Understanding the experiences of farmers in Virginia regarding the impact of working in extreme weather conditions on their health and well-being: A key informant study

By

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Dedications

To my late great-grandfather and great grandmother Howes, the first farmers I ever interviewed, whose hands were strong, and hearts were warm.

To my parents who taught me to read, write, ask lots of questions, and care about the world around me.

To my wife, Marcy, who has listened to and challenged my ideas and supported this endeavor.

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Abstract

Background: Virginia is experiencing periods of prolonged heat, wildfire smoke exposure and other extreme weather conditions that have been magnified by climate change. Farmers in Virginia are essential workers who are at risk for physical and mental health impacts of exposure to high heat and wildfire smoke while working outdoors during extreme weather conditions. While there are studies in the literature that consider the health risks of farmworkers who work in extreme conditions, there are no recent studies of farmers facing the same challenges.

Objective: The purpose of this study was to explore the experiences, concerns, impact on health and well-being and actions of farmers in Virginia regarding their working conditions related to extreme weather conditions related to climate change.

Methodology: A qualitative study using an interpretive phenomenological approach was conducted to document the lived experiences of farmers in Virginia. Fifteen 30-minute semi-structured interviews were conducted with farmers, key informants, and stakeholders. Thematic analysis was used to analyze results. Constructs from the Health Belief Model and the Social-Ecological Model health behavior change theories were applied to the coding process and thematic analysis was used to analyze and report results.

Results: Seventeen participants (seven farmers, six key informants and four stakeholders) participated in semi-structured interviews ranging from nine minutes to 67 minutes. Through deductive and inductive coding, a total of 44 categories/codes/subcodes were assigned and analyzed line-by-line resulting in 475 excerpts. Five themes were identified: *Farm work continues in extreme weather, Compliance is hard, Trust in self, Co-op and the Farm Bureau, Nothing we can't handle and Changes to the work.*

Conclusions: Farmers in Virginia recognize the risks of climate change (or extreme weather conditions) but continue to work no matter what the conditions may be. They admit challenges with compliance with protective behavior and have a defined circle of trust that centers on the individual, the Co-op and the Farm Bureau. Insights from this study can inform future model-based public health interventions for farmers in Virginia. Future studies could replicate or build on this protocol to further understand whether the farmers and other essential outdoor workers are truly ready for the extreme weather conditions.

Keywords: Heat-related illness, wildfire smoke, air quality, social isolation, mental health, farmer, farmworker, agriculture, climate change, extreme weather, outdoor worker, Health Belief Model, Social-Ecological Model

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List of Abbreviations

AQI	Air Quality Index
Cal/OSHA:	California Division of Occupational Safety and Health Administration
CDC:	Centers for Disease Control and Prevention
CDPH:	California Department of Public Health
CHIPS:	California Heat Illness Prevention Study
EPA:	Environmental Protection Agency
HBM:	Health Belief Model
HRI:	Health Related Illness
IPA:	Interpretative Phenomenological Analysis
IRB:	Institutional Review Board
OSHA:	Occupational Safety and Health Administration
PM:	Particulate Matter
PPE:	Personal Protective Equipment
SEM:	Socio Ecological Model
U.S.:	United States of America
WCAHS:	Western Center for Agricultural Health and Safety
WFS:	Wildfire Smoke
WHO:	World Health Organization

Chapter One: Introduction

Extreme weather patterns such as heat, drought, wildfire and flooding across the world have been attributed to climate change (Clarke et al., 2022; Otto, 2023) and in recent years Virginia farmers have experienced many of these extreme weather conditions, particularly increasing periods of high heat (National Aeronautics and Space Administration, 2024) and wildfire smoke (WFS) exposure (Locklear & Hercyk, 2023; Virginia Department of Health). The mental health implications of exposure to climate related weather are an emerging area of concern (Charlson et al., 2021). Farmers are already vulnerable to social isolation (Hammersley et al., 2021), that can be associated with negative health consequences and an increased rate of mortality (Naito et al., 2021). As essential outdoor workers, farmers cannot escape the extreme weather conditions (Hyland et al., 2024). Farmers could be increasingly subjected to the combined impact of heat, WFS exposure and social isolation, yet there are no recent studies where farmers have been asked how they are coping with the challenges of working outdoors in extreme weather conditions.

Farms in Virginia are typically operated by a middle-aged couple or a small family with very few outside farmworkers. Of the 41,500 farms in Virginia, 97% are still owned by a family (Virginia Department of Agriculture and Consumer Services, 2024). The present study will focus on the needs of these farm owners. In this project, farmers (farm owners) will be distinguished from farmworkers (employed or contracted workers). The proportion of farmworkers who are "migrant workers" as defined by the U.S. Department of Labor is declining (Farmworker Justice, 2022), thus unless the literature specifically involved migrant farmworkers, the more global term of farmworker will be used herein. The average farmer in Virginia is beyond middle age (National Agriculture Statistics Service, 2022), a life stage when all Americans begin to be at

risk for chronic health conditions associated with middle age (Boersma et al., 2020). In the most recent survey of farmers by the United States Department of Agriculture, the average age of farmers in Virginia was 59.2 in 2022 compared with 58.5 in 2017 (National Agriculture Statistics Service, 2022). Of the 67,798 producers (farmers), only 5,139 identified as young producers in the 2022 survey. Farmers and farmworkers have been shown to have cardiovascular disease (Desai et al., 2022), pulmonary issues (Puvvula et al., 2022) and obesity (López-Cevallos et al., 2019), all conditions that can be aggravated by working in adverse conditions (Almetwally et al., 2020; Doiron et al., 2019; Heaney et al., 2022; Humphreys et al., 2022; Manisalidis et al., 2020; Vert et al., 2017).

To explore the current concerns of farmers in Virginia, an interpretive phenomenological qualitative research study was conducted, using semi-structured interviews to understand the perceptions of Virginia farmers regarding the impact of extreme weather on their health and well-being. The exploration of perceptions of Virginia farmers was informed by two health behavior change theories, the Health Belief Model (HBM) and the Socio-Ecological Model (SEM). This project was particularly interested in the health impacts to farmers from working in periods of high heat and poor air quality due to WFS, two extreme working conditions that have been amplified by climate change.

Statement of the Problem

The World Health Organization (WHO) has identified heat stress as the leading cause of weather-related deaths (2024b). There is growing evidence that exposure to poor air quality can have detrimental health impacts in the areas of respiratory, heart, and mental health (Almetwally et al., 2020; Doiron et al., 2019; Eguiluz-Gracia et al., 2020; Manisalidis et al., 2020; Vert et al.,

2017). The risks to farmers are amplified because most of the strenuous work occurs outside in the heat of summer and early fall when adverse conditions are most likely present.

In addition to the physical health impacts related to climate change, there is emerging evidence that there is a mental health impact on farmworkers when they have to work in adverse conditions such as high heat or poor air quality, particularly in the Western U.S. (Hyland et al., 2024; Wadsworth et al., 2022). When the farmer or farmworker feels they have no choice but to work in extreme conditions, despite concerns for their own health, it can cause stress for the farmer (Riden et al., 2020). Farmer mental health has typically been represented in the literature by articles concerned with farmer suicide (Younker & Radunovich, 2021), and the "burden of farming" is often listed as a contributing factor to suicide (Kohlbeck et al., 2022). According to the National Rural Health Association, the suicide rate for farmers in the U.S. is 3.5 times the rate of the rest of the population (Eisenreich & Pollari, 2023). It can be difficult to reach farmers and understand their stressors (Kohlbeck et al., 2022) and public health initiatives need to carefully consider whether working in extreme conditions is contributing to the poor mental health of farmers before developing interventions to address the issue.

Significance of the Problem

Farming is one of the most hazardous professions in the United States of America (U.S.), with the highest fatality rate of 23.5 fatalities per 100,000 FTE workers in 2022 compared to 3.7 per 100,000 for all other professions (U.S. Department of Labor, 2023). More than half (56%) of all deaths in agriculture in 2022 were in farmers 55 years and over (2024a). Most deaths and injuries are from equipment and other hazards on the farm or from transportation of farmers and farmworkers (U.S. Department of Labor, 2023).

