidemiology in the 21st century: an ecosocial perspective. *International journal of epidemiology*, 30(4), 668-677.
- Krieger, N. (2011). Ecosocial Theory of Disease Distribution: embodying societal & ecologic context. *Epidemiology and the People's Health: Theory and Context*.
- Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J., & Power, C. (2003). Life course epidemiology. *Journal of Epidemiology & Community Health*, 57(10), 778-783.
- Kulldorff, M. (2001). Prospective time periodic geographical disease surveillance using a scan statistic. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 164(1), 61-72.
- Kulldorff, M., & Nagarwalla, N. (1995). Spatial disease clusters: detection and inference. *Statistics in medicine*, 14(8), 799-810.
- Kulldorff, M., Heffernan, R., Hartman, J., Assunção, R., & Mostashari, F. (2005). A space-time permutation scan statistic for disease outbreak detection. *PLoS medicine*, 2(3), e59.
- Kwan, M. P. (1999). Gender and individual access to urban opportunities: a study using space-time measures. *The Professional Geographer*, 51(2), 210-227.
- Kwan, M. P. (2012). How GIS can help address the uncertain geographic context problem in social science research. *Annals of GIS*, 18(4), 245-255.
- Lacy, Elaine C. 1988. "Mexican Immigrant Workers in the Southwest: The 1920s and the 1980s." *Review of Latin American Studies* 1, no. 2: pg. 110.
- Lakhan, S. E., & Vieira, K. F. (2008). Nutritional therapies for mental disorders. *Nutrition journal*, 7(1), 2.
- Lantz, P. M., Dupuis, L., Reding, D., Krauska, M., & Lappe, K. (1994). Peer discussions of cancer among Hispanic migrant farm workers. *Public Health Reports*, 109(4), 512.
- Lara, M., Gamboa, C., Kahramanian, M. I., Morales, L. S., & Hayes Bautista, D. E. (2005). Acculturation and Latino health in the United States: a review of the literature and its sociopolitical context. *Annu. Rev. Public Health*, 26, 367-397.

- Larson, A. and Plascencia, L. (1993). Migrant Enumeration Study, Office of Minority Health.
- Lauer R.M., Lee J., Clarke W.R. (1975). Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. *J Pediatr*; 86: 697–706.
- Lentz, J. A. (2012). *Developing A Geospatial Protocol for Coral Epizootiology*. Doctoral Dissertation, 551. https://digitalcommons.lsu.edu/gradschool_dissertations/551.
- Levine, N. (2015). CrimeStat: A spatial statistics program for the analysis of crime incident locations (v 4.02). *Ned Levine & Associates, Houston, Texas, and the National Institute of Justice, Washington, DC August*.
- Levin, J. S. (1996). How religion influences morbidity and health: Reflections on natural history, salutogenesis, and host resistance. *Social Science & Medicine*, 43(5), 849-864.
- Lewin, K. (1951). Field theory in social science: selected theoretical papers (Edited by Dorwin Cartwright). Oxford, England: Harpers.
- Leyse-Wallace, R. (2013). *Nutrition and mental health*. CRC Press.
- Lieber, C. L. (2008). *Cardiovascular Disease Among Latino Migrant Farmworkers: Developing A Culturally Sensitive Health Promotion Education Program for the Work Setting*. Doctoral dissertation, University of Arizona.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.548.7303&rep=rep1&type=pdf>.
- Link, B. G., & Phelan, J. C. (1996). Understanding sociodemographic differences in health--the role of fundamental social causes. *American journal of public health*, 86(4), 471-473.
- Littlefield, C., & Stout, C. L. (1987). A survey of Colorado's migrant farmworkers: Access to health care. *International Migration Review*, 688-708.
- Loader, C. R. (1991). Large-deviation approximations to the distribution of scan statistics. *Advances in Applied Probability*, 23(4), 751-771.
- Lockwood, S. (2004). Transportation in Rural America: Challenges and Opportunities. University of Minnesota Center for Transportation.
- Los Angeles Times (2017). "Mapping L.A. – North Hollywood."
<http://maps.latimes.com/neighborhoods/neighborhood/north-hollywood/>. Last accessed: 11/7/2018.

- Love, D., & Lindquist, P. (1995). The geographical accessibility of hospitals to the aged: a geographic information systems analysis within Illinois. *Health services research, 29*(6), 629.
- Lovett, A., Haynes, R., Sünnerberg, G., & Gale, S. (2002). Car travel time and accessibility by bus to general practitioner services: a study using patient registers and GIS. *Social science & medicine, 55*(1), 97-111.
- Luo, J., Tian, L., Luo, L., Yi, H., & Wang, F. (2017). Two-Step Optimization for Spatial Accessibility Improvement: A Case Study of Health Care Planning in Rural China. *BioMed research international, 2017*.
- Luo, W., & Qi, Y. (2009). An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians. *Health & place, 15*(4), 1100-1107.
- Luo, W., & Wang, F. (2003). Measures of spatial accessibility to health care in a GIS environment: synthesis and a case study in the Chicago region. *Environment and Planning B: Planning and Design, 30*(6), 865-884.
- Macionis, J. J., & Gerber, L. M. (2011). Sociology, 7th Canadian edn. *Toronto, Ontario, Canada: Prentice Hall*.
- Mainous, A. G., Diaz, V. A., & Carnemolla, M. (2008). Factors affecting Latino adults' use of antibiotics for self-medication. *The Journal of the American Board of Family Medicine, 21*(2), 128-134.
- March, J. G. (1994). *Primer on decision making: How decisions happen*. Simon and Schuster.
- Marshall, S. A., Ip, E. H., Suerken, C. K., Arcury, T. A., Saldana, S., Daniel, S. S., & Quandt, S. A. (2018). Relationship between maternal depression symptoms and child weight outcomes in Latino farmworker families. *Maternal & child nutrition, e12614*.
- Mason, M. (2010). Sample size and saturation in Ph.D. studies using qualitative interviews. In *Forum qualitative Sozialforschung/Forum: qualitative social research* (Vol. 11, No. 3).
- Massey, D. S. (1987). Understanding mexican migration to the United States. *American Journal of Sociology, 92*(6), 1372-1403.
- May, J. M. (1950). Medical geography: its methods and objectives. *Geographical Review, 40*(1), 9-41.
- May, J. M. (1958). The Ecology of Human Disease. *The Ecology of Human Disease*. MD Publications Inc. New York, New York.

