Correlating Food Environment with COVID-19 across Wyoming to better Understand the Disproportionate Impacts of the Pandemic

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Learning Actively Mentoring Program

UNIVERSITY OF WYOMING

Learning Actively
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Project Summary:

Food inaccessibility is often disproportionate, leaving marginalized communities as the most impacted. Access to diets consisting of energy-rich, nutrient-poor foods have been shown to be linked with metabolic disorders like obesity and hypertension, and these comorbidities have implications to severe COVID-19 complications. In addition to chronic disease, food insecurity can be a considerable issue for children, as they need proper nutrition and access to food for healthy development. Many children in food insecure households rely on government food and nutrition assistance programs. With necessary closures to limit the pandemic, these food networks have experienced interruptions. Moreover, Fremont County, Wyoming, is specifically experiencing an inequitable share of COVID-19 hospitalizations and deaths. In rural and frequently understudied states like Wyoming, a further study is needed to illuminate if there is a connection between food access and acute COVID-19 infections. There is also not much information on how pandemic shutdowns affected children in food insecure households in Wyoming. Through a county-specific data analysis of Wyoming, the goal of this research is to elucidate the connections between the food environment, obesity, and the outcome severity of COVID-19 infections. Another goal is to better understand the disproportionate impacts of the current pandemic on Fremont County.

We propose that Wyoming counties which have a more-limited access to food will also have higher obesity rates (Body Mass Index $\geq$ 30) and more-severe COVID-19 outcomes. Due to COVID-19 shutdowns, we hypothesize that nutritionally poor environments and dysfunctional food networks positively correlate with a higher prevalence of chronic and acute diseases, including COVID-19 outcomes. We also hypothesize that participation in dietary supplementation programs and home gardening initiatives negatively correlate with acute and chronic disease hospitalization rates, also including COVID-19 hospitalization and mortality rates.

We will work collaboratively with our community partner, the Wyoming Public Health Lab (WPHL), to gather county-based data regarding chronic and infectious diseases. We will obtain food environment data from USDA ERS and Feeding America, and detailed demographic data from the Wyoming Department of Health Equity. By reading these data into R, we will be able to determine if there are statistically significant correlations between COVID-19 hospitalization and mortality rates, food access, diet, and participation in community dietary

supplement and home gardening programs. In addition, we will create and share educational resources to inclusively communicate our findings with Wyoming health agencies, Fremont County, and our community partners and stakeholders to better support current food initiatives and nutritional supplementation programs, like school lunch programs.

Intellectual Merit: By creating statistical comparisons to the state of Wyoming, and individual Wyoming counties, this research will help to clarify how limited access to nutritional foods correlates with chronic conditions like obesity and with the outcome of COVID-19 infections. This work could support future inquiry into the interfaces between COVID-19, other chronic conditions, such as stress and hypertension and nutritional environment. It will also bring a better understanding of why Fremont County, which encompasses the Wind River Indian Reservation (WRIR), has been disparately affected by COVID-19. Very little research has investigated correlations between food networks, food aid programs, diet, and COVID-19 outcomes in rural states; this research could guide similar studies in other rural territories, both locally and globally. Findings could be used to inform and incentivize preventative medicine through diet.

Broader Impacts: In doing this research as an undergraduate cohort, it provides an opportunity to foster uplifting, academic relationships with peers, mentors, community partners, stakeholders, and a local community. It also instills the fundamental and ethical importance of environmental justice through scientific research. In designing our informative presentation with interactive visuals, we will provide inclusively accessible data that supports and attracts current and future sustainable food initiatives. This study could also be used to showcase how nutritious food is important to a developing child's health and how the overall gut microbiome is important to general health and building immunity. Furthermore, we will provide educational outreach opportunities on how nutrient-dense, locally grown, and culturally relevant foods positively impact the gut-brain axis of the human microbiome. Being able to educate about food insecurity as an associated risk factor for many chronic and acute health conditions, including COVID-19 severity, is a way to constructively impact the overall health of any disadvantaged community. This project is also informed by a participatory action research model that would ultimately lead to increased liberation, indigeneity, sovereignty, and cultural restoration on the WRIR.

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Project Description

Statement of Problem & Significance

Food insecurity and access to food that is nutritious, affordable, and economically sustainable is inequitable, often leaving underprivileged individuals in food deserts or food mirages (Burman, 2020). The lack of obtaining healthy provisions, access to low-quality fruits and vegetables, and essential diets consisting of energy-rich, nutrient-poor foods promote poor-health outcomes like obesity, diabetes, and hypertension (high blood pressure) (Love et al., 2018). Furthermore, an unhealthy diet or a diet lacking nutrients has been linked to poor mental and physical health (Schwartz & Rothbart, 2019). The COVID-19 pandemic has caused many food network disruptions across the country, including interruptions in public-school food networks. The National School Lunch Program (NSLP) and the School Breakfast Program provide free or reduced-price meals for low-income children. For these children facing food insecurity, school-provided meals may be the only source of healthy food available to them. Additionally, when household income is changed or lost, affording healthy food becomes more difficult. A survey done in June 2020 showed an increase in food insecurity beginning in March, at the start of the shutdowns (Patrick et al., 2020). Parental job loss or furlough, in addition to school-provided meal program suspensions during shutdown, may have caused this increase.

The presence of specific pre-existing conditions and chronic illnesses greatly predict the likelihood of experiencing severe complications due to COVID-19. Because groups with a lower socioeconomic status and minority ethnic background face a higher prevalence of chronic diseases like obesity, they may also face a disproportionate and increased risk for severe illness and death from COVID-19 (Vas et al. 2020). This project was inspired by community partners that have addressed concerns that COVID-19 is inequitably affecting Wyoming, and that COVID-19-associated hospitalization rates are the highest among Native Americans (Porter & Hull, 2020). Nowhere are these concerns more alarming than Fremont County. This central-western county is an area that includes the Wind River Indian Reservation (WRIR). As of August 8, 2020, the age-adjusted hospitalization rates associated with COVID-19 are highest amongst Native Americans (CDC, 2020). This is not because Native Americans are incautious; this is a direct result of facing a multitude of health disparities on a daily basis. Some of these include diabetes, hypertension, chronic liver disease, polluted soil and air, lack of access to

affordable healthy foods and healthcare, overrepresentation in essential worker positions, and general lack of opportunities (Alcendor, 2020). Though Native Americans only make up 2% of the Wyoming state population, as of June 25, 2020, they represented 45% of the total deaths experienced in the state. Even before COVID-19 arose, Native Americans living on the WRIR had been shown to have a 16-year age gap in the life expectancy compared to a typical white individual living in Wyoming (Wyoming Office of Health Equity, 2020).