In the U.S., farmworkers have 20 times the rate of death from heat-related illness (HRI) than the general rate for workers in other settings (Parsons et al., 2022). The death rate for exposure to WFS is not measured. The National Institute for Occupational Safety and Health is in the process of drafting its first ever hazard review on the impact of WFS on outdoor workers(Centers for Disease Control and Prevention, 2024b). In addition to the physical health risks, the anxiety and stress from working in extreme conditions may be detrimental to the mental health of farmers.

Purpose and Significance of the Research

The purpose of this study was to explore the perceptions of farmers in Virginia regarding the impact of extreme weather due to climate change on their physical and mental health. Most of the recent studies in the U.S. have been conducted to understand farmworkers' risks and have identified concerns about working in periods of high heat, poor air quality, and extreme weather patterns. (Riden et al., 2020; Smith et al., 2021; Wadsworth et al., 2022).

In contrast, there are no recently published studies focused on small farm owners who may have no choice but to do the work themselves. Whether the owners of small family farms in Virginia are taking steps to mitigate their exposure to heat and poor air quality was not known. Further, there was a need to understand whether the concerns Virginia farmers have about heat, poor air quality, and other climate-related risks are impacting their own outlook toward their health and the viability of their farm. No other studies currently exist that have asked farmers in Virginia about their perceptions of extreme weather related to climate change and its health impacts. The last peer-reviewed study in the U.S. assessing farmer impressions of climate change was conducted retrospectively in 2011 using survey data of Iowa farmers (Arbuckle et al., 2013).

Research Questions

Four research questions were explored during the proposed study. As an exploratory study, there are no preconceived hypotheses, though the literature and health behavior change theories informed the interpretation of the results.

Table 1

Research Questions

	Question
1.	What experiences do farmers in Virginia have regarding extreme weather conditions (such as high heat and poor air quality)?
2.	What concerns do farmers in Virginia have about working outside within extreme weather conditions (such as high heat and poor air quality)?
3.	How is working in extreme weather conditions impacting Virginia farmers' health and well-being?
4.	What actions are farmers in Virginia taking to protect themselves from the impacts of extreme weather conditions?

Chapter Two: Literature Review

Farmers have been subjected to harsh outdoor conditions since the advent of agriculture nearly 12,000 years ago (Carey, 2023; Johns Hopkins Center for a Livable Future, 2024); however, there is a growing realization that outdoor working conditions are worsening due to climate change (Johns Hopkins Center for a Livable Future, 2024). In 2018, the World Economic Forum cited climate issues as the most pressing threat to the world economies, including "extreme weather events and natural disasters, failure of climate change mitigation and adaptation, water crises, biodiversity loss, and air and soil pollution" (The Lancet Planetary Health, 2018). All of these climate issues impact farmers' health and well-being. As the world gets hotter, HRI will increasingly threaten the health of people who work outdoors (World Health Organization, 2024b). With warmer conditions, the impacts of WFS will be more pronounced (World Health Organization, 2024a). The mounting hazards of working in both conditions could contribute to anxiety and depression in an already stressed farmer (Hyland et al., 2024; Riden et al., 2020; Wadsworth et al., 2022).

Due to the short-term duration of HRI and WFS events, the literature is limited but evolving. Previous studies are predominantly qualitative with a few quantitative studies that consider the impact on hospital emergency department utilization. Further, most of the existing studies on HRI and WFS have focused on the impacts on physical health. The impact of climate-related conditions on mental health has only been referenced anecdotally in the literature. This review will highlight health safety risks for farmers, the available literature on the adverse physical health impacts of working in periods of high heat and WFS, the potential mental health ramifications of working in these conditions, the unique public health challenges for farmers in Virginia and the theoretical framework for this study.

Health Safety Risks for Farmers

Farmers are vulnerable to a comparatively large rate of health problems (Hammersley et al., 2021) and the farming, fishing, and forestry occupations have the highest fatality rate of all occupational groups at 23.5 fatalities per 100,000 FTE workers in 2022 (U.S. Department of Labor, 2023). Most fatalities have historically occurred due to accidents involving farm equipment or the transportation of farmworkers to and from the worksite on the farm. The accident rate associated with the transportation of farmworkers has increased significantly in recent years (U.S. Department of Labor, 2022). However, most public health work in farming has historically been limited to workplace safety, pesticide exposure mitigation, and food-borne illnesses.

Studies of public health in farming have primarily centered around the immediate occupational health and safety risks of the farmworkers (Sakala, 1987; Wadsworth et al., 2022). A foundational review conducted by Sakala (1987) concluded that the primary occupational exposures migrant farmworkers faced were pesticides, exposure to heat, workplace accidents, and poor hygiene in the field and most efforts for the past three decades have been focused on those areas. Later research of migrant farmworkers affirmed they are challenged by hazardous work environments, less than ideal living conditions, cultural barriers, and lack of access to health care (Hansen & Donohoe, 2003). Specific medical problems migrant farmworkers experience at a rate above the average rate of the general population includes infectious diseases, pesticide-related illnesses, dermatitis, heat stress, respiratory conditions, and musculoskeletal disorders (Hansen & Donohoe, 2003).

Heat Related Illness (HRI)

Heat stress has been identified by the World Health Organization (WHO) as the leading cause of weather-related deaths (2024b). According to the Centers for Disease Control and Prevention (CDC), approximately 1,220 people in the U.S. are killed by extreme heat each year (2023). The CDC indicates that even young and healthy people who participate in physical activities in hot weather can be impacted (2023). Recognition of HRI as a major public health issue is a recent phenomenon and the CDC just released the Heat and Health Initiative to protect (2024). Americans from heat exposure that includes a heat risk forecasting tool and guidance for clinician discussions with their patients.

Farmers must continue to work in high-heat conditions to maintain and harvest their crops due to their significant investment and potential for loss if the crop is not taken to market (Hyland et al., 2024). This is intensified by the fact that harvesting, the most labor-intensive work on the farm, is often performed at the hottest time of the year. California passed the first outdoor heat illness prevention rule in 2005 after four farmworkers died from HRI (Kuang, 2024). This rule requires shade and water when the temperature reaches 80 degrees Fahrenheit and additional breaks when the temperature reaches 95 degrees Fahrenheit (Kuang, 2024). Much of the work that led to recent efforts to train farmworkers to reduce their exposure to HRI was prompted by the California Heat Illness Prevention Study (CHIPS) that was initiated in 2013 to understand the physiological response to heat and physical work among California farmworkers (Courville et al., 2016). During the CHIPS, researchers placed heat monitoring devices on Latino farmworkers and found that 8.3% of the workers had a core body temperature greater than an acceptable level of 38.5 degrees Celsius, and 10.8% experienced dehydration (Mitchell et al., 2017).

The heat from continued exposure to the sun is not a new concern for farmworkers. Significant reviews in the past have cautioned that there is little in place to protect farmworkers from “heat stroke, heat exhaustion, heat cramps and heat rash” (Sakala, 1987, p. 669). Legislation to protect farmworkers is a relatively recent phenomenon. It was not until 2005, that California passed legislation that required farmers to provide farmworkers with shade for breaks and cool, clean drinking water, one quart for each employee for each hour of work (Salladay & Vogel, 2005). This legislation was the first in the country and also required an education campaign to teach farmworkers and farmers to identify symptoms of heatstroke and seek help (Salladay & Vogel, 2005). More recent legislation signed in California allows farmworkers who work outside to use their paid sick leave to avoid smoke, heat or flooding conditions (Office of Governor Gavin Newsom, 2024).

When both heat and air pollution are present, the risks can be deadly to farmers and farmworkers, however, peer-reviewed articles addressing farmworker deaths due to HRI are rare, and studies of days when both heat and air pollution are unsafe do not exist. California is often studied because it has the largest population and the largest claims databases in the U.S. However, even in California underreporting can lead to an incomplete picture of the problem. The 2022 annual report produced by the California Division of Occupational Safety and Health (Cal/OSHA) only reported two heat-related deaths among farmworkers, yet a study of Cal/OSHA records conducted by a newspaper found that 168 farmworkers died suddenly in California from 2018 to 2022, while working on days when the temperature exceeded 80 degrees Fahrenheit (Gross & Aldhous, 2023). The analysis noted that many of the deaths occurred on days when both high heat and poor air quality were factors, indicating that working on days when both are present carries enormous risks.