- McBride, J., & Sergie, M. A. (2016). NAFTA's Economic Impact. *Council on Foreign Relations*.
- McCauley L. (2001). Work characteristics, pesticide exposures among migrant agricultural families: a community-based research approach. *Environ Health Perspect*; 109(5):533–8.
- McClure, H. H., Snodgrass, J. J., Martinez, C. R., Eddy, J. M., Jiménez, R. A., & Isiordia, L. E. (2010). Discrimination, psychosocial stress, and health among Latin American immigrants in Oregon. *American Journal of Human Biology*, 22(3), 421-423.
- McDonald, K. N. (2013). *Social Epidemiology and Spatial Epidemiology: An Empirical Comparison of Perspectives*. Doctoral dissertation, University of Minnesota. <https://search.proquest.com/docview/1702712484?pq-origsite=gscholar>.
- McEntee, J. C., & Ogneva-Himmelberger, Y. (2008). Diesel particulate matter, lung cancer, and asthma incidences along major traffic corridors in MA, USA: A GIS analysis. *Health & Place*, 14(4), 817-828.
- McLafferty, S. (2015). Disease cluster detection methods: recent developments and public health implications. *Annals of GIS*, 21(2), 127-133.
- McMichael, A. J. (1999). Prisoners of the proximate: loosening the constraints on epidemiology in an age of change. *American journal of epidemiology*, 149(10), 887-897.
- McMichael, A. J. (2001). *Human frontiers, environments, and disease: past patterns, uncertain futures*. Cambridge University Press, p. 16.
- Meissner, D. (2004). US temporary worker programs: lessons learned. *Migration Information Source*.
- Melchior, M., Caspi, A., Milne, B. J., Danese, A., Poulton, R., & Moffitt, T. E. (2007). Work stress precipitates depression and anxiety in young, working women and men. *Psychological medicine*, 37(8), 1119-1129.
- Melnick, A. L. (2002). *Introduction to geographic information systems in public health*. Jones & Bartlett Learning. Aspen Publishers, Inc. Gaithersburg, MD.
- Melnick, A. L., & Fleming, D. W. (1999). Modern Geographic Information Systems-Promise and Pitfalls.
- Méndez-Lázaro, P., Muller-Karger, F. E., Otis, D., McCarthy, M. J., & Rodríguez, E. (2018). A heat vulnerability index to improve urban public health management in San Juan, Puerto Rico. *International journal of biometeorology*, 62(5), 709-722.

- Merriam-Webster Dictionary. *Acculturation*. (n.d.). Retrieved May 7, 2018, from <https://www.merriam-webster.com/dictionary/acculturation>.
- Merrill, R. M. (2015). *Introduction to epidemiology*. Jones & Bartlett Publishers, Burlington, MA.
- Michigan Department of Agriculture (1988). Food and Agricultural Development Statistics. Lansing: Michigan Agricultural Statistics Service.
- Migration Policy Institute (2015). The Salvadoran Diaspora in the United States. Rockefeller Foundation-Aspen Institute Diaspora Program (RAD).
- Mikolajczyk, R. T., El Ansari, W., & Maxwell, A. E. (2009). Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. *Nutrition Journal*, 8(1), 1.
- Miller, R. P. (1995). Beyond method, beyond ethics: Integrating social theory into GIS and GIS into social theory. *Cartography and Geographic Information Systems*, 22(1), 98-103.
- Miller, S. I., & Fredericks, M. (2006). Mixed-methods and evaluation research: Trends and issues. *Qualitative Health Research*, 16(4), 567-579.
- Minuti, M. P. (2014). Commercial Pursuits: Workers' Compensation Exemptions Rooted in the Past Wilt with the Growth of Sustainable Farming. *Wake Forest JL & Pol'y*, 4, 231.
- Miranda, M. L., Ferranti, J., Strauss, B., Neelon, B., & Califf, R. M. (2013). Geographic health information systems: a platform to support the 'triple aim.' *Health affairs*, 32(9), 1608-1615.
- Mokdad, A. H., Bowman, B. A., Ford, E. S., Vinicor, F., Marks, J. S., & Koplan, J. P. (2001). The continuing epidemics of obesity and diabetes in the United States. *Jama*, 286(10), 1195-1200.
- Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F., Bales, V. S., & Marks, J. S. (2003). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Jama*, 289(1), 76-79.
- Mokhtar, N., Elati, J., Chabir, R., Bour, A., Elkari, K., Schlossman, N. P., ... & Aguenau, H. (2001). Diet culture and obesity in northern Africa. *The Journal of nutrition*, 131(3), 887S-892S.