Very little research has investigated correlations between food access, diet, and COVID-19 outcomes in rural states like Wyoming. By comparing county-specific data regarding food accessibility and food networks, and chronic diseases like obesity, we aim to better illuminate correlations with COVID-19 morbidity and mortality rates, and to better understand the disproportionate impacts on Fremont County and the WRIR. This research could guide similar studies in other rural territories, both locally and globally. Findings could be used to inform and incentivize preventative medicine through diet.

Introduction

Relevant Literature

According to the USDA, "food insecurity is a household-level economic and social condition of limited or uncertain access to adequate food" (USDA ERS, 2020), and in 2018, insecurity affected more than 14.3 million households and 11 million children in the US (Feeding America, n.d.). Wyoming, a rural state, has the prevalent issues of food deserts and food mirages, which indicate a limited access to healthy foods and to culturally appropriate foods, respectively. Consistent access to nutritious food is one of the largest contributors to food insecurity and it is associated with an increased risk for obesity, type II diabetes, cardiovascular risk factors, and some cancers (Berryhill et al., 2018). In 1997, the World Health Organization (WHO) recognized that obesity was becoming a global health problem (James, 2008), and it continues to be a major contributor to the global burden of chronic disease and disability (WHO, 2020). With obesity, the deregulation of glucose and insulin resistance triggers diabetes, and the lack of salt homeostasis initiates hypertension. People of any age with specific underlying medical conditions have an increased risk of severe illness from COVID-19 comorbidity, and obesity, diabetes, and hypertension have all been implicated to increase this risk (CDC, 2020).

A healthy, varied diet that is rich in nutrients also fosters a diverse gut microbiome. The microbiome is a delicate balance of microbial communities that synergistically work with our own cells to make necessary products by competing with pathogenic bacteria to digest nutritional resources. Low gut microbiome diversity increases the risk of obesity, depression, and anxiety. Therefore, loss, gain, and retention of microbes directly affects a person's overall health (Ishaq et al., 2019). This is particularly important in children for healthy development and for the prevention of chronic health conditions, colds and stomachaches, impairment in math and reading skills, and iron deficiency (Ralston et al., 2017). According to the Wyoming Hunger Initiative, 36.42% of children participated in school lunch programs in Wyoming in 2019 (Wyoming Hunger Initiative 2019).

Other chronic diseases like prolonged stress and high cortisol levels are linked to metabolic-related conditions like type II diabetes and obesity because cortisol increases blood sugar and insulin resistance. Increased stress levels are sensed by the hypothalamus which secretes corticotropic releasing hormone (CRH) onto the pituitary gland. CRH makes adrenocorticotropic hormone (ACTH), which stimulates the adrenal gland to make cortisol (Alcendor, 2020; Carabotti et al., 2015). In addition, ACTH also stimulates the adrenal gland to release the hormone aldosterone which increases sodium, and subsequently water retention in the body, leading to increase in blood volume. Aldosterone is involved in the last steps of the renin-angiotensin-aldosterone system (RAAS) pathway and leads to an increase in blood pressure. SARS-CoV-2 infection also leads to an activation of the RAAS pathway due to the spike proteins being able to fit into and exploit angiotensin converting enzyme-2 (ACE-2) receptors to infect and multiply within host lung cells. This drop in ACE-2 availability causes a buildup of angiotensin II (ANG-II), which leads to hyper-activation of the RAAS pathway and severely increased blood pressure (Alcendor, 2020). Because SARS-CoV-2 leads to an increase in blood pressure, those individuals already experiencing hypertension, due to stress or otherwise, experience a worsened impact of COVID-19.

The SARS-CoV-2 virus may also gain selective entry to host cells via the ACE-2 receptors on adipose cells which leads to cell-damaging effects and the reduction of pancreatic beta-cell function and increased insulin resistance (Kassir, 2020; Vas et al., 2020). This results in adipose tissue inflammation, and possibly an improper immune response. In addition, adipose tissues have high ACE-2 receptor expression and obese individuals have larger adipose cells,
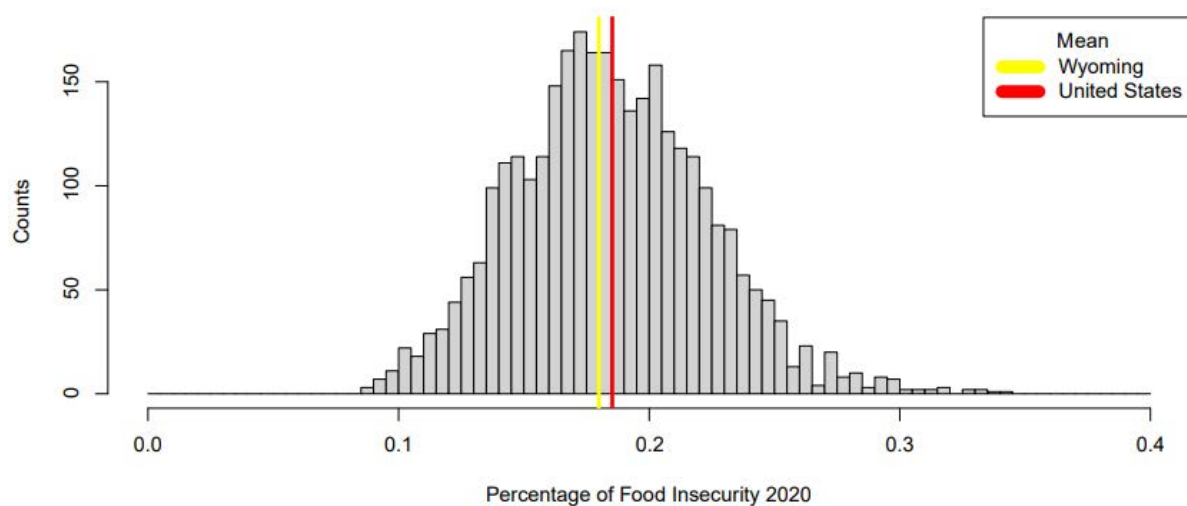
leading to a higher amount of ACE-2 membrane expression in obese individuals (Kassir, 2020). Cortisol also effects the immune system by decreasing antibody production, increasing cytokine-induced inflammation, and decreased autophagy, which results in overgrowth of unhealthy bacteria and dead cell matter. When healthy probiotic bacteria are absent from the gut, there is an impaired ability to control the growth of disease-causing bacteria. If the gut microbiome population is adequate and healthy, it makes life for pathogenic bacteria difficult to sustain (Kane et al., 2015). This is further complicated by the gut-brain axis, a bidirectional pathway between the GI tract and the nervous system, which allows an interplay between the products made by gut microbiota and neural signals (Carabotti et al., 2015). Interestingly, the old phrase "you are what you eat" is gaining a new dimension of merit with our understanding of the microbiome. Obesity, diabetes, and hypertension almost always coexist, and as a COVID-19 comorbidity, they can lead to significant health disparities (Love et al., 2018).