Aside from the impact on health, there is emerging evidence that high heat can increase the chances of being injured on the job (Park et al., 2021). Using claims from the California Department of Workers Compensation database, Park et al. (2021) found that hotter days resulted in significant increases in workplace injuries on days with temperatures between 85 and 90 degrees Fahrenheit, leading to a 5 to 7 % increase in same-day risk, and days above 100 degrees leading to a 10 to 15 % increase in risk compared to days in the 60s.

With the increased awareness of the effects of HRI and air quality, there is a need to expand the research to include the exposure of farmers to these risks. In a recent study in California, that imitated the CHIPs study, the core body temperature of farmworkers was measured to study the effect of their work rate, hydration status, and clothing (Vega-Arroyo et al., 2019). In the study, none of the farmworkers reported HRI symptoms, yet 15% had below normal hydration, and 45% % had a body temperature over 38 degrees Celsius for at least three minutes (Vega-Arroyo et al., 2019) The researchers concluded that perhaps the best way to mitigate HRI on hot days was to reduce the rate of work.

Wildfire Smoke Health Hazards

In recent years, the amount of hazardous air quality days due to WFS in the U.S. has been increasing (Childs et al., 2022). WFS from wilderness areas is not healthy to breathe, and smoke from fires that include suburban areas often includes toxic chemicals, making the air even more dangerous (California Air Resources Board, 2023). If a community is in a low-lying area and the wind is weak, as it often is in summer, smoke can linger in the air for days, weeks, or even months (American Lung Association, 2023).

In addition to the natural and property loss caused by wildfires, the human body can be subjected to adverse health effects (Black et al., 2017). If an individual is directly in the path of

the fire, burns or even death can occur. There is growing awareness and research activity on the physical and mental health aspects of WFS exposure (Heaney et al., 2022; Hutchinson et al., 2018; Mirabelli et al., 2022; Riden et al., 2020; Wadsworth et al., 2022). There is also growing evidence that exposure to poor air quality can have detrimental health impacts in the areas of respiratory, heart, and mental health (Almetwally et al., 2020; Doiron et al., 2019; Eguiluz-Gracia et al., 2020; Manisalidis et al., 2020; Vert et al., 2017).

For people in both the community where the wildfire occurs and those nearby, the health effects can be caused by exposure to poor air quality high in particulate matter (Heaney et al., 2022). Particulate Matter (PM) is defined by the Environmental Protection Agency (EPA) as the mixture of "solid particles and liquid droplets found in the air (Environmental Protection Agency, 2023, p. "What is PM" section)" $PM_{2.5}$ are fine inhalable particles with diameters of 2.5 micrometers or smaller. This is the point at which there is the greatest concern for health as the particulates can get deep into the lungs and bloodstream. Even short-term exposure to $PM_{2.5}$ can have lasting health effects (Lu et al., 2015). WHO (2023b) defines a safe level of $PM_{2.5}$ as less than 10 micrograms/cubic meter of air.

Breathing in air with high particulate matter can have long-term effects on the lungs and other organs of the body (California Air Resources Board, 2023). WFS can contain particulates so small there is no way for the body to expunge them. WFS has been shown to cause physical harm to the body, particularly in cardiovascular and pulmonary systems. Firefighters and residents living in areas experiencing wildfire were often the subject of previous reviews (Humphreys et al., 2022; Psarros et al., 2017; Psarros et al., 2018). A meta-analysis of the health effects of short-term exposure to high particulate matter in China found that increased particulate matter increased the total non-accidental mortality (Lu et al., 2015). An earlier review of time-

series studies from 1993 to 2003 found that short-term exposure to air pollutants is an important predictor of increased hospital and emergency room use around the world (Wilson et al., 2004).

When the impact of WFS has been studied, it has historically been focused on smoke inhalation and related adverse cardiac and asthma outcomes. For example, pediatric visits to emergency and urgent care facilities at a San Diego hospital increased when WFS was present (Aguilera et al., 2021). Exposure to WFS has shown to exacerbate respiratory disease, worsen birth outcomes, and cause cardiovascular events (D'Evelyn et al., 2022; Goin et al., 2024). Outdoor workers and socially disadvantaged groups can be disproportionately exposed to WFS and the related complications (D'Evelyn et al., 2022). In interviews conducted with educational and healthcare leaders in Paradise, California following the 2018 Camp Fire, there was universal concern that the social vulnerability of residents had a bearing on the health impacts of the fire (Hamideh et al., 2022).

Exposure to WFS can result in unplanned visits to healthcare providers, even if the wildfire is several miles away. During the 2004-2009 wildfire seasons, California providers experienced and increase in unscheduled cardiorespiratory hospital visits due to residents exposed to fine particulate matter below $PM_{2.5}$ from wildfires in adjacent geographic areas (Heaney et al., 2022). By combining information from the Goddard Earth Observing System, daily emissions from the Global Fire Emissions Database and hospital claims records, exposure to WFS $PM_{2.5}$was positively associated with unscheduled hospital visits for cardiac and respiratory diseases (Heaney et al., 2022). Hispanic individuals had the highest association between smoke event days and hospital visits for acute respiratory infections. The Heaney et al. (2022) study is one of the only studies showing an association with unscheduled hospital visits for both respiratory and cardiac patients, though an earlier study of Medi-Cal utilization

following the 2007 San Diego fires found that some children aged 0-4 experienced a 72% increase in respiratory diagnoses and children aged 0-1 experienced a 243% increase for asthma diagnosis (Hutchinson et al., 2018). Because the presence of WFS is temporary in nature, the impact on healthcare utilization has only occasionally been studied in detail (Heaney et al., 2022; Hutchinson et al., 2018).

International and national health organizations recognize the need to focus on WFS, but few offer practical steps that could be taken by outdoor workers such as farmers. The WHO recognizes that wildfires can have a significant effect on health and well-being (2024a), but aside from a few general cautions on its website, there is very little information provided. Further, there are no reports of meetings or proceedings by the WHO regarding WFS (2024a). The California Department of Public Health (CDPH) report on Wildfire Smoke, Considerations for California's Public Health Officials (2022) includes recommendations on staying safe when WFS is present. Like many important messaging efforts, the report suggests the following strategies to reduce exposure: "Stay Indoors, Manage Indoor Air Quality, Avoid Smoky Conditions, Reduce Physical Activity and Consider Temporary Re-Location" (California Department of Public Health, 2022, pp. 30-33); all three of which would be impossible for outdoor workers such as farmers.

Extreme weather impacts on Mental Health

There is less known about the impact of working in extreme weather on the mental health of farmers. Social isolation and loneliness is a national crisis (Office of the Surgeon General, 2023), and farmers face occupational isolation that can undermine their sense of connectedness (Hammersley et al., 2021). The most extreme adverse mental health impact can be death by suicide, and this has been studied in farmers who have a higher rate than any other occupational

group (Bryan et al., 2021; Kohlbeck et al., 2022; Younker & Radunovich, 2021). Reviewing what is known about the consequences of extreme weather and climate change on mental health in the general population can also inform future studies of farmer mental health (Charlson et al., 2021; Henning-Smith et al., 2022; Patz, Grabow, et al., 2014). The literature on social isolation, suicide, and mental health impacts of climate change on farmers is therefore essential to review.

Social Isolation and Loneliness

Around the world, social isolation has been associated with negative health consequences and an increased rate of mortality (Naito et al., 2021). In the U.S., a sentinel study by the National Academies of Sciences, Engineering and Medicine identified social isolation and loneliness as a serious public health risk that affects nearly 25% of Americans 65 and older (National Academies of Sciences, 2020). The CDC has highlighted loneliness and social isolation as factors associated with a 50% increased risk in dementia, 29% increased risk of heart disease, and a 32% increased risk of stroke (2021a). The U.S. Surgeon General released a report, Our Endemic of Loneliness and Isolation, that further emphasized all of the risks that loneliness and social isolation can contribute to, concluding by calling it an urgent public health concern and emphasizing the need for additional efforts to create social connection (Office of the Surgeon General, 2023).