- Molla, Y. B., Rawlins, B., Makanga, P. T., Cunningham, M., Ávila, J. E. H., Ruktanonchai, C. W., ... & Moran, A. C. (2017). Geographic information system for improving maternal and newborn health: recommendations for policy and programs. *BMC pregnancy and childbirth*, 17(1), 26.
- Mooney, C. Z. (1997). *Monte carlo simulation* (Vol. 116). Sage Publications, Inc. Thousand Oaks, CA.
- Moore, D. A., & Carpenter, T. E. (1999). Spatial analytical methods and geographic information systems: use in health research and epidemiology. *Epidemiologic reviews*, 21(2), 143-161.
- Moos, P. (1980). Social-ecological perspectives on health. *Health psychology: A handbook*.
- Moreno, G., Morales, L. S., Batts, F., Noguera, C., Isiordia, M., & Mangione, C. M. (2015). Migration, Health Care Behaviors, and Primary Care for Rural Latinos with Diabetes. *Journal of Immigrant and Minority Health*, 1-6.
- Morgan, D. L. (1998). Practical strategies for combining qualitative and quantitative methods: Applications to health research. *Qualitative health research*, 8(3), 362-376.
- Morris, J. N. (1975). *Uses of epidemiology* (No. 3rd edition). Churchill Livingstone 23 Ravelston Terrace, Edinburgh, EH4 3TL.
- Morse, Janice M. (1994). Designing funded qualitative research. In Norman K. Denzin & Yvonna S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed., pp.220-35). Thousand Oaks, CA: Sage.
- Morton, L. W., & Blanchard, T. C. (2007). Starved for access: life in rural America's food deserts. *Rural Realities*, 1(4), 1-10.
- Mottillo, S., Filion, K. B., Genest, J., Joseph, L., Pilote, L., Poirier, P., ... & Eisenberg, M. J. (2010). The metabolic syndrome and cardiovascular risk: a systematic review and meta-analysis. *Journal of the American College of Cardiology*, 56(14), 1113-1132.
- Motwani, R., & Raghavan, P. (2010). *Randomized algorithms* (pp. 12-12). Chapman & Hall/CRC.
- Murawski, L., & Church, R. L. (2009). Improving accessibility to rural health services: The maximal covering network improvement problem. *Socio-Economic Planning Sciences*, 43(2), 102-110.
- Murrow, E.R. (1960) *Harvest of Shame* [Television documentary]. New York, New York: CBS Broadcasting Inc.

- Naiman, D. Q., & Priebe, C. E. (2001). Computing scan statistic p values using importance sampling, with applications to genetics and medical image analysis. *Journal of Computational and Graphical Statistics*, 10(2), 296-328.
- National Center for Farmworker Health (NCFH). Facts about farmworkers. (2012). Retrieved at [http://www.ncfh.org/docs/fs-facts%about%20farm workers.pdf](http://www.ncfh.org/docs/fs-facts%about%20farm%20workers.pdf). Last accessed: 1/31/17.
- National Center for Farmworker Health (NCFH). (2017). Michigan Interagency Migrant Services Committee; Collaborations and Partnerships. http://www.ncfh.org/uploads/3/8/6/8/38685499/michigan_interagency_migrant_services_committee-collaborations_and_partnerships.pdf. Last accessed: 1/21/18.
- National Eye Institute (2015) - <https://nei.nih.gov/health/diabetic/retinopathy>. Last accessed: 10/23/2017.
- National Oceanic and Atmospheric Administration – National Climatic Data Center (2018) - <https://www.ncdc.noaa.gov/>. Last accessed: 11/15/2018.
- Nattinger, A. B., Kneusel, R. T., Hoffmann, R. G., & Gilligan, M. A. (2001). Relationship of distance from a radiotherapy facility and initial breast cancer treatment. *Journal of the National Cancer Institute*, 93(17), 1344-1346.
- Nekola, J. C., & White, P. S. (1999). The distance decay of similarity in biogeography and ecology. *Journal of Biogeography*, 26(4), 867-878.
- Neutra, R., Swan, S., & Mack, T. (1992). Clusters galore: insights about environmental clusters from probability theory. *Science of the total environment*, 127(1-2), 187-200.
- Ng, D. M., & Jeffery, R. W. (2003). Relationships between perceived stress and health behaviors in a sample of working adults. *Health Psychology*, 22(6), 638.
- Ngai, M. M. (2004). *Impossible subjects: Illegal aliens and the making of modern America*. Princeton University Press. Princeton, NJ.
- Nichols, M., Stein, A. D., & Wold, J. L. (2014). Health status of children of migrant farm workers: farm worker family health program, Moultrie, Georgia. *American journal of public health*, 104(2), 365-370.
- Nita, S., Pécout, A., Lombaerde, P. D., Neyts, K., & Gartland, J. (2017). *Migration, free movement, and regional integration*. UNESCO Publishing.
- Northridge, M. E., Sclar, E. D., & Biswas, P. (2003). Sorting out the connections between the built environment and health: a conceptual framework for navigating pathways and planning healthy cities. *Journal of Urban Health*, 80(4), 556-568.