These chronic diseases are also highly prevalent in Native American communities (Berryhill et al., 2018). Daily chronic stress experienced by many Native Americans corroborates these factors. Racism embedded into everyday society has caused chronic cortisol release (L'Dawn Olsen & Chesie Lee, zoom meeting, 2020; NIHCM, 2020). On top of physiological changes, this has led to loss of food sovereignty and food indigeneity, which has also led to high rates of depression and anxiety in Native Americans (Berryhill et al., 2018). These daily chronic stressors combined with historical trauma-induced epigenetic changes lie at the root of many health disparities experienced by Native Americans today, making this population particularly vulnerable to COVID-19. In addition, access to affordable, culturally appropriate, healthy food is a challenge for many Native Americans living on Western Indian Reservations. Native Americans were traditionally hunters and used the land to cultivate crops, and thus mainly consumed plant-based diets supplemented with low-fat meats and fish (Bauer et al., 2012; O'Connell et al., 2012). Today however, Native Americans living on reservations often rely on food assistance programs and they mainly purchase fast-foods or shop small convenient or grocery stores, which typically have limited and more-costly access to high-quality produce and low-fat foods (Bauer et al., 2012; Berryhill et al., 2018). When race ethnicities are pushed to live in specific locations, such as Native American reservations, marginalization can be mapped by geographic areas (Bauer et al., 2012). Here, we can geographically see socioeconomic status disproportionately affect access to nutritional food and the prevalence of certain diseases (Bauer

et al., 2012, Melvin et al., 2020; Vas et al., 2020). Thus, examining food access using a geographic (county-by-county) approach will enable us to identify regions of marginalization.

Preliminary Work and Researcher Standpoint

While many conflate rurality with agricultural abundance, data show that food insecurity is as big of a problem in Wyoming as it is in the broader United States. Below is a histogram generated by our research team using the *2020 Map the Meal* data set from Feeding America.
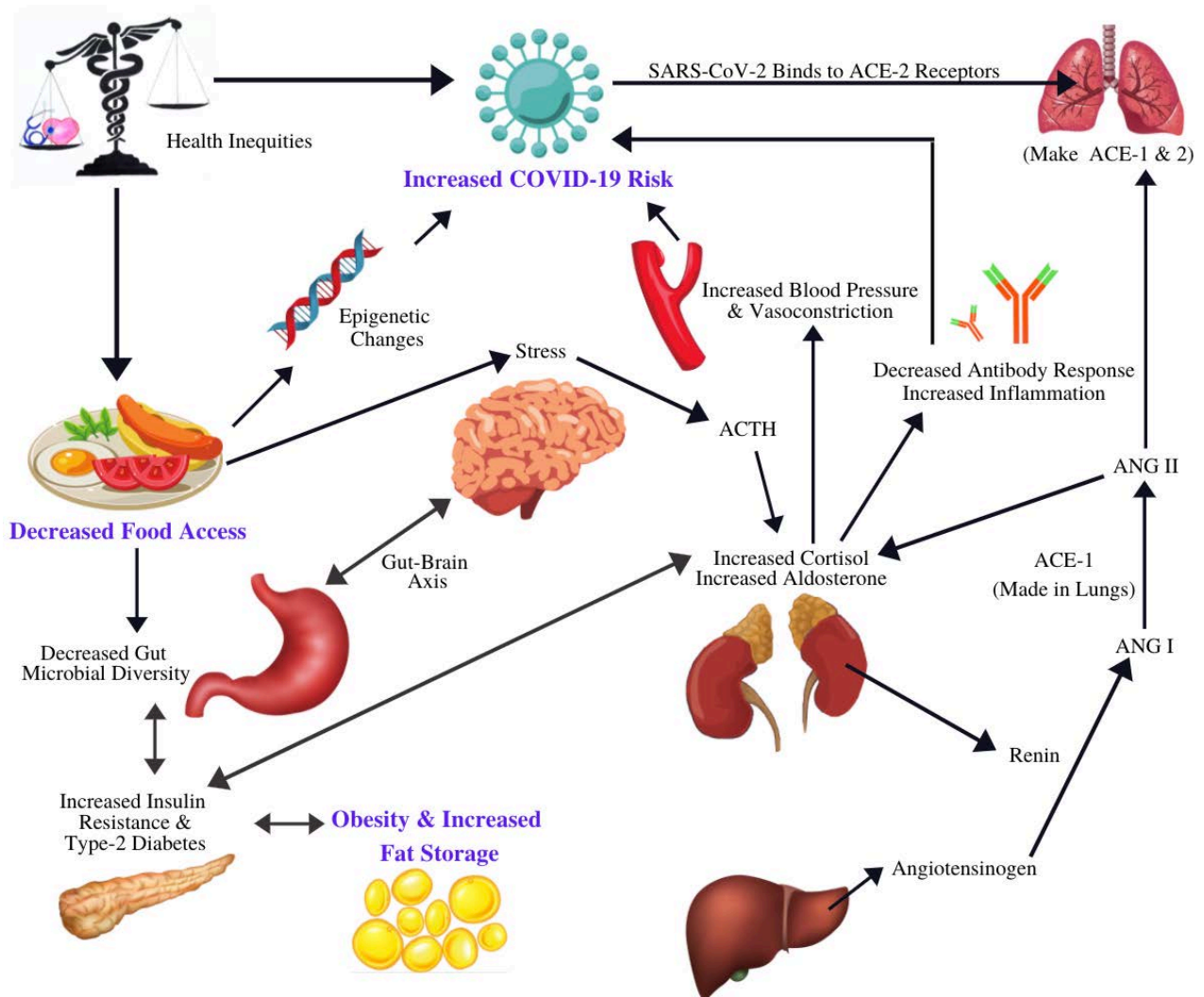

Through the attendance of meetings with community members in Fremont County, we found that the problems related to acute and chronic health disparities are numerous. One overarching problem is accessibility to nutritious foods (Alma Law, zoom meeting, September 14, 2020; L'Dawn Olsen, zoom meeting, September 30, 2020). However, other issues include the loss of ancestral diet, historical trauma, current prejudice, racism (L'Dawn Olsen, zoom meeting, September 30, 2020), access to healthcare, and violence and domestic abuse (Alma Law, zoom meeting, September 14, 2020). Addressing food access alone will be beneficial, but inequitable food access and chronic and acute health disparities are all complex issues and will require an intricate, transdisciplinary resolution.