According to the U.S. Census Bureau Household Pulse Survey, 14% of Virginians reported being lonely in 2024 (Sleight & Gollub, 2024), slightly higher than the national average rate of 13%. In the preindustrial and colonial times, farmers had to be socially connected to do many tasks on the farm, such as planting, harvesting and barn raising (Dabney, 1971). In the present age of pervasive low-cost technology, and the ability to farm without the use of farmworkers, farmers may be much more likely to work in isolation (Purc-Stephenson et al.,

2023). That isolation can lead to worsening mental health. Previous interviews of farmers in the western U.S. found that social connectedness is essential to improve the resilience of farmer mental health (Freeman et al., 2024).

Farmers often face long hours working alone without social interaction (Hammersley et al., 2021). Prolonged isolation can lead to depression (Motillon-Toudic et al., 2022). In the past, farmers may have turned to the church for social support (Paul et al., 2019), but church attendance is on the decline in Virginia with only 44% of residents indicating that they attend church regularly (Pew Research Center, 2024). What is less researched and reported is the impact that stresses of the farmer and the increasing social isolation can have on the day-to-day life of living farmers.

Virginia has geographic features that contribute to the social isolation of farmers. The Blue Ridge and Alleghany mountains that run the entire 325 miles from the Tennessee to Maryland border (Virginia Tourism Corporation, 2024) create a physical wall between the Eastern and Western portions of the state that was difficult to traverse until the advent of the railroads and the Blue Ridge tunnel (Lyons, 2014). Southwestern Virginia remains very rural and isolated due to a legacy of coal production (Zuckerbrod, 2001) and the lack of an interstate running east to west (Virginia Economic Development Partnership, 2023). The remote farms of the Eastern Shore of Virginia are separated by the Chesapeake Bay from mainland Virginia and are difficult to access from major cities (Accomack-Northampton Planning District Commission, 2019). In the Southside, an area South of Richmond that runs from Roanoke to Newport News, vast tracts of land and small towns create an isolation that has changed little since the colonial period (Virginia Economic Development Partnership, 2023).

There are a few positive findings shown in research regarding farmers and isolation. For example, in California, farmers who were involved in a direct market-to-consumer relationship were found to have great resilience (Durant et al., 2023). Further, a recent study in Wisconsin found that co-ops had a positive role to play and that they could lead to increased connectedness among farmers (Liang et al., 2022). Virginia has the Virginia Cooperative Extension service operated out of Virginia Polytechnic Institute and State University (VPI), and there are groups of beginning farmers supported by VPI and Virginia State University (VSU) that are active across the state who regularly engage with farmers. These groups are potential sources of social connectedness and serve as important key informants for initiatives with farmers in Virginia.

Farmer Suicide Deaths

The literature on farmer mental health is dominated by studies of farmer death by suicide with studies dating back to the 1980s (Younker & Radunovich, 2021), and the "burden of farming" is often listed as a contributing factor to suicide (Kohlbeck et al., 2022). Reviews conducted in the U.S. continue to show that farmers are at an increased rate of suicide (Bryan et al., 2021). In 2021, the U.S. death rate for suicide was 14.8 per 100,000 (Centers for Disease Control and Prevention, 2021b). According to the National Rural Health Association, the suicide rate for farmers in the U.S. is 3.5 times the rate of other occupational sectors of the population and is the highest rate for any profession (Eisenreich & Pollari, 2023). Studies of farmer suicides have found that most are over 65 years old, most deaths involve a firearm, and there is often a physical health problem present (Miller & Rudolphi, 2022). The presence of a physical health problem has been shown to be a key risk factor for adverse mental health in farmers (Daghagh Yazd et al., 2019). Suicide is not strictly psychological but is also affected by social connectedness, a concept advanced by sociologist Emile Durkheim that is applied to a recent

study of farmers to examine social connectedness as an indicator of mental health (Kumar et al., 2022). In a study in India, where the government has formed commissions and social programs to help prevent suicide in farmers, the farmers who experienced death by suicide had lower rates of relationships with their family, friends, and neighbors, and the government agencies that could assist with loans and debt forgiveness (Kumar et al., 2022). Farmers have been shown to face many occupational stressors that can lead to risk factors that may include withdrawing from social connections during a period of personal crisis (Purc-Stephenson et al., 2023).

Mental Health Studies

Climate change has been linked to adverse mental health outcomes in the general population (Patz, Frumkin, et al., 2014). There is evidence that depression may be aggravated by weather (Patz, Grabow, et al., 2014). In a review of 120 original studies published between 2001 and 2020, climate-related natural exposures were shown to lead to "psychological distress, worsened mental health, and higher mortality among people with pre-existing mental health conditions, increased psychiatric hospitalizations, and heightened suicide rates" (Charlson et al., 2021, p. 4486).

Farmers in the Midwest have cited the weather as one of the five significant stressors (Henning-Smith et al., 2022). Farmworkers have also acknowledged that there is a mental health impact when they have to work in adverse conditions such as high heat or poor air quality, particularly in the Western U.S. where an arid Mediterranean climate can mean six-month-long summers without rain (Hyland et al., 2024; Wadsworth et al., 2022). When the farmer or farmworker recognizes the dangers to their own health, but feels they have no choice but to continue to work in extreme conditions, it can cause stress for them (Riden et al., 2020).

Most of the studies that have been conducted linking emotional stress and trauma due to extreme weather have been conducted in areas subjected to WFS. Because WFS is in the air, it affects everyone, and there can be a sense of powerlessness in that there is no escape from the hazards associated with WFS (Riden et al., 2020; Wadsworth et al., 2022). Studies have found that people who live in areas where wildfires occur can be subjected to emotional distress (Mao et al., 2022; Mirabelli et al., 2022; Rodney et al., 2021). Residents who simply live in an area adjacent to a wildfire can have emotional distress, anxiety, and other negative mental outcomes, simply because they are saturated by news coverage and warnings from public health officials (Mao et al., 2022; Mirabelli et al., 2022; Rodney et al., 2021). The emotions can be amplified in members of the population who may not have the means to avoid the hazardous air, particularly if they live in housing where they cannot filter the air or if they are outdoor workers such as farmworkers who must continue to work in poor air quality (Wadsworth et al., 2022). The presence of WFS can increase the level of anxiety and trauma in the communities affected (Humphreys et al., 2022; Psarros et al., 2018). For those who have survived a fire in their own community, there can be PTSD that can be triggered on the anniversaries of fires or the next fire season (Psarros et al., 2017; Psarros et al., 2018).

PM from WFS can impact the mental health of an individual. There is evidence that PM may enter the central nervous system and cause inflammation and stress or damage to blood vessels, allowing the particles and the toxins to pass through the blood-brain barrier, which could lead to mood disorders, depression and suicide (Gladka et al., 2018). PM exposure, which is often associated with WFS, has been shown to increase stress hormone levels (Li et al., 2017). In a large-scale survey in Barcelona, respondents who had lived in areas with long-term exposure to

high air pollution defined by the presence of $PM_{2.5}$ reported higher rates of anxiety (Vert et al., 2017).

Farm Safety and Public Health Initiatives

The federal government farm safety efforts began with a focus on occupational hazards but have expanded to consider the health of the farmer and farmworker. The National Institute of Occupational Safety and Health (NIOSH) created the Agriculture Health and Safety Initiative in 1990 to help prevent accidents and illness among agricultural workers and their families. The Western Center for Agricultural Health and Safety (WCAHS) housed at the University of California Davis was one of the original two NIOSH centers for agriculture safety and is a leader in the study and prevention of the impacts of heat and WFS (University of California Davis Office of Research, 2022). Today, the WCAHS region includes California, Oregon, Washington, and Hawaii, all states that have a long history of agriculture combined with a high degree of risk of high heat and wildfire.

Agricultural workers are particularly vulnerable to WFS exposure because they must often work outside during WFS events (Riden et al., 2020). While new regulations are on the books in California to protect agricultural workers during periods of poor air quality, inconsistency in the implementation of regulations was observed in structural interviews of agricultural employers (Riden et al., 2020). Interviews and focus group discussions conducted in three regions in California found that agricultural employers had varying knowledge about wildfires, workers had been exposed to poor air quality and the agricultural workers had difficulty obtaining safety equipment during fires (Riden et al., 2020; Wadsworth et al., 2022). After determining that gaps between the agricultural employer and agricultural worker continue to exist in understanding the legal requirements and steps necessary to protect farmworker

health, the WCAHS has trained thousands of farmworkers across California on safety practices during extreme weather (University of California Davis Office of Research, 2022, 2024a).