- Nyberg, S. T., Fransson, E. I., Heikkilä, K., Ahola, K., Alfredsson, L., Bjorner, J. B., ... & Hamer, M. (2014). Job strain as a risk factor for type 2 diabetes: a pooled analysis of 124,808 men and women. *Diabetes care*, 37(8), 2268-2275.
- O'Cathain, A. (2009). Mixed methods research in the health sciences: A quiet revolution. *Journal of Mixed Methods Research*, volume 3:1.
- Odoi, A., S. W. Martin, P. Michel, J. Holt, D. Middleton, and J. Wilson. (2004). "Determinants of the geographical distribution of endemic giardiasis in Ontario, Canada: a spatial modelling approach." *Epidemiology and infection* 132, no. 05, pp. 967-976.
- Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2010). *Prevalence of obesity in the United States, 2009-2010* (pp. 1-8). Hyattsville, MD: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.
- Oliver, G., Wardle, J., & Gibson, E. L. (2000). Stress and food choice: a laboratory study. *Psychosomatic medicine*, 62(6), 853-865.
- Omer, I. (2006). Evaluating accessibility using house-level data: A spatial equity perspective. *Computers, Environment and Urban Systems*, 30(3), 254-274.
- Openshaw, S. (1991). A view on the GIS crisis in geography, or, using GIS to put Humpty-Dumpty back together again. *Environment and Planning A*, 23(5), 621-628.
- Openshaw, S., Charlton, M., Wymer, C., & Craft, A. (1988). A mark 1 geographical analysis machine for the automated analysis of point data sets. *International Journal of Geographical Information System*, 1(4), 335-358.
- Ortega, A. N., Fang, H., Perez, V. H., Rizzo, J. A., Carter-Pokras, O., Wallace, S. P., & Gelberg, L. (2007). Health care access, use of services, and experiences among undocumented Mexicans and other Latinos. *Archives of Internal Medicine*, 167(21), 2354-2360.
- Ozdenerol, E. (2017). *Spatial Health Inequalities: Adapting GIS Tools and Data Analysis*. CRC Press.
- Pabon-Nau, L. P., Cohen, A., Meigs, J. B., & Grant, R. W. (2010). Hypertension and diabetes prevalence among US Hispanics by country of origin: The National Health Interview Survey 2000-2005. *Journal of general internal medicine*, 25(8), 847-852.
- Passel, J. S., Director, P. T., & Lopez, M. H. (2009). A portrait of unauthorized immigrants in the United States. Pew Hispanic Center, Washington D.C.
- Patton, M. Q. (1987). *Qualitative evaluation and research methods*. SAGE Publications Inc. Thousand Oaks, CA.

- Pedigo, A. S., & Odoi, A. (2010). Investigation of disparities in geographic accessibility to emergency stroke and myocardial infarction care in East Tennessee using geographic information systems and network analysis. *Annals of epidemiology*, 20(12), 924-930.
- Penchansky, R., & Thomas, J. W. (1981). The concept of access: definition and relationship to consumer satisfaction. *Medical care*, 127-140.
- Pérez-Escamilla, R., & Putnik, P. (2007). The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. *The Journal of nutrition*, 137(4), 860-870.
- Perilla, J. L., Wilson, A. H., & Wold, J. L. (1998). Listening to migrant voices: Focus groups on health issues in South Georgia. *Journal of Community Health Nursing*, 15(4), 251-263.
- Pettitt, D. J., Bennett, P. H., Knowler, W. C., Baird, H. R., & Aleck, K. A. (1985). Gestational diabetes mellitus and impaired glucose tolerance during pregnancy: long-term effects on obesity and glucose tolerance in the offspring. *Diabetes*, 34(Supplement 2), 119-122.
- Pfeifer, G. M. (2016). Pesticides, migrant farm workers, and corporate agriculture: How social work can promote environmental justice. *Journal of Progressive Human Services*, 27(3), 175-190.
- Pickles, J. (1991). Geography, GIS, and the surveillant society. In *Papers and proceedings of applied geography conferences* (Vol. 14, No. 8, pp. 80-91). New York, NY: State University Press.
- Pickles, J. (1999). Arguments, debates, and dialogues: the GIS-social theory debate and the concern for alternatives. *Geographical Information Systems: Principles and Technical Issues*, 1, 49-60.
- Piore, M. J. (1979). *Birds of passage: migrant labor and industrial societies*. Cambridge University Press. Cambridge University Press, Cambridge, England. p. 229.
- Portes, A., & Bach, R. L. (1985). *Latin journey: Cuban and Mexican immigrants in the United States*. Univ of California Press.
- Poss, J., Pierce, R., & Prieto, V. (2005). Herbal remedies used by selected migrant farmworkers in El Paso, Texas. *The Journal of Rural Health*, 21(2), 187-191.
- Poulton, R., Caspi, A., Milne, B. J., Thomson, W. M., Taylor, A., Sears, M. R., & Moffitt, T. E. (2002). Association between children's experience of socioeconomic disadvantage and adult health: a life-course study. *The lancet*, 360(9346), 1640-1645.

- Presidential Commission on Migrant Labor. (1951). *Migratory Labor in American Agriculture*. Washington, DC: U.S. GPO.
- Priebe, C. E., Olson, T., & Healy Jr, D. M. (1997). A spatial scan statistic for stochastic scan partitions. *Journal of the American Statistical Association*, 92(440), 1476-1484.
- Pun-Cheng, L. S. (2017). Distance decay. *The International Encyclopedia of Geography*.
- Pyykkönen, A. J., Räikkönen, K., Tuomi, T., Eriksson, J. G., Groop, L., & Isomaa, B. (2009). Stressful life events and the metabolic syndrome: The PPP-Botnia Study. *Diabetes care*, 33(2): 378-384. American Diabetes Association.
- Qenani, E., MacDougall, N., & Roy, S. (2016). Vigorous Physical Activity and Obesity? – The Paradox of California Farmworker Population. In 2016 Annual Meeting, July 31-August 2, 2016, Boston, Massachusetts (No. 235530). Agricultural and Applied Economics Association.
- Quandt, S. A., Brooke, C., Fagan, K., Howe, A., Thornburg, T. K., & McCurdy, S. A. (2015). Farmworker housing in the United States and its impact on health. *New Solutions: A Journal of Environmental and Occupational Health Policy*, 25(3), 263-286.
- Quandt, S. A., Groeschel-Johnson, A., Kinzer, H. T., Jensen, A., Miles, K., O'Hara, H. M., ... & Arcury, T. A. (2018). Migrant Farmworker Nutritional Strategies: Implications for Diabetes Management. *Journal of agromedicine*, 23(4), 347-354.
- Quesada, J., Hart, L. K., & Bourgois, P. (2011). Structural vulnerability and health: Latino migrant laborers in the United States. *Medical anthropology*, 30(4), 339-362.
- Raphael, D. (Ed.). (2009). *Social determinants of health: Canadian perspectives*. Canadian Scholars' Press. Toronto, Ontario.
- Ravenstein, E. G. (1885). The laws of migration. *Journal of the statistical society of London*, 48(2), 167-235. Chicago, Ill.
- Read, S., Bath, P. A., Willett, P., & Maheswaran, R. (2013). New developments in the spatial scan statistic. *Journal of Information Science*, 39(1), 36-47.
- Reeder LG. Social epidemiology: an appraisal. (Revised version of a paper read at the annual meeting of the American Sociological Association, San Francisco, September 1969). In: Jaco EG (ed.). *Patients, Physicians, and Illness*. 2nd Edn. New York: The Free Press, 1972, pp. 97–101.
- Reeder, J. A. (2000). *Harvesting hunger: measuring food insecurity and hope in Oregon's Mexican agriculture and seafood workers* (Doctoral dissertation). <http://www.diabetesmonitor.com/b42.htm>.