In our meeting with the representatives from the Riverton Peace Mission, a quote by Lilla Watson was shared, "If you have come here to help me, you are wasting your time. But if you have come because your liberation is bound up with mine, then let us work together" (L'Dawn

Olsen, zoom meeting, September 30, 2020). While our team does not identify as Native, we do believe that there needs to be more diverse representation in science. Our research team has varying motivations for social justice work, ranging from queer and disabled identities, to non-Native minority backgrounds, to general allies for food sovereignty. Our mission statement is, "To provide educational resources that supports Fremont County & WRIR food initiatives to decrease health disparities and promote food sovereignty," and our collective liberation depends on healing trauma that our systems have created. We, as a society must understand the stark, deadly consequences of prolonged inequities over many generations. In addition, we must begin to prioritize other ways of knowing than just traditional bench top scientific knowledge. Incorporation of indigenous knowledge will lead to more relevant, just, and effective solutions to combat wicked problems. There are already several grassroots, Native-led food justice movements on the WRIR that have shown promising results. Our goal is to highlight these positive stories and showcase how solutions are already being created through their cultural values of community, indigeneity, and sovereignty.

Conceptual Model

There is a very complex interplay between multiple aspects that affect human physiology and the potential to exacerbate COVID-19. However, our research will center our focus on food access, obesity, and COVID-19 outcomes.

Justification of Approach

Our research will be led by the virtues of participatory action research (PAR) to keep the voices of those who are most affected at the forefront of this project. The PAR model is a collective commitment to investigate a problem, a desire to engage in constant team and self-reflection, a joint decision to engage in collective action that leads to a useful solution that benefits the people involved, and the building of relationships between researchers and participants in the planning, implementation, and dissemination of the research process (McIntyre, 2008).

Regarding data acquisition, one free, easy, and effective screening tool for generally assessing obesity and metabolic abnormalities is the BMI calculator (CDC, 2020; James, 2008). BMI has also been supported to show utility in identifying patients at high risk of severe COVID-19 (Alkhatib et al., 2020). After obtaining data sets, they will be read into R for analysis. R is a scientifically powerful programming language that was primarily developed for statistical analysis. It is an accessible open-source software, it is free, and any individual can inspect it and report errors to decrease the chance of mistakes. The coding required for use can be saved to efficiently share or repeat analyses. R also works well for almost any specific data set need because many packages are available that extend the capabilities for analysis and the creation of advanced graphics (RShiny). ArcGIS StoryMaps is another powerful graphic-generating software that will be used because it connects the use of stories to give the maps significant meaning. The use of advanced graphics and the ability to connect it with a positive story will harmonize with our objective in creating a presentation that respects the cultural values of an impacted community.

Research Plan

Objectives

o To better understand the relationships between food environment, diet, obesity, and the outcome severity of COVID-19 in Wyoming.
o To better understand how COVID-19 has impacted school-provided meals and food insecurity regarding children in low-income and impoverished households in Wyoming.
o To better understand why Fremont county and the WRIR are being inequitably affected by COVID-19.

o To determine if access to locally grown produce (through existing dietary supplement and food justice programs) on the WRIR is associated with multifaceted improvement to overall health.

o Through outreach, to engage and provide our stakeholders, including the Wyoming Public Health Lab, WRIR, Riverton Peace Mission, Fremont County Public Schools, and the Fremont County communities, with information and data visuals that work to attract investors to support existing food and health justice initiatives.

o To create information that is culturally mindful and aligns with the values of those most inequitably affected.

Hypotheses

H1: Wyoming counties with more food inaccessibility, as defined by Feeding America, and poorer diets will positively correlate with more chronic diseases and more COVID-19 morbidity and mortality.

H2a: Food insecurity will be greater from March to August 2020 than before the COVID-19 shutdowns for low-income and impoverished households.

H2b: School-provided meals through programs like the National School Lunch Program and the School Breakfast Program increase food security in children from food-insecure households.

H3a: Native American living in Wyoming are disproportionately affected COVID-19, and these disproportionate frequencies will increase for Fremont County as compared to the rest of Wyoming.

H3b: Native Americans living in Wyoming who are currently involved in community-based gardening and/or food distribution programs have a lower prevalence of COVID-19.
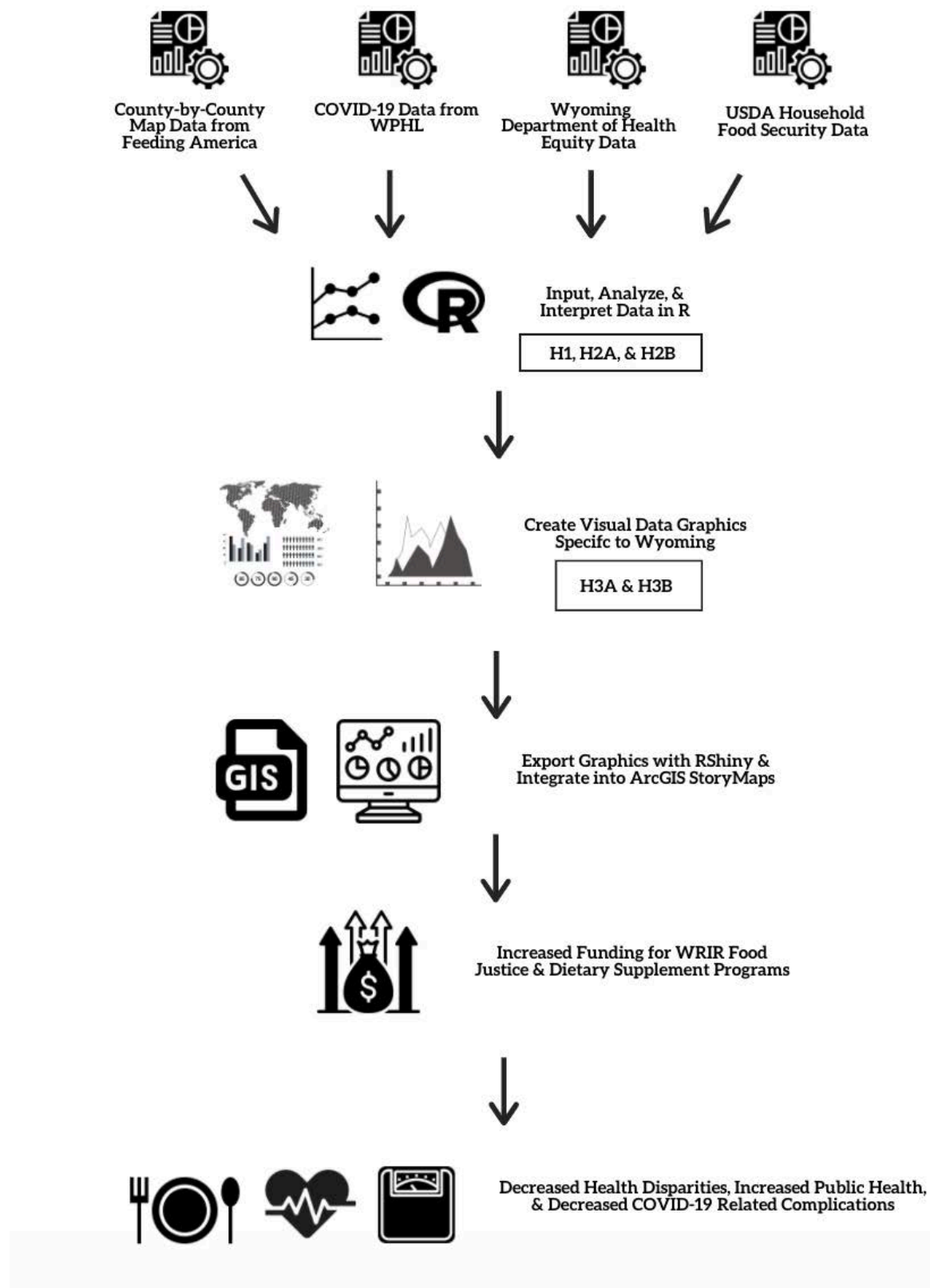
Specific Aims