There is an emerging awareness of the need for additional studies that examine the impact of both HRI and WFS, which often occur simultaneously. Structured interviews in California found that agricultural workers have anxiety about the impact of HRI and WFS on their health (Riden et al., 2020). In absence of peer-reviewed studies, some reporters with Inside Climate News, conducted their own review of publicly available California OSHA records and determined that it was difficult to know whether deaths in farmworkers were due to high heat, fine particle pollution, or both (Gross & Aldhous, 2023). The journalists acknowledged that a rigorous study would need to be conducted to determine whether the farmworker died from heat or fine particle pollution, but to date, no such study exists.

There are no known peer reviewed articles published in the last five years that have asked farmers about their opinions regarding climate change and their health. The most recent article that studied farmer attitudes toward climate used secondary survey data from Iowa farmers was conducted in 2011 (Arbuckle et al., 2013). In the study, farmers reported whether they disagreed or agreed that climate would have an impact on agriculture, farm operations, and whether extreme weather events would happen more frequently. One of the conclusions of the study was that farmers who believed climate change was the driver of extreme weather events were more apt to be willing to pursue actions to adapt to the change (Arbuckle et al., 2013). In a study conducted in California, farmers were interviewed and then farmworkers impressions were obtained in subsequent focus groups (Riden et al., 2020; Wadsworth et al., 2022). The differences in perceptions of farmers compared to farmworkers was subsequently examined. During the focus groups, some of the farmworkers anecdotally commented that they were

concerned about the impact of working outdoors in extreme conditions on their physical and mental health (Riden et al., 2020; Wadsworth et al., 2022).

Challenges for Farmers in Virginia

As Virginia's average daily temperatures rise, there will be an increasing need for farmers and farmworkers to prepare to work in hot and arid conditions. According to the University of Maryland climate change city tool, Richmond, Virginia's climate in 2080 will feel like today's climate in Channelview, Texas, a town near Houston (University of Maryland, 2024). If the climate does become as hot as Texas, there will likely be periods of extended drought and more arid conditions.

During the early summer of 2024, much of Virginia was under a "heat dome" where warm air is trapped near the surface, and there were extended periods where the heat index was over 90 degrees Fahrenheit every day (National Aeronautics and Space Administration, 2024). In early 2023, in another event, WFS from Canadian wildfires blanketed much of Virginia for several days, and late in the summer, there was a fire in Bedford County that covered much of central Virginia with unhealthy air (Locklear & Hercyk, 2023). If these conditions continue, Virginia farmers will continue to be faced with high heat and "bad air" days, akin to the adverse weather that farmers on the West Coast and Southwest have long endured.

Theoretical Framework

This project was conducted in the context of two theoretical frameworks. The first framework that informed the study was the HBM, which is a behavior-change theory that considers motivation, perceived threat, and perceived barriers to change (McKenzie et al., 2023). The HBM consists of constructs regarding an individual's health beliefs toward a condition, including their perceived susceptibility to acquiring the condition, the perceived severity, the

perceived benefits of actions to reduce the risk, and their own perceived barriers from action (Alyafei & Easton-Carr, 2024). The individual's self-efficacy or ability to perform a preventive behavior and the cues to action or stimuli they are receiving also contribute (Alyafei & Easton-Carr, 2024). The HBM model has been used to frame previous studies of farmworker public health studies (Arcury et al., 2002; Bay & Heshmati, 2016; Brock et al., 2012). In a recent study of farmworkers conducted in Georgia, the researchers found that 50% of the farmworkers answered HRI first aid questions incorrectly (Smith et al., 2021). To increase farmworker understanding of the perceived benefits of actions to reduce risks associated with HRI, additional efforts at education of farmworkers are necessary. Such training could be modeled after successful trainings conducted by the Western Center for Agricultural Health and Safety that train farm owners and farmworkers to seek shelter and shade and alter working hours (University of California Davis Office of Research, 2024a).

In a study of Hispanic farmworkers working on the Florida-Georgia state line, the farmworkers did not report being concerned about HRI, despite the fact that 19% of them had experienced HRI symptoms (Luque et al., 2020). The authors concluded that this may indicate a gap between awareness and reality of the danger. Farmworkers in Washington who had been provided training and an intervention consisting of a phone application where they could enter their symptoms experienced an improvement in physiological strain when they perceived the threat and recognized that their actions could benefit their health (Chavez Santos et al., 2022). The issue of trust in the organization or agency providing public health information has also been shown to be a factor as to whether the knowledge is accepted. A continuing challenge voiced by some of the agriculture workers in the aforementioned California focus groups was that they did not trust Cal/OSHA and other government agencies which could undermine the agriculture

workers acceptance of Cal/OSHA interventions if the worker does not trust the agency or perceive the intervention as beneficial (Riden et al., 2020; Wadsworth et al., 2022).

The second theoretical framework the study was based on was the Socio-Ecological Model (SEM) which frames health promotion efforts in five levels of influence: the individual, interpersonal, organizational, community, and public policy (Glanz et al., 2008). In other words, health behavior of an individual is shaped by the social context of their own lived experience (McKenzie et al., 2023). Part of the challenge of efforts to teach safe practices during times of high heat and WFS is developing strategies that engage farmers with all their spheres of influence. All five levels of influence are important for the farmer to enable healthy behavioral changes to climate-related health threats. Prior to implementing effective interventions to promote physical and mental health, the myriad of relationships the farmer has with themselves, other farmers, organizations, community and agriculture organizations, and the government should be considered (McKenzie et al., 2023). Public health initiatives will be more successful when paired with existing channels the farmer already looks to for support (Liang et al., 2022). Engaging the farmer through all five levels will increase the probability of success of efforts to improve the physical and mental well-being and may even improve the social connectedness of the farmer in the process (Liang et al., 2022; McKenzie et al., 2023).

A farmer's relationship to the five levels can be complicated by the historical notion of the self-sustaining comprehensive farmer that has been at the heart of American mythology since westward expansion (Smith, 1950). For almost two centuries, the ideal of the independent farmer working their own land was promoted. In recent years as a new generation of beginning farmers has spawned, some are questioning the myth of the yeoman farmer (Calo, 2020). The very work the farmer does lends itself to reinforcing the myth that they can do it all. Today's farmer is

intertwined in a web of the very individual, interpersonal, community, and public policy levels that the SEM espouses. There is no way to operate independently as a farmer, the very success of the farm depends on relationships the farmer has at all five levels.

The SEM has been used in previous studies of farmworkers (Nguyen-Thi-Lan et al., 2021; Vamos et al., 2022). Nguyen-Thi-Lan et al. (2021) applied the SEM to understand farmers across seven provinces in Vietnam's perception of climate change, risk attitudes and the role of government. Farmers indicated that applying technology, protecting the land from erosion, and diversifying livestock were influenced by SEM levels and cited the importance of government initiatives in helping to mitigate climate impacts on farming. Another study by Vamos et al. (2022) exploring the success of a human papillomavirus immunization campaign for Hispanic migrant farmworkers, identified a number of potential barriers at the different SEM levels including parental approval, transportation, and community acceptance of the vaccine Other published perspective articles suggest that the SEM can be applied to clinical patients by nursing staff when treating for HRI during a heat event (Bernhardt & Amiri, 2024) and developing health policy interventions to improve total well-being (Rony & Alamgir, 2023). While there are not many examples in the literature applying SEM to farmers, the model is a widely accepted framework for developing behavior-change interventions and will be useful for understanding Virginia farmer's experiences within varying levels of influence.

Gaps in the Literature

Little is known about Virginia farmers' concerns regarding the impact of high heat and negative air quality on their physical and mental health and the viability of their farms. Studies of WFS are increasing, but significant gaps remain about the impact of WFS on the human body (Black et al., 2017; Davison et al., 2021). Knowledge gaps on the mental health risks of climate

change are higher in groups that face social marginalization (Parry et al., 2019). The few studies published in recent years that comment on WFS and mental health have been qualitative and focused on surveys or structured interviews (Hamideh et al., 2022; Mirabelli et al., 2022; Riden et al., 2020; Wadsworth et al., 2022) and many are international (Psarros et al., 2017; Psarros et al., 2018; Rodney et al., 2021).