- Reid, A., & Schenker, M. B. (2016). Hired farmworkers in the US: Demographics, work organisation, and services. *American journal of industrial medicine*, 59(8), 644-655.
- Reid, D.D. (1969). The beginnings of bronchitis. *Royal Society of Medicine*; 62: 311 – 16.
- Reperant, Leslie A., and Peter Deplazes. (2005). "Cluster of *Capillaria hepatica* infections in non-commensal rodents from the canton of Geneva, Switzerland." *Parasitology Research* 96, no. 5: 340-342.
- Richards, R., & Smith, C. (2006). The impact of homeless shelters on food access and choice among homeless families in Minnesota. *Journal of nutrition education and behavior*, 38(2), 96-105.
- Richmond, C., Elliott, S. J., Matthews, R., & Elliott, B. (2005). The political ecology of health: perceptions of environment, economy, health, and well-being among 'Namgis First Nation. *Health & place*, 11(4), 349-365.
- Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (Eds.). (2003). *Qualitative research practice: A guide for social science students and researchers*. Sage Publishers, Inc. Thousand Oaks, CA.
- Rizzo, T. A., Metzger, B. E., Dooley, S. L., & Cho, N. H. (1997). Early malnutrition and child neurobehavioral development: insights from the study of children of diabetic mothers. *Child development*, 68(1), 26-38.
- Robertson, C., Nelson, T. A., MacNab, Y. C., & Lawson, A. B. (2010). Review of methods for space–time disease surveillance. *Spatial and spatio-temporal epidemiology*, 1(2), 105-116.
- Rochin, R. I., Santiago, A. M., & Dickey, K. S. (1989). *Migrant and seasonal workers in Michigan's agriculture: a study of their contributions, characteristics, needs, and services* (No. 1). Julian Samora Research Institute, Michigan State University.
- Rose, D., & Quade, D. (2006). The agricultural worker health and housing program. *Los Angeles: The California Endowment*.
- Rosmond, R. (2005). Role of stress in the pathogenesis of the metabolic syndrome. *Psychoneuroendocrinology*, 30(1), 1-10.
- Rossmann, G. B., Rallis, S. F., Phlegar, J. M., & Abeille, A. (1998). *Dynamic teachers: Leaders of change*. Corwin Press, Inc. Thousand Oaks, CA.
- Rothenberg, D., & Epp, R. (2003). With these hands: the hidden world of migrant farm workers today. *Labour*, (51), 315.

- Rothman, K. J., Greenland, S., & Lash, T. L. (Eds.). (1998). *Modern epidemiology*. Annals of Emergency Medicine. Lippincott Williams & Wilkins.
- Rovio, S. P., Pahkala, K., Nevalainen, J., Juonala, M., Salo, P., Kähönen, M., ... & Taittonen, L. (2017). Cardiovascular risk factors from childhood and midlife cognitive performance: the Young Finns Study. *Journal of the American College of Cardiology*, 69(18), 2279-2289.
- Rushton, G., & Lolonis, P. (1996). Exploratory spatial analysis of birth defect rates in an urban population. *Statistics in Medicine*, 15(7-9), 717-726.
- Sabel, C. E., Boyle, P. J., Löytönen, M., Gatrell, A. C., Jokelainen, M., Flowerdew, R., & Maasilta, P. (2003). Spatial clustering of amyotrophic lateral sclerosis in Finland at place of birth and place of death. *American Journal of Epidemiology*, 157(10), 898-905.
- Sallis, J., and Owen, N. (2015). In *Health Behavior: Theory, Research, and Practice*. John Wiley & Sons, p. 67 – 75.
- Sanders, L. (2007). Introduction to Models in Spatial Analysis. ISTE, London, pp. xv-xxvii, Geographical Information Systems series.
- Sarig, Y., Thompson, J. F., & Brown, G. K. (2000). *Alternatives to Immigrant Labor? The Status of Fruit and Vegetable Harvest Mechanization in the United States*. Center for Immigration Studies.
- SaTScan. (2005). SaTScan Home Page. Available: <http://www.satscan.org/>. Last accessed: 7 May 2018.
- Schafft, K. A., Jensen, E. B., & Hinrichs, C. C. (2009). Food deserts and overweight schoolchildren: Evidence from Pennsylvania*. *Rural Sociology*, 74(2), 153-177.
- Scherpenzeel, A., & Saris, W. E. (2017). Multitrait-Multimethod Models for Longitudinal. *Longitudinal models in the behavioral and related sciences*, 381.
- Sciatti, E., Lombardi, C., Ravera, A., Vizzardi, E., Bonadei, I., Carubelli, V., ... & Metra, M. (2016). Nutritional deficiency in patients with heart failure. *Nutrients*, 8(7), 442.
- Scribner, R. (1996). Paradox as paradigm--the health outcomes of Mexican Americans. *American journal of public health*, 86(3), 303-305.
- Scribner, R., & Dwyer, J. H. (1989). Acculturation and low birthweight among Latinos in the Hispanic HANES. *American journal of public health*, 79(9), 1263-1267.