o To identify associations between food environment, diet, obesity, and COVID-19 outcomes, we will acquire food inaccessibility data from the USDA ERS and Feeding America databases. We will acquire county-specific obesity (BMI) and COVID-19 data by utilizing the WPHL's chronic and infectious disease database and through personal communications.

o We will also be using data sets from USDA ERS, Feeding America, and WPHL to identify associations between food insecurity, school-provided meals, children in low-income and impoverished households, and the effects of pandemic on food access.

o We will gather pre-COVID data sets to be able to compare to food accessibility, food networks, and school-provided meals regarding post-COVID changes.

o We will gather data to determine if there are statistically significant improvements in pre-existing health conditions, COVID-19 hospitalization, and general mortality rates after participation in community and home gardening programs.

o We will read data into R and perform ANOVA tests, t-tests, regression models, structural equation models, and mixed effects models to assess correlations between food access, diet, obesity, school-provided lunch, and COVID-19 data. We will then overlay these data onto maps to visualize geographic distribution.

o We will use RShiny/ArcGIS software to create interactive visuals that will be uploaded to the Wyoming Department of Health's website that can be accessed by the general public.

Project Timeline

Week/Date	Tasks
Preliminary Phase: Initial Stakeholder Meeting August 24, 2020	• Meet with Dr. Hull (Microbiology Laboratories Manager at Wyoming Public Health Lab) • Meet with Dr. Porter (Researcher for Growing Resilience)
Preliminary Phase: Data Acquisition August 24, 2020 – September 24, 2020	• Feeding America's 2013-2020 Map the Meal Gap data was requested on September 14, 2020 and received on September 21, 2020 • Wyoming Department of Health Equity demographic data • Meeting with Alma • Meeting with Riverton Peace Mission
Day 2: October 5, 2020	Application phase begins
Week 1: October 11-17	• Acquire additional diet data • Enter data into R • Acquire relevant literature • Turn in Team Proposal Draft
Week 2: October 18-24	• Research appropriate analysis for our data: Hierarchical Linear Regression, Structural Equation Modeling, ANOVA • Enter any additionally acquired data into R • Begin data analysis via R • Discuss analysis with our Data Specialists
Week 3: October 25-31	• Begin learning R, ShinyApp, and ArcGIS • Data analysis: continued • Begin building data visualizations • Meet with Data Specialists again: visual and statistical guidance
Week 4: November 1-7	• Begin making ArcGIS StoryMap • Telling Our research proposal story • Finalize data analysis
Week 5: November 8-14	• Finish sections of proposal draft: • Results and Discussion • Reference Annotations • Finalize data visuals
Week 6: November 15-21	• Review Rubric and feedback • Final edits
Week 7: November 22-28	• End of Application Phase • Integration and Pre-Presentation
Final Day: December 10th, 2020	Final Virtual Showcase 3:30-5:00 pm

Design Schematic

County-by-County
Map Data from
Feeding America

COVID-19 Data from
WPHL

Wyoming
Department of Health
Equity Data

USDA Household
Food Security Data

Input, Analyze, &
Interpret Data in R

H1, H2A, & H2B

Create Visual Data Graphics
Specifc to Wyoming

H3A & H3B

GIS

Export Graphics with RShiny &
Integrate into ArcGIS StoryMaps

Increased Funding for WRIR Food
Justice & Dietary Supplement Programs

Decreased Health Disparities, Increased Public Health,
& Decreased COVID-19 Related Complications

Methods & Materials

Our research team has combined expertise ranging from epidemiology and computational biology, to racial justice and traditional storytelling. Our work will be done with constant consultation from our community partners at the WPHL and Riverton Peace Mission. At the WPHL, we will be specifically working with Dr. Talbott, of the epidemiology unit, and Dr. Hull, the Microbiology Laboratories Manager. We have two subject matter expert graduate students on our team. Sierra Jech, a PhD student in CU Boulder's Ecology and Evolutionary Biology Department, specializes in interdisciplinary quantitative biology. Ella DeWolf, MS student in the University of Wyoming's Botany Department, specializes in R and data visualization. Our environmental justice expert, Dr. Porter, a University of Wyoming Associate Professor in the Division of Kinesiology & Health and Wyoming Excellence Chair in Community & Public Health, is also a collaborative partner for our research. At the Riverton Peace Mission, we are working closely with L'Dawn Olsen and Chesie Lee. L'Dawn is an Eastern Shoshone tribal descendant and the Equity and Inclusion Specialist for the Wyoming Coalition Against Domestic Violence and Sexual Assault, and Chesie is the contact representative for the Riverton Peace Mission and a racial justice accomplice.

After acquiring county-specific obesity (BMI) and COVID-19 data by utilizing the WPHL's chronic and infectious disease database, and food inaccessibility data from the USDA ERS database and Feeding America database, we will read our data into R for analysis. Past research has shown utility in regression modeling regarding food insecurity and COVID-19 outcomes (Alkhatib et al., 2020; Bauer et al., 2012; Berryhill et al., 2018). Regression analyses will be performed to examine the correlations between food access and obesity (BMI), and food access and COVID-19 outcomes. Mixed effects models and structural equation modeling will be used to analyze the networks between these factors, and to control for variables like age or population density. Chi-squared tests will be performed to test how likely it is that an observed distribution is due to chance. By comparing county-specific data, we will be able to look for Wyoming correlations and then see how Fremont County and the WRIR specifically compare.

Analysis & Expected Results

Data analysis will be performed through the creation of Microsoft Excel tables, which will be saved as .csv files, and read into R. We will store our coding data on a GitHub repository

and our sensitive demographic data on a secure form of Google Drive. We will have our data readily accessible for our community partners and collaborators.

Table 1 illustrates the expected and unexpected outcomes for our research. The unexpected outcomes also have concepts that we propose would lead to the outcome.