Even less is known about the long-term effects of HRI and WFS and whether the body can recover from exposure to adverse conditions. There are a few published articles demonstrating the impact of prolonged heat or WFS in a community and the impact on health system utilization. Where studies do exist, they are not often replicated which makes it difficult to measure the reliability of results. Research on the impact of wildfires tends to be focused on communities that directly experienced the fire (Hamideh et al., 2022; Humphreys et al., 2022; Mao et al., 2022; Psarros et al., 2017). There do not appear to be any studies in the past decade that measure the combined impact of heat and wildfires smoke on the mental health of individuals in areas adjacent to a community affected by an extreme weather event.

Most of the research regarding exposure to HRI and WFS comes from the western U.S., where long dry summers result in conditions that allow for multiple wildfires that may burn for weeks or months, resulting in widespread WFS. While high heat and wildfires have always been present in the western U.S., the length and intensity are growing due to dramatic weather changes associated with climate change (Childs et al., 2022). In large portions of the western U.S. (California, Colorado, Nevada, Oregon, and Washington), the climate is Mediterranean, where it does not rain for six months of the year. Wildfires tend to occur in late summer after months of dried-out flora. With increased average annual temperatures, the wildfire “season” is starting earlier and lasting longer (World Health Organization, 2024a). In the past, the focus on

disasters and wildfires has been the physical destruction and economic recovery of the vulnerable communities affected by the wildfire (Hamideh et al., 2022; White & Haas, 1975).

The qualitative studies on working in high heat and WFS that have been conducted in the last five years have been concerned with understanding farmworkers' perception of risk when exposed to working in these conditions (Riden et al., 2020; Smith et al., 2021; Wadsworth et al., 2022). These studies have a common thread that farmworkers have anecdotally voiced concern about working in periods of high heat, poor air quality, and extreme weather patterns. Aside from the aforementioned study that looked at Iowa farmers impressions of climate change (Arbuckle et al., 2013), there have been no recently published studies focused on small farm owners who may have no choice but to do the work themselves. What is not known is whether the owners of small family farms in Virginia are taking steps to mitigate their exposure to heat and poor air quality. Further, there is a need to understand whether concerns farmers in Virginia have about heat, poor air quality, and other climate-related risks are impacting their own outlook toward their health and the viability of their farm.

There are no known studies of the combined impact of HRI, WFS, and mental health on farmers in Virginia. A search of the last ten years of articles of "heat related illness health risk" or "air quality health risk" to Virginia farmworker returned zero results. A qualitative exploratory study is necessary to gain insight into the current concerns of farmers in Virginia. There remains a gap in the knowledge of whether farmers in Virginia are currently concerned about HRI, WFS, and mental health impacts of climate change. There is a further gap in understanding the perspectives of the family farm owners themselves, who often do most of the work on their own farms.

Chapter Three: Methodology

Study Design

The proposed study followed a qualitative study design using semi-structured interviews to understand the perceptions of farmers in Virginia regarding the impact of extreme weather on their health. This is a phenomenological approach where the goal was to understand the lived experience and views of the participant (Pope & Mays, 2020). Thematic and interpretative phenomenological analysis (IPA) was used to analyze the data. IPA has been useful in studies to understand patient's experiences in accepting medication and treatment plans (Luna-Meza et al., 2021; Téllez-López et al., 2023) and was applied in this study to understand how farmers experience and interpret extreme weather patterns and their impact on their own health.

Participants

The following is a description of the inclusion and exclusion criteria used for participants.

Inclusion

Participants included farmers, key informants, and stakeholders. Farmers were defined as farmers who own or lease land and operate family farms located within the Commonwealth of Virginia. Large "corporate-owned" farms will be excluded. Key informants included those who had knowledge of Virginia farmer's experiences and resources available and included representatives from agriculture safety organizations such as the Farm Bureau. Key informants who hold government offices that directly affect Virginia farmers were also contacted. Stakeholders include those who have implemented or will implement public health initiatives or programs with Virginia farmers. Table 2 lists the potential participants that were invited to participate.

Table 2

Participant Invitees

Key Informant	Farmers	Stakeholders
• Secretary of Agriculture and Forestry for the Commonwealth of Virginia • Virginia Department of Agriculture and Consumer Services Commissioner • Farm Bureau Leadership • Virginia Beginning Farmer and Rancher Coalition leaders • Centers for Disease Control and Prevention National Center for Occupational Safety and Health / Agricultural Safety • USDA's National Institute of Food and Agriculture (NIFA) Farm Safety program	• Established/multi-generational farmers • Beginning farmers	• Virginia Department of Public Health • Cooperative Extension staff • Virginia Forestry Landowners leadership • Future Farmers of America

Participants were recruited using a purposeful sample, to ensure that key organizations and farmers that operate a farm in Virginia were included. The sample drew on established contacts within the Commonwealth of Virginia. In addition, snowball sampling was utilized, as needed, to identify additional participants who met the study criteria.

Exclusion

Farmers who work at large corporate farms were excluded from the study, as the research questions were focused on family-owned farmers. Farmers who are not yet 18 years old were

excluded from the study. Any farmer who does not reside in Virginia was excluded as the study is focused on farmers who are currently living on their own farm in Virginia. Key informants and stakeholders who do not work in Virginia or have occupational responsibility for farmers in Virginia were excluded. Key informants and stakeholders who do not have direct knowledge of the experience of farmers in Virginia were also be excluded. No more than one representative of each organization was selected to participate. The screening for exclusion took place during the informed consent process before the interviews were scheduled.

Institutional Review Board

Since the project involved interviewing human subjects, the project was submitted to Radford University's Institutional Review Board (IRB) for approval before any interviews were conducted. The IRB approved the project with approval number 2024-171 on January 6, 2025 (Appendix B). At the time of scheduling, each interviewee was given a copy of the informed consent document (Appendix C). Prior to the interview, each interviewee was asked for consent to participate in the study and have the interview recorded and coded. All the information was kept confidential and transcripts, once created, were deidentified. Only the interviewer and principal investigator had access to the raw data. There were no names or personal identifying information included in the final study. The participants were informed to contact the Principal Investigator with any concerns, and none were reported.

Research Procedures

Each potential participant was contacted by email and invited to participate in the interview as part of the study. Informed consent and study information was provided with the invitation. Once the participant agreed and provided consent, an interview was scheduled and conducted virtually through Zoom, via telephone, or in person. The interviews were scheduled at

times that were convenient for the participant. Participants did not receive compensation for their time or participation. The interview protocol is provided in Appendix A.

Interviews were limited to 30 minutes unless a key informant or stakeholder also had farming experience and wished to elaborate on their personal farming experiences. At the beginning of the interview, the interviewee was asked if they consented to recording. If the interviewee objected to recording, they were asked if they consented to handwritten notes. In the case where handwritten notes were created, the information conveyed was typed up immediately following the interview. A minimum of 15 interviews (five interviews for each of the three categories) was proposed. Each interview consisted of up to 11 questions for key informants and stakeholders and nine questions for farmers. Table 3 maps the interview questions for farmers to the research questions.