- Shankar, J., Ip, E., Khalema, E., Couture, J., Tan, S., Zulla, R. T., & Lam, G. (2013). Education as a social determinant of health: issues facing indigenous and visible minority students in postsecondary education in western Canada. *International journal of environmental research and public health*, 10(9), 3908-3929.
- Sharkey, J. R., Dean, W. R., & Johnson, C. M. (2011). Association of household and community characteristics with adult and child food insecurity among Mexican-origin households in colonies along the Texas-Mexico border. *Int J Equity Health*, 10(1), 19.
- Shaw, S. J. (2005). The politics of recognition in culturally appropriate care. *Medical Anthropology Quarterly*, 19(3), 290-309.
- Sherman, R. L., Henry, K. A., Tannenbaum, S. L., Feaster, D. J., Kobetz, E., & Lee, D. J. (2014). Peer Reviewed: Applying Spatial Analysis Tools in Public Health: An Example Using SaTScan to Detect Geographic Targets for Colorectal Cancer Screening Interventions. *Preventing chronic disease*, 11.
- Shi, L., & Starfield, B. (2001). The effect of primary care physician supply and income inequality on mortality among blacks and whites in US metropolitan areas. *American journal of public health*, 91(8), 1246-1250.
- Shorris, E. (2012). *Latinos: A biography of the people*. WW Norton & Company.
- Shotland, J. (1989). *Full Fields, Empty Cupboards: The Nutritional Status of Migrant Farmworkers in America*.
- Shue, H. (1996). *Basic rights: Subsistence, affluence, and US foreign policy*. Princeton University Press.
- Silverman, B. L., Metzger, B. E., Cho, N. H., & Loeb, C. A. (1995). Impaired glucose tolerance in adolescent offspring of diabetic mothers: relationship to fetal hyperinsulinism. *Diabetes care*, 18(5), 611-617.
- Šipuš, D., & Abramović, B. (2017). The possibility of using public transport in rural area. *Procedia engineering*, 192, 788-93.
- Slesinger, D. P., & Cautley, E. (1981). Medical utilization patterns of Hispanic migrant farmworkers in Wisconsin. *Public Health Reports*, 96(3), 255.
- Slesinger, D. P., & Pfeffer, M. J. (1992). Migrant farm workers. *Rural poverty in America*, 135-153.
- Slocum, R. (2006). Anti-racist Practice and the Work of Community Food Organizations. *Antipode*, 38(2), 327-349.

- Smith, J. K., & Heshusius, L. (1986). Closing down the conversation: The end of the quantitative-qualitative debate among educational inquirers. *Educational researcher*, 15(1), 4-12.
- Son, Y. J., & Song, E. K. (2013). High nutritional risk is associated with worse health-related quality of life in patients with heart failure beyond sodium intake. *European Journal of Cardiovascular Nursing*, 12(2), 184-192.
- Spangler, J. G., Arcury, T. A., Quandt, S. A., & Preisser, J. S. (2003). Tobacco use among Mexican farmworkers working in tobacco: implications for agromedicine. *Journal of agromedicine*, 9(1), 83-91.
- Spiewak, R. (2001). Pesticides as a cause of occupational skin diseases in farmers. *Annals of agricultural and environmental medicine*, 8(1), 1-5.
- Ståhle, A., Marcus, L., & Karlström, A. (2005). Place Syntax: Geographic accessibility with axial lines in GIS. In *Fifth international space syntax symposium* (pp. 131-144). Techne Press.
- Stein, Z., Susser, M., Saenger, G., & Marolla, F. (1975). *Fame and Human Development. The Dutch Hunger Winter of 1944 – 45*. New York: Oxford University Press.
- Stephen L. (2004). Mixtec farmworkers in Oregon: linking labor and ethnicity through farmworker unions and hometown associations. In: Fox J, Rivera-Salgado G, editors. *Indigenous Mexican Migrants in the United States*. Center for U.S.-Mexican Studies, Center for Comparative Immigration Studies. San Diego: University of California; p. 179–202.
- Stephen, L. (2001). Globalization, the state, and the creation of flexible indigenous workers: Mixtec farmworkers in Oregon. *Urban Anthropology and Studies of Cultural Systems and World Economic Development*, 189-214.
- Stimson, R. J. (1983). Research design and methodological problems in the geography of health. London, p. 321-34.
- Stokols, D. (1992). Establishing and maintaining healthy environments: toward a social ecology of health promotion. *American psychologist*, 47(1), 6.
- Stokols, D., Grzywacz, J. G., McMahan, S., & Phillips, K. (2003). Increasing the health promotive capacity of human environments. *American journal of health promotion*, 18(1), 4-13.
- Sugumaran, Ramanathan, Scott R. Larson, and John P. DeGroote. (2009). "Spatio-temporal cluster analysis of county-based human West Nile virus incidence in the continental United States." *International journal of health geographics* 8, no. 1, 43.