Table 1: Expected & Unexpected Results of Wyoming vs. Fremont County Chi Square Test Comparing Variables to COVID-19 Hospitalization and Mortality Rates

	Wyoming	*Fremont County*
Pre-Existing Health Conditions & Chronic Illness	*Expected:* Higher incidence of pre-existing health conditions and chronic illness will directly correlate to higher COVID-19 hospitalization and mortality rates. *Unexpected:* Lower incidence of pre-existing health conditions and chronic illness will directly correlate to no change in or higher COVID-19 hospitalization and mortality rates. This may be due to geographic isolation of the chronically ill population.	*Expected:* There will be disproportionately higher levels of pre-existing health conditions and chronic illness and a disproportionately higher risk of COVID-19 complications in Fremont County than in the broader statewide community. *Unexpected:* There will be no difference or lower levels of pre-existing health conditions and chronic illness and disproportionately lower risk of COVID-19 complications in Fremont County than in the broader statewide community. This result may be due to COVID-19 cases being under reported in the county.
Race and Ethnicity	*Expected:* People who self-identify as Native American will have higher rates of COVID-19 than expected in relation to the demographic proportion that they occupy *Unexpected:* People who self-identify as white will have higher rates of COVID-19 than expected in relation to the demographic proportion that they occupy. This result may be due to the presence of pre-existing health conditions in the self-identified white population.	*Expected:* People who self-identify as Native American will have disproportionally higher rates of COVID-19 than expected in Fremont County in relation to the demographic proportion that they occupy when compared to the broader statewide community. *Unexpected:* People who self-identify as white will have higher rates of COVID-19 than expected in relation to the demographic proportion that they occupy. This may be due to pre-existing health conditions in the self-identified white population.

Access to Culturally Appropriate, Affordable, & Healthy Food	*Expected:* Access to nutritious and culturally appropriate food will directly correlate with lower rates of COVID-19. *Unexpected:* Access to nutritious and culturally appropriate food will have no impact on or worsen the overall health and risks associated with COVID-19. This result may be due to lack of access to nutritious and culturally appropriate foods.	*Expected:* Access to nutritious and culturally appropriate food in Fremont County will have a disproportionate impact on lowering COVID-19 severity than in the broader statewide community. *Unexpected:* Access to nutritious and culturally appropriate food in Fremont County will have no impact on lowering COVID-19 severity compared to the broader statewide community. This may be due to higher prevalence of pre-existing health conditions.
Participation in Food Justice Initiatives	*Expected:* Participation in local food initiatives will have a statistically significant impact on lowering COVID-19 severity. *Unexpected:* Participation in local food initiatives will have no impact on or worsen the overall health and risks associated with COVID-19. This may be due to food access through family members or participation in national food assistance programs instead of local initiatives.	*Expected:* Participation in local food initiatives in Fremont County have a disproportionately statistically significant impact on lowering COVID-19 severity than in the broader statewide community. *Unexpected:* Participation in local food initiatives in Fremont County worsens the overall health and risks associated with COVID-19. This result may be due to local food initiatives providing unhealthy food.
Socioeconomic Status and Poverty	*Expected:* Lower socioeconomic status will be directly correlated to significantly higher COVID-19 hospitalization and mortality rates. *Unexpected:* Lower socioeconomic status will be directly correlated to lower or unchanged COVID-19 hospitalization and mortality rates. This may be due to COVID-19 cases being under reported, or lack of access (financially or geographically) to hospitals.	*Expected:* Lower socioeconomic status in Fremont County will have a disproportionately statistically significant correlation to higher COVID-19 hospitalization and mortality rates. *Unexpected:* Lower socioeconomic status in Fremont County will be directly correlated to lower or unchanged COVID-19 hospitalization and mortality rates. This may be due to COVID-19 cases being under reported, or lack of access (financially or geographically) to hospitals.

References and Annotated Bibliography

Alcendor, Donald J. 2020. "Racial Disparities-Associated COVID-19 Mortality among Minority Populations in the US." *Journal of Clinical Medicine*, 9(8), 2442. doi: 10.3390/jcm9082442.

o *Accessed through the NCBI PubMed Database. There are many health disparities that predispose racial minority populations to higher risk of severe complications or death due to COVID-19 such as: diabetes, hypertension, cardiovascular disease, and chronic obstructive pulmonary disease. This article discusses the social determinants of each pre-existing condition and why they increase the risk of COVID-19 related complications, it proposes policies and societal models to help combat disparities, and it gives a really great diagrams of how each pre-existing condition effects the physiology of SARS-CoV-2 infection. Cited 1,548 times.*

Alkhatib, Ala L., Kreniske, Jonah, Zifodya, Jerry S., Fonseca, Vivian, Tahboub, Mohammad, Khatib, Joanna, Denson, Joshua L., Lasky, Joseph A., Lefante, John J., and Christine M. Bojanowski. 2020. "BMI is Associated with Coronavirus Disease 2019 Intensive Care Unit Admission in African Americans." *Obesity*.
https://doi.org.libproxy.uwyo.edu/10.1002/oby.22937

o *Accessed through Web of Science. This article found that age, higher BMI, and obstructive lung disease were associated with severe COVID-19 in an African American population. It also supported the utility of BMI in identifying patients at high risk for severe COVID-19.*

Bauer, Katherine W., Widome, Rachel, Himes, John H., Smyth, Mary, Rock, Bonnie H., Hannan, Peter J., and Mary Story. 2012. "High food insecurity and its correlates among families living on a rural American Indian Reservation." *American Journal of Public Health*, 102(7), 1346–1352. https://doi.org/10.2105/ AJPH.2011.300522

o *Accessed through NCBI. This article extended previous research in demonstrating a high occurrence of food insecurity among Native Americans and identified potential determinants and consequences of food insecurity such as fast-food consumption, convenient store use, and perception of barriers in food access that mainly reflect economic limitations.*

Berryhill, Kelly, Hale, Jason, Chase, Brian, Clark, Lauren, He, Jianghua, and Christine M. Daley. 2018. "Food Security and Diet Among American Indians in the Midwest." *Journal of Community Health*, 43(5), 901–907. https://doi.org/10.1007/s10900-018-0501-5

o *Accessed through NCBI. This article also extended previous research but found that regional data was more alarming than other available literature regarding low or very low food security. They found that there were significant differences in food security levels based on demographic variables ultimately linked to health characteristics and/or poverty.*

Burman, Erin. 2020. John Hopkins Center for a Livable Future. October 1st, 3pm.

o *Conducted over Zoom Video Conferencing. This presentation elucidated the differences between food deserts and food mirages. It also clarified the statistical relationships that can be addressed, how a lack of pertinent data affects them, and how to interpret statistical data concerning food environments and the prevalence of COVID-19.*

Carabotti, Marila, Scirocco, Annuziata, Maselli, Maria A., and Carola Severi. 2015. "The gut-brain axis: Interactions between enteric microbiota, central and enteric nervous systems." https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4367209/

o *Accessed via NCBI PMC database. This article defines the gut-brain axis and how it is bidirectional. Cited 632,000 times.*