Table 3

Research and Interview Questions for Farmers

Research Question	**Interview Question**
RQ1: What experiences do farmers in Virginia have regarding extreme weather conditions (such as high heat and poor air quality)?	Question 2: **What concerns do you have about protecting yourself from the impacts of worsening weather conditions?** a. Probe: What types of changes have you seen in the conditions on your farm in your lifetime? b. Probe: What types of changes do you anticipate? c. Probe: Tell me about any concerns about working in high heat? d. Probe: Tell me about any concerns about working on days with poor air quality? e. Probe: Do you have similar concerns for your family?

	f. Probe: Do you have similar concerns for people you hire to work on the farm?
RQ2: What concerns do farmers in Virginia have about working outside within extreme weather conditions (such as high heat and poor air quality)?	Question 2: **What concerns do you have about protecting yourself from the impacts of worsening weather conditions?** a. Probe: What types of changes have you seen in the conditions on your farm in your lifetime? b. Probe: What types of changes do you anticipate? c. Probe: Tell me about any concerns about working in high heat? d. Probe: Tell me about any concerns about poor air quality? e. Probe: Do you have similar concerns for your family? f. Probe: Do you have similar concerns for people you hire to work on the farm?
RQ3: How is working in extreme weather conditions impacting Virginia farmers' health and well-being?	Question 5: **Have you ever been worried about the impact of climate change on your own health and well-being? What is it that you worry about?** g. Probe: Have you ever worried about the health of your family? Workers? h. Probe: Have you ever worried about the viability of your farm if climate change dramatically impacts the weather conditions?
RQ4: What actions are farmers in Virginia taking to protect themselves from the impacts of extreme weather conditions?	Question 3: **On days with high heat or poor air quality, what do you do?** a. Probe: What types of changes have you made under these conditions?

	b. Probe: What types of preventive measures have you taken? Question 4: **Have you ever been concerned about the impact of worsening weather conditions on the viability of your farm operations? What are some of your concerns?** a. Probe: Do you have any examples of actions taken to adjust your crops/animals, etc.? b. Probe: Do you have any concerns of an economic impact to your own farm due to extreme weather? Question 6: **How likely are you to take protective measures in the future? What would help encourage you to do so? What about other farmers in Virginia?** Question 8: **Are there any other thoughts or suggestions you have regarding farm safety while working outdoors that we did not have the chance to talk about?** (For example, is there anything you would want to share with a beginning farmer?)

Key informants and stakeholders' questions (Table 4) were focused on the experiences and feasibility of delivering health safety interventions to farmers. The questions were influenced by studies conducted by the Western Center for Agriculture Health and Safety (WCAHS) at the University of California, Davis (University of California Davis Office of Research, 2024b), which receives funding from the Center for Disease Control and Prevention/National Institute of Occupational Safety and Health. Researchers from the WCAHS are widely published in agricultural health safety (Pinkerton et al., 2000; Riden et al., 2020; Wadsworth et al., 2022). Heather E. Riden, Program Director for Agricultural Health and Safety in the Department of

Public Health Sciences and the Western Center for Agricultural Health and Safety at University of California, Davis, reviewed the questions and made suggestions prior to the commencement of interviews.

Table 4

Research and Interview Questions for Key Informants and Stakeholders

Research Question	**Interview Question**
RQ1: What experiences do farmers in Virginia have regarding extreme weather conditions (such as high heat and poor air quality)?	Question 3: **Have you had any experience with farm safety education? Please elaborate.** Question 4: **What concerns do you have about protecting farmers and farmworkers from the impacts of worsening weather conditions such as high heat and poor air quality?**
RQ2: What concerns do farmers in Virginia have about working outside within extreme weather conditions (such as high heat and poor air quality)?	Question 3: **Have you had any experience with farm safety education? Please elaborate.** Question 4: **What concerns do you have about protecting farmers and farmworkers from the impacts of worsening weather conditions such as high heat and poor air quality?**
RQ3: How is working in extreme weather conditions impacting farmers health and well-being?	Question 4: **What concerns do you have about protecting farmers and farmworkers from the impacts of worsening weather conditions such as high heat and poor air quality?** Question 6: **Are you concerned about the impact of changing weather conditions on farm viability within the Commonwealth of Virginia?**
RQ4: What actions are farmers in Virginia taking to protect themselves from the impacts of extreme weather conditions?	Question 5: **On days of high heat or poor air quality, what do you think the farmer should do to protect themselves and their farmworkers?**

	Question 10: **Do you have any other thoughts or suggestions that we did not get to talk about?**

At the beginning of each call, the interviewer read the script that is included in Appendix A. The script provides another opportunity to acknowledge consent to participate and to provide consent to be recorded. The interviews were conducted during January and February 2025. By conducting interviews in the winter months, there was a greater chance of reaching farmers. All interview transcripts and notes were stored in a secure cloud drive on the researcher's computer. If any handwritten notes are taken, they will be immediately scanned and saved to the cloud. Paper notes were retained and will be stored in a locked cabinet for three years following the study. Data analysis began in March of 2025.

Data Analysis

All interviews, with permission, were recorded, and the audio was converted to written transcripts using Otter.ai. The transcripts were then reviewed, and any transcription errors were corrected. Transcripts and any notes from interviews that were not recorded were typed and exported into the qualitative data analysis software Dedoose for further analysis. Thematic analysis was used to look for patterns and identify themes between participant responses that were interconnected. Thematic analysis has been useful in providing summary-level observations (Nowell et al., 2017). First, the data was sorted in a categorical fashion to sort the information by type of participant (e.g. farmers and key informants) and type of question. Since some of the key informants and stakeholders were also farmers, there was overlap in themes by type of respondent. Secondly, a phenomenological approach was taken to help understand how the

farmer is interpreting the impacts in terms of their lived experience as they relate to the identified themes (Wolgemuth et al., 2025).

The data analysis included four steps typically followed in thematic data analysis: data immersion, coding, categories, and themes (Green et al., 2007). The coding began by compiling the data from the interview transcripts then disassembling the data before reassembling and interpreting using codes and thematic analysis (Castleberry & Nolen, 2018). During the data immersion stage, the interview data was slowly and methodically reviewed to identify the essence of what each interviewee was communicating (Green et al., 2007). The data from the interview transcripts was loaded into Otter.ai (Otter.ai, 2024) and then Dedoose (SocioCultural Research Consultants, n.d.), and both software programs assisted in identifying coding, categories and themes.

Prior to beginning the coding process, deductive codes were created after consideration of HBM constructs and the SEM levels of individual, interpersonal, organizational, community, and public policy (Glanz et al., 2008). Prior to the deductive coding process, the HBM constructs were defined in the context of the present study

Table 5. Examples of adaptive work and PPE were created and applied to each HBM construct prior to deductive coding (

Table 5). The four research questions were developed by condensing the seven HBM constructs to four questions. Research Question 1 regarding the experiences were intended to gauge the perceived susceptibility and the barriers they face. Research Question 2 which asks about their concerns attempted to assess the perceived severity. Research Question 3 which asked what the farmers thought the impact had on their own health was intended to ascertain whether they saw benefits to practicing safe behaviors. Finally, Research Question 4 which asked what actions farmers were taking was intended to uncover what the cues to action and whether the potential for self-efficacy was present.

Table 5

Application of HBM to Farmers working in extreme weather conditions

Construct	Adaptive Work Behavior (avoiding heat or poor AIQ)	Use of Personal Protective Equipment (PPE) (including clothing)
Perceived Susceptibility	Farmers understand that exposure to high heat or poor AIQ can lead to health consequences	Farmers have had sun exposure or had trouble breathing when PPE was not utilized.
Perceived Severity	Farmers believe the consequences of exposure to heat, or poor AIQ are significant enough to change part of day they are working	Farmers believe that their health has been impacted on days that they were exposed to extreme weather conditions.
Perceived Benefits	Farmers believe shifting work patterns can prevent adverse health impacts	Farmers understand that the use of hats, protective clothing and/or masks can help protect their own health
Perceived Barriers	Farmers point out that they cannot always avoid the work. The cows must be fed, the crops must be harvested.	Farmers raise the issue that protective equipment can slow you down or make you uncomfortable. For example, wearing long sleeve shirt or mask on hot days can make you hotter and less effective.
Cues to Action	Farmers are aware of high heat advisory or poor AIQ warnings in weather apps or by radio announcements.	Farmers are aware of high heat advisory or poor AIQ warnings in weather apps or by radio announcements. Farmers add protective clothing or masks based on recommendations.
Self-Efficacy	Farmers receive guidance from local and farm authorities on how to protect themselves.	Farmers have received training to wear protective gear during extreme weather events.

Similarly, the SEM constructs were also applied to the study prior to coding (Table 6). Some of the interview questions were designed to solicit the participants opinion of how the farmer's lived experience fits within the SEM levels of influence. A deductive code book was created that incorporated both the HBM and SEM to anticipated responses.