- Susser, M., Watson, W., & Hopper, K. (1985). Social class and disorders in health. *Sociology in medicine*, 3140-3145.
- Susser, M.W., and Watson, W. (1962). *Sociology and Medicine*. London: *Oxford University Press*.
- Syme, S. L., Hyman, M. M., & Enterline, P. E. (1965). Cultural mobility and the occurrence of coronary heart disease. *Journal of Health and Human Behavior*, 178-189.
- Tanser, F., Gijsbertsen, B., & Herbst, K. (2006). Modelling and understanding primary health care accessibility and utilization in rural South Africa: an exploration using a geographical information system. *Social science & medicine*, 63(3), 691-705.
- Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches* (Vol. 46). Sage.
- Taylor, J. E., & Thilmany, D. (1993). Worker turnover, farm labor contractors, and IRCA's impact on the California farm labor market. *American Journal of Agricultural Economics*, 75(2), 350-360.
- Tedders, S. H., Schafer, E., Eveland, A. P., Dever, G. A., & Vogel, R. L. (1998). Some physician perceptions of migrant and seasonal farm worker health in 45 rural Georgia counties. *Journal of Agromedicine*, 5(3), 61-77.
- TerraSeer, Inc. (2006). ClusterSeer. Available: <http://www.biomedware.com>. Last accessed 7 May 2018.
- Thacker, S. B., & Buffington, J. (2001). Applied epidemiology for the 21st century. *International journal of epidemiology*, 30(2), 320-325.
- Thomas J., Avis, and Bradley P Carlin. (2003). Late detection of breast and colorectal cancer in Minnesota counties: an application of spatial smoothing and clustering. *Statistics in Medicine* 22, no. 1, pp. 113-127.
- Thomas-Bachli, A. L., Pearl, D. L., Berke, O., Parmley, E. J., & Barker, I. K. (2017). A geographic study of West Nile virus in humans, dead corvids and mosquitoes in Ontario using spatial scan statistics with a survival time application. *Zoonoses and public health*, 64(7).
- Thompson Jr, C. D., & Wiggins, M. F. (Eds.). (2009). *The human cost of food: Farmworkers' Lives, labor, and Advocacy*. University of Texas Press. Austin, TX.
- Tobler, W. R. (1970). A computer movie simulating urban growth in the Detroit region. *Economic geography*, 46(sup1), 234-240.

- Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition*, 23(11), 887-894.
- Townsend, M. S., Peerson, J., Love, B., Achterberg, C., & Murphy, S. P. (2001). Food insecurity is positively related to overweight in women. *The Journal of nutrition*, 131(6), 1738-1745.
- Trichopoulos, D. (1990). Hypothesis: does breast cancer originate in utero? *Lancet*; 335: 939 – 40.
- Turnbull, B. W., Iwano, E. J., Burnett, W. S., Howe, H. L., & Clark, L. C. (1990). Monitoring for clusters of disease: application to leukemia incidence in upstate New York. *American Journal of Epidemiology*, 132(suppl), 136-143.
- Turnbull, J., Martin, D., Lattimer, V., Pope, C., & Culliford, D. (2008). Does distance matter? Geographical variation in GP out-of-hours service use: an observational study. *Br J Gen Pract*, 58(552), 471-477.
- United States Bureau of Labor Statistics 2014 - <http://www.bls.gov/ooh/farming-fishing-and-forestry/agricultural-workers.htm#tab-7>. Last accessed: May 20, 2017.
- United States Census Bureau (American Fact Finder) (2010) http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_1YR_B02005&prodType=table. Last accessed: May 31, 2017.
- United States Census Bureau (American Fact Finder) (2010) City of Los Angeles - https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml. Last Accessed: May 31, 2017.
- United States Department of Agriculture. (2016). <http://www.ers.usda.gov/topics/inthe-news/california-drought-farm-and-food-impacts/california-drought-crop-sectors.aspx>. (Last accessed: April 8, 2018).
- United States Department of Agriculture. (2012). “Census of Agriculture - County Profile: Ventura County.” www.nass.usda.gov/Publications/AgCensus/2012/Online_Resources/County_Profiles/California/index.php. Last accessed: 11/7/2018.
- United States Department of Health and Human Services. (1993). Guidelines for Primary Medical Care/Dental HPSA Designation. (Codified 42 CFR Chapter 1, Part 5) 1993. <http://bhpr.hrsa.gov/shortage/hpsas/designationcriteria/medicaldentalthpsaguidelines.html>. Last accessed: January 24, 2018.

- United States Department of Health and Human Services. (2014). *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. (Last accessed: 2018 May 13, 2018).
- United States Department of Labor, Office of the Assistant Secretary for Policy. (1991). *Findings from the National Agricultural Workers Survey (NAWS) 1989: A Demographic and Employment Profile of Perishable Crop Farm Workers*, Research Report No. 2, iv + 94 pp.
- United States Geological Survey. (2010). “High Plains Water-Level Monitoring Study (Groundwater Resources Program).” <https://ne.water.usgs.gov/ogw/hpwlms/physsett.html>. Last accessed: 11/7/2018.
- Ulin, P. R., Robinson, E. T., & Tolley, E. E. (2005). *Qualitative methods in public health*. San Francisco, CA: JosseyBass.
- University of Nebraska Medical Center. (2013). *Migrant Farmworker Health in Nebraska*. https://www.unmc.edu/publichealth/cscash/_documents/209675_Migrant%20Farmworkers%20Flyer_English_FINAL.pdf. (Last accessed: May 13, 2018).
- Uppaluri, C. R., Schumm, L. P., & Lauderdale, D. S. (2001). Self-reports of stress in Asian immigrants: effects of ethnicity and acculturation. *Ethnicity & disease*, 11(1), 107-114.
- Van Meter, K. C., Christiansen, L. E., Hertz-Picciotto, I., Azari, R., & Carpenter, T. E. (2008). A procedure to characterize geographic distributions of rare disorders in cohorts. *International journal of health geographics*, 7(1), 26.
- Vega WA, Amaro H. Latino outlook: good health, uncertain prognosis. (1994). *Annu Rev Public Health*, 15:39–67.
- Vega, W. A., Scutchfield, F. D., Karno, M., & Meinhardt, K. (1985). The mental health needs of Mexican-American agricultural workers. *American Journal of Preventive Medicine*, 1(3), 47-55.
- Vega, W., Warheit, G., & Palacio, R. (1985). Psychiatric symptomatology among Mexican American farmworkers. *Social Science & Medicine*, 20(1), 39-45.
- Villarejo D, Lighthall D, Bade B., et al. (2000). *Suffering in Silence: A Report on the Health of California’s Agricultural Workers*. Woodland Hills, CA: The California Endowment; 2000. Available at: www.calendow.org. Last accessed November 21, 2016.