Centers for Disease Control and Prevention (CDC). 2020. "Coronavirus Disease 2019 (COVID-19) Data Visualization." *U.S. Department of Health & Human Services*. https://www.cdc.gov/coronavirus/2019-ncov/covid-data/data-visualization.htm

o *Accessed through Riverton Peace Project. This resource shows a bar graph detailing the breakdown of COVID-19 hospitalization rates down by race. American Indian and Alaska Natives are the most likely to be hospitalized due to COVID-19 complications. This resource is pertinent to our research because it illustrates that this problem has a broad area of significance.*

Centers for Disease Control and Prevention (CDC). 2020. "Healthy Weight, Nutrition, and Physical Activity: About Adult BMI". *U.S. Department of Health & Human Services*. https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html

- *Accessed on the web. This page was pertinent because it gave the BMI calculation and suggested the use of BMI as a screening tool to generally assess normal weight, overweight, obesity, and the potential for metabolic disorders.*

Coleman-Jensen, Alisha, Rabbitt, Matthew P., Gregory, Christian A., and Anita Singh. "Household Food Security in the United States in 2019." Economic Research Report no. 275, *U.S. Department of Agriculture, Economic Research Service*, 2020.

- *Coleman-Jensen et al. 2020 was found on the United States Department of Agriculture's Economic Research Service website, under the topic "Food Insecurity". This document discusses food insecurity in America for the year of 2019. The authors gathered data using surveying methods and data from the Census. This source provides recent information on food insecurity before the COVID-19 pandemic, as well as information about household participation in nutrition programs.*

Feeding America. n.d. "Hunger in America." Accessed September 30, 2020. https://www.feedingamerica.org/hunger-in-america

- *Accessed on the web. This webpage was pertinent because it had broad statistics concerning food insecurity in America.*

Ishaq, Suzanne L., Rapp, Maurissa, Byerly, Risa, McClellan, Loretta S., O'Boyle, Maya R. Nykanen, Anika, Fuller, Patrick J., Aas, Calvis, Stone, Jude M., Killpatrick, Sean, Uptegrove, Manami M., Vischer, Alex, Wolf, Hannah, Smallman, Fiona, Eymann, Houston, Narode, Simon, Stapleton, Ellee, Cioffi,, Camille C., and Hannah F. Tavalire. 2019. "Framing the discussion of microorganisms as a facet of social equity in human health." *PLoS Biology* 17(11): e3000536. https://doi.org/10.1371/journal.pbio.3000536

- *Provided by The Microbes and Social Equity working group. This article talks about how the disparities in access to microbes and protection from environmental toxins is essential to health and well-being. A more diverse microbiome is associated with greater health and wellness, but racial minorities and those of low SES often have limited access to acquiring these microbes. Public policy changes that could increase the equity of access to microbes would be: requiring businesses to offer their employees parental paid leave so that parents are able to properly bond and transfer microbes to a newborn child during the perinatal*

period, access to greater quality of nutrition and food sources, limiting industrial ability to pollute outdoor spaces, supporting urban farms, creating more water treatment facilities, and adding green spaces. Cited 6,740 times.

James, Philip T. 2008, "The epidemiology of obesity: the size of the problem." *Journal of Internal Medicine*, 263, 336-352. doi:10.1111/j.1365-2796.2008.01922.x

o *Accessed through Web of Science. This article was an epidemiological review of obesity. It provided the history of obesity, the use of BMI to crudely measure for obesity (including optimum BMI and cut-off values for mortality), and described the links with insulin resistance/diabetes, and hypertension. It also gave some insight into at-risk populations and contributing factors like inactivity, food pricing and availability, and food marketing.*

Kane, Anne V., Dinh, Duy M., and Honorine D. Ward. 2015. "Childhood malnutrition and the intestinal microbiome." *Pediatric Research,* 77(1-2), 256-62. doi:10.1038/pr.2014.179

o *Accessed through NCBI database. This article discusses the effect of malnutrition on the gut microbiome of children. The article looks at how malnutrition and the gut microbiome are connected, and how different external factors, such as geography, also play into the changes of the microbiome. The authors cite that malnutrition can lead to changes in the gut microbiome, which can impair immune function and susceptibility to disease. Another interesting topic they look at is how the microbiome can affect absorption of nutrients, and a compromised microbiome can impair this. Methods to assess child malnutrition was the WHO Anthro Survey Analyzer software (R package), the Microbial Dysbiosis Index, and the Subramanian et al. relative microbiota maturity and microbiota-for-age-Z-score. This is very pertinent to our research because it may illuminate how bad the problem of malnutrition actually is amongst children living on the WRIR. Cited 1,900 times.*

Kassir, Radwan. 2020. "Risk of COVID-19 for patients with obesity." *Obesity reviews: an official Journal of the International Association for the Study of Obesity*, 21(6), e13034. https://doi.org/10.1111/obr.13034

o *Accessed through NCBI. This article was brief but provided some possible explanations to the mechanistic links between obesity and it being a risk factor for COVID-19. It also*

described BMI being significantly higher in patients with severe COVID-19 compared to normal patients

Love, Charlotte V., Taniguchi, Tori E., Williams, Mary B., Noonan, Carolyn J., Wetherill, Marianna S., Salvatore, Alicia L., Jacob, Tvli, Cannady, Tamela K., Standridge, Joy, Spiegel, Jennifer, and Valarie Jernigan. 2018. "Diabetes and Obesity Associated with Poor Food Environments in American Indian Communities: The Tribal Health and Resilience in Vulnerable Environments (THRIVE) Study." *Current Developments in Nutrition*, 3(Suppl 2), 63–68. https://doi.org/10.1093/cdn/nzy099

o *Accessed through Web of Science. This study examined the relationships between chronic disease, food environment, food retailer choice, and produce consumption in rural Oklahoma American Indian communities. They found that the use of convenience stores, gas stations, and Dollar Stores as a source of food was associated with obesity and diabetes. Further, they maintain that nutritious food initiatives are needed, but that Tribal leadership can drive these to support the community's health.*

Law, Alma. 2020. Food Equity Initiatives in Fremont County. September 14, 4pm.

o *Conducted over Zoom Video Conferencing. This informal interview with Mr. Law, an English teacher at Riverton Middle School, was relevant to our research because the information provided came from a Fremont County community member who is directly involved in food justice initiatives.*

McIntyre, Alice. 2008. Participatory action research. Los Angeles: Sage Publications.

o *Accessed through Google Books. This short book is about participatory action-based research. Participatory action-based research is rooted in collaborative communication and building relationships with community members where the work is taking place. It is crucial to engage often in both team and self-reflection to insure clarity. It is very pertinent and germane to our research because we are looking to use this research model.*