- Villarejo, D. (2003). The health of US hired farm workers. *Annual Review of Public Health*, 24(1), 175-193.
- Villarejo, D., McCurdy, S. A., Bade, B., Samuels, S., Lighthall, D., & Williams, D. (2010). The health of California's immigrant hired farmworkers. *American journal of industrial medicine*, 53(4), 387-397.
- Villermé, L. 1840. *Tableau d'Etat Physique et Moral des Ouvriers*, Vol 2. Paris: Renouard.
- Virchow, R. L. K (1848/1985). *Collected essays on public health and epidemiology* (Vol. 1). Science History Publications, USA.
- Waldinger, R., & Bozorgmehr, M. (Eds.). (1996). *Ethnic Los Angeles*. Russell Sage Foundation.
- Wallenstein, S. (2009). Joseph Naus: Father of the scan statistic. In *Scan Statistics* (pp. 1-25). Birkhäuser Boston.
- Waller, L. A., & Gotway, C. A. (2004). Spatial clustering of health events: regional count data. *Applied Spatial Statistics for Public Health Data*, 200-271.
- Walsh, R. (2011). Lifestyle and mental health. *American Psychologist*, 66(7), 579.
- Wan, N., Zhan, F. B., Zou, B., & Chow, E. (2012). A relative spatial access assessment approach for analyzing potential spatial access to colorectal cancer services in Texas. *Applied Geography*, 32(2), 291-299.
- Wan, N., Zou, B., & Sternberg, T. (2012). A three-step floating catchment area method for analyzing spatial access to health services. *International Journal of Geographical Information Science*, 26(6), 1073-1089.
- Wang, Fahui, John Hartmann, Wei Luo, and Pingwen Huang. (2006). "GIS-based spatial analysis of Tai place names in southern China: an exploratory study of methodology." *Geographic Information Sciences* 12, no. 1, pp. 1-9.
- Waugh, A. (2006). *The Missing Link-Transportation in Political Ecology: The Case of the Interstate Highway System*. Macalester College.
- Waxweiler, R. J., Stringer, W., Wagoner, J. K., Jones, J., Falk, H., & Carter, C. (1976). Neoplastic risk among workers exposed to vinyl chloride. *Annals of the New York academy of Sciences*, 271(1), 40-48.
- Webb, E. J., Campbell, D. T. (1966). *Unobtrusive measures: Nonreactive research in the social sciences* (Vol. 111). Chicago: Rand McNally.

- Weigel, M. M., Armijos, R. X., Hall, Y. P., Ramirez, Y., & Orozco, R. (2007). The household food insecurity and health outcomes of US–Mexico border migrant and seasonal farmworkers. *Journal of Immigrant and Minority Health*, 9(3), 157-169.
- Welch, H. G., Larson, E. B., & Welch, W. P. (1997). Could distance be a proxy for severity-of-illness? A comparison of hospital costs in distant and local patients. *Health services research*, 28(4), 441.
- Weller, S. C., Baer, R. D., de Alba Garcia, J. G., & Rocha, A. L. S. (2008). Susto and nervios: Expressions for stress and depression. *Culture, Medicine, and Psychiatry*, 32(3), 406-420.
- White, K., Haas, J. S., & Williams, D. R. (2012). Elucidating the role of place in health care disparities: the example of racial/ethnic residential segregation. *Health services research*, 47(3pt2), 1278-1299.
- Wilkinson, R. G., & Marmot, M. (Eds.). (2003). *Social determinants of health: the solid facts*. World Health Organization.
- Wills, R. (1998). *Human instincts, everyday life, and the brain: a paradigm for understanding behavior*. Charlottetown: N.P. University of Prince Edward Island.
- Wong, L. Y., Heng, B. H., Cheah, J. T. S., & Tan, C. B. (2012). Using spatial accessibility to identify polyclinic service gaps and volume of under-served population in Singapore using Geographic Information System. *The International journal of health planning and management*, 27(3).
- Wylie, John L., Teresa Cabral, and Ann M. Jolly (2005). "Identification of networks of sexually transmitted infection: a molecular, geographic, and social network analysis." *Journal of Infectious Diseases* 191, no. 6, pp. 899-906.
- Yankauer, A. (1950). The relationship of fetal and infant mortality to residential segregation: an inquiry into social epidemiology. *American Sociological Review*, 15(5), 644-648.
- Yeates, M. H. (1968). *An introduction to quantitative analysis in economic geography* (No. HF1025 Y4). New York, McGraw-Hill, p. 182.
- Yen, I. H., & Syme, S. L. (1999). The social environment and health: a discussion of the epidemiologic literature. *Annual review of public health*, 20(1), 287-308.
- Zhang, X., Lu, H., & Holt, J. B. (2011). Modeling spatial accessibility to parks: a national study. *International Journal of Health Geographics*, 10(1), 31.
- Zhou, B. F. (2002). Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *Biomedical and environmental sciences: BES*, 15(1), 83-96.

Zimmerman, C., Kiss, L., & Hossain, M. (2011). Migration and health: a framework for 21st century policy-making. *PLoS medicine*, 8(5), e1001034.

Zorbaugh, H. W. (1929). *The gold coast and the slum* (Vol. 227). Chicago: University of Chicago Press.

Zwar, N., Harris, M., Griffiths, R., Roland, M., Dennis, S., Powell Davies, G., & Hasan, I. (2006). A systematic review of chronic disease management.