Melvin, Sandra C., Wiggins, Corey, Burse, Nakeitra, Thompson, Erica, and Maude Monger. 2020. "The Role of Public Health in COVID-19 Emergency Response Efforts From a Rural Health Perspective." *Preventing Chronic Disease*, 17(E70). https://doi.org/10.5888/pcd17.200256

o *Accessed through the CDC Website. This article relates the pandemic to rurality and minorities that are already often disenfranchised. With regards to rurality, they state that specific elements contribute to the inequitable role of COVID-19 on health systems, including the size, revenue, and budget of rural health facilities, socioeconomic demographics of patients, and access barriers like travelling.*

O'Connell, Meghan, Buchwald, Dedra S., and Glen E. Duncan. 2011. "Food access and cost in American Indian communities in Washington State." *Journal of the American Dietetic Association*, 111(9), 1375–1379. https://doi.org/10.1016/j.jada.2011.06.002

o *Accessed through NCBI. This article examines the food environment of Washington's American Indian reservations as they relate to the number, type and location of food stores, the availability and cost of food items, and how they compare to off-reservation access and locations*

Olsen, L'Dawn, and Chesie Lee. 2020. Collaborating with Food Justice Initiatives and Natives in Fremont County. September 30, 10am.

o *Conducted over Zoom Video Conferencing. This informal interview with L'Dawn Olsen, an Eastern Shoshone descendant and the Equity and Inclusion Specialist for the Wyoming Coalition Against Domestic Violence and Sexual Assault, and Chesie Lee, a non-Native social justice 'accomplice' aimed at equitable food initiatives, was relevant to our research because the information provided came from two community members, one Native and one non-Native, who are directly involved in the WRIR community's overall health and food justice initiatives.*

Patrick, Stephen W., Henkhaus, Laura E., Zickafoose, Joseph S., Lovell, Kim, Halvorson, Alese, Loch, Sarah, Letterie, Mia, and Matthew M. Davis. 2020. "Well-Being of Parents and Children During the COVID-19 Pandemic: A National Survey." *Pediatrics*. https://doi.org/10.1542/peds.2020-016824.

o *Patrick et al. 2020 was found using NCBI database by searching for "food insecurity" and "covid-19". This article discusses the impacts of the COVID-19 pandemic and its subsequent shutdowns on parents and children. The data was gathered using a survey. This source was useful because it was so recent and discussed food insecurity during the pandemic.*

Porter, Christine, and Noah Hull. 2020. Meeting Learning Coaches and Community Partners. August 24, 1:20pm.

o *Conducted over Zoom Video Conferencing. This introductory lecture session was when we met our learning coaches and community partners. Dr. Porter described wicked problems and environmental justice concerning COVID-19, and Dr. Hull acknowledged that Wyoming was disproportionately affected by COVID-10 and stated some concerns.*

Ralston, Katherine, Treen, Katie, Coleman-Jensen, Alisha, and Joanne Guthrie. "Children's Food Security and USDA Child Nutrition Programs." Economic Information Bulletin no. 174, *U.S. Department of Agriculture, Economic Research Service*, 2017.

o *Ralston et al. 2017 was found on the United States Department of Agriculture's Economic Research Service website. This publication shows information gathered by the authors for the Economic Research Service. Using ERS-backed research publications as their sources, this source is showcasing the connection between child food security and nutrition programs such as the NSLP. This source provided data on how food insecurity and nutrition programs are linked. The article also listed the effects that food insecurity has on the health of children.*

Schwartz, Amy E., and Michah W. Rothbart. 2020. "Let Them Eat Lunch: The Impact of Universal Free Meals on Student Performance." *Journal of Policy Analysis and Management,* 39(2), 376–410. https://doi.org/10.1002/pam.22175.

o *Schwartz and Rothbart 2020 was accessed through the NCBI database. It is a recent study that shows the relationship between academic performance and school-provided lunch programs. This source provided information about how school-provided lunches are beneficial to school children.*

USDA ERS. 2020. "Food Insecurity." Definitions of Food Security. Last modified September 9, 2020. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx#CNSTAT

o *Accessed through the web. This site provided the technical definition for 'food insecurity.'*

Vas, Prashanth, Hopkins, David, Feher, Michael, Rubino, Francesco, and Martin. B. Whyte. 2020. "Diabetes, obesity and COVID-19: A complex interplay." *Diabetes Obesity & Metabolism*, 22(10), 1892–1896. https://doi-org.libproxy.uwyo.edu/10.1111/dom.14134

o *Accessed through Web of Science. This article helps to illustrate the complex mechanistic and clinical relationships between diabetes and severe COVID-19 outcomes. It also describes the concept that SARS-CoV-2 might cause metabolic disorder by attacking beta-cells through ACE-2 receptor introduction. The authors also suggest that minorities have disproportionate risk for severe COVID-19 because they also have a high prevalence metabolic disorders, but that access to health care might also significantly contribute to the outcome.*

World Health Organization (WHO). 2020. "Obesity: Obesity and Overweight Factsheet." *World Health Organization*. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

o *Accessed through the web. This factsheet presents information regarding obesity and overweight and the fact that these two conditions are a global issue and have become a health burden regarding the economics of healthcare.*

Wyoming Hunger Initiative. 2019. "2019 Annual Report." *Wyoming Hunger Initiative*, 2019. https://www.nohungerwyo.org/

o *Wyoming Hunger Initiative is an organization that aims to spread awareness and provide solutions to food insecurity, particularly in children, in the state of Wyoming. The Initiative was started in October 2019 by First Lady Jennie Gordon, wife of Wyoming Governor Mark Gordon. This organization teams up with local food aid groups around the state to combat food insecurity, especially in children. This source was very insightful and provided valuable information about food insecurity in Wyoming for this study.*

Wyoming Office of Health Equity's Chronic Disease Prevention Program. 2020. "Focus on Healing." *Wyoming Department of Health*. https://health.wyo.gov/wp-content/uploads/2020/08/2020-WRIR-Publ-Focus-on-Healing-f-1.pdf

o *Accessed through Riverton Peace Mission. It discusses how the WRIR community has tried to heal from the disproportionate impacts that COVID-19 has had on them. It talks about how the Eastern Shoshone and Northern Arapahoe tribes share the land and experience hardships related to food access and sustainability. "Other food sustainability initiatives are being explored and initiated like a permanent foodbank with community-based distribution, a meat processing plant, a producers' food coop, a commercial licensed kitchen, expanded*

farmers' markets, commercial greenhouses and food grown on the WRIR for the schools,
restaurants including at the casinos and health care providers on or near the WRIR." This
source is pertinent and germane to our research because it come directly from Wyoming
Department of Health's data and highlights many of the health inequities on the WRIR that
have led them to have such severe COVID-19 complications and mortality rates