Table 6

Application of SEM to Farmers working in extreme weather conditions

Construct	Adaptive Work Behavior (avoiding heat or poor AIQ)	Use of Personal Protective Equipment (PPE) (including clothing)
Individual	Farmers have their own belief that drives them to either ignore or act to prevent exposure to risky work conditions	Farmers have their own belief that drives them to either avoid or utilize PPE during high-risk weather conditions
Interpersonal	Farmers are influenced by family and friends to ignore risks or alter behavior	Farmers are influenced by family and friends to either avoid or utilize PPE during high-risk weather conditions.
Organizational	Farmers are influenced by their organizations such as Farm Bureau, Co-op, etc. to ignore risks or alter behavior	Farmers are influenced by their organizations such as Farm Bureau, Co-op, etc. to either avoid or utilize PPE during high-risk weather conditions
Community	Farmers are influenced by community and civic groups they belong to such as the church, Ruritans, in their approach to extreme conditions.	Farmers are influenced by community and civic groups they belong to such as the church, Ruritans, in their approach whether to utilize PPE during high-risk weather conditions.
Public Policy	Farmers are required by regulation to adapt their workday	Farmers are aware of government initiatives and regulatory actions to promote use of PPE to avoid health risks

As the interviews were analyzed, inductive coding was used to identify other patterns that emerge from the data (Nowell et al., 2017). IPA was applied to understand the farmer's own lived experience. By using IPA, the experiences were analyzed without preexisting preconceptions, and the experiences themselves gave rise to the codes and themes. The codebook was adjusted to include inductive codes.

Once initial codes were ascribed to comments made by the interviewees, the code information was then be sorted into categories. The categorization process was a form of synthesis where the individual codes were mapped to categories (Saldaña, 2009). During the coding process, it was as if you are building an outline in reverse, where the initial codes were the finer details grouped into categories (Saldaña, 2009) Finally, the categories were synthesized into themes (Pope & Mays, 2020). Themes are the overall major summary phenomenon of the research, usually something that was a recurring idea that was observed (Pope & Mays, 2020)

Limitations

This project is exploratory in nature, and the results was limited by the responses given by participants and the ability to aggregate meaningful results. Due to the limited interviewing capacity and the scope of the capstone project, there were not enough participants to allow for a comparative analysis of responses by farmers, informants, and stakeholders with different characteristics. Farmers were considered a homogeneous group in the present study. There was no attempt to separate out different types of farmers who may have different amounts of exposure to outdoor work or varying intensity of work. For example, a farmer who goes out twice a day to check on and feed cattle could have significantly less exposure than a farmer who must go out and harvest a strawberry crop all day in the heat of the summer. Farms in different regions and elevations of the Commonwealth may experience different weather conditions and may have had varied exposures to weather related risks.

The project used a purposeful sample, which is a non-probability sampling method that can be viewed as a limitation. Convenience samples, another form on non-probability sampling methods are often questioned on the basis that they are not as externally valid as a representative sample that is randomly drawn from the population (Andrade, 2021); however, others have

shown that convenience samples can have no measurable differences from the population under study (Ellis et al., 2023). By involving three types of participants, limitations due to the non-probability sampling design were designed to be minimized.

Researcher bias is another limitation. The fact that one researcher conducted all the work independently does not allow for cross-validation of the interview technique. The researcher conducting the interviews and analyzing the data had personal experience as a farmer in Virginia with three years of experience working on the farm in the adverse conditions under study. Subsequent studies may wish to involve multiple researchers, perhaps some with greater or less experience with farming.

Delimitations

As the proposed study participant was limited to farmers in Virginia, it may not be generalizable to other states or other regions of the country. Because the intended participant for the study is a family-owned farm, the results may not apply to larger corporate-scale farms. Within Virginia, there is a wide variety of microclimates due to variability in geography, which could limit generalizability. For example, a farmer's experience in the mountains at 2,000 feet above sea level could be very different than that of a farmer who lives in a coastal area just above sea level. The study was conducted in the winter to capture as many farmers as possible during the months when they experience less activity. Future studies may wish to contact the farmer at multiple points in the year to minimize any responses due to seasonality or limited recall.

Timeline

The following was the timeline for the project.

Activity	Date
Proposal Defense	December 4, 2024
IRB Review Submitted	December 19, 2024
IRB Approval Issued	January 6, 2025
Interviews Conducted	January 30– February 2025
Data Analysis	March 2025
Writing Final Paper	April 2025
Capstone Final Defense	May 2025

Conclusion

This chapter discussed the research method for investigating the lived experiences of farmers in Virginia as related to working in extreme weather conditions associated with climate change. Farmers, key informants and stakeholders were interviewed, and their transcripts were reviewed and analyzed during a data immersion phase. Then the information was organized through the qualitative process of coding, categorizing and theme identification using an IPA perspective. The results will be presented in a dissertation report and presentation along with discussion and conclusions.

Chapter 4: Results

Introduction

To gain an understanding of the experiences of farmers in Virginia, interviews were conducted with farmers and key informants. The interviews were semi-structured, and questions were designed to answer the four research questions: What are the experiences of farmers in Virginia with working in extreme conditions? What are their concerns? Do they think working in extreme weather is impacting their health & well-being? And what actions are they taking to protect themselves? As presented in Chapter 3, the research questions were based on the seven HBM constructs. In addition, within the probing questions, the participants were asked to share who they thought had the greatest influence on their decision-making, which is a method of understanding how the farmers' lived experience falls within the SEM constructs.

Once the interviews were complete and the answers were coded, phenomenological approach was taken, allowing the initial codes to be mapped to categories, which were then synthesized into themes (Nowell et al., 2017; Pope & Mays, 2020; Saldaña, 2009; Wolgemuth et al., 2025). In other words, what were the farmers really saying? This chapter will provide an overview of the data collection process, analysis, and results. The results are presented in the context of the themes that were created. A discussion of the themes in relation to the research questions will be presented in Chapter 5.

Descriptive Findings

Twenty-nine potential participants were contacted via email and invited to participate in the study. Of the 29 potential participants, 17 participated in a recorded interview, for a response rate of 58.6%. The recruitment rate is reflected in Table 7. One potential stakeholder participant declined because they were no longer working with farmers. The other 11 potential participants

either did not respond or, in the case of a few key informants and stakeholders, referred one of their colleagues for participation. None of the USDA or OSHA invitees responded to invitations to participate.

Table 7

Participant Recruitment Results

Role	Invited	Participated	Percentage
Farmer	9	7	77.8%
Key Informant	13	6	46.2%
Stakeholder	7	4	57.1%
Total	29	17	58.6%

Seventeen participants were interviewed during 15 interviews (two of the interviews included two participants at the same time). Of the total participants, 15 had experience with or were actively farming in nine different counties in Virginia: Albemarle, Augusta, Bedford, Botetourt, Cumberland, Floyd, Greene, Montgomery and Pulaski. The farmers were clustered in Central Virginia and there was a significant cluster of key informants in the New River Valley due to the affiliation and presence of Virginia Tech, the land-grant university that houses the Virginia Co-operative Extension Service.

A total of 395 minutes or 6.6 hours of interviews were transcribed. The transcripts were created using Otter.ai, manually reviewed for accuracy, and loaded into Dedoose to be coded, enabling a detailed analysis and review. A total of seven farmers were interviewed. The interview length of each farmer participant ranged from nine minutes to 27 minutes, the six key informants ranged from 23 to 63 minutes and the stakeholders ranged from 14 to 22 minutes (Table 8). Eight of the 10 key informants and stakeholders were actively engaged in farming in addition to their professional role. Throughout this section, when farmers are mentioned, it refers to the seven farmer participants, and key informants to the six key informants and stakeholders to

the four stakeholders. If participants are used as a descriptor, it refers to all three participant roles combined.

Table 8

Participant Role, Location and Interview Length

Descriptor Role	Title	Interview Length	Engaged in Farming?
Farmer	Farmer	15	Yes
Farmer	Farmer	15	Yes
Farmer	Farmer	11	Yes
Farmer	Farmer	22	Yes
Farmer	Farmer	27	Yes
Farmer	Farmer	9	Yes
Farmer	Farmer	13	Yes
Key Informant	Farm Bureau Volunteer	31	Yes
Key Informant	VT Safety Instructor	29	Yes
Key Informant	VT Safety Instructor	29	Yes
Key Informant	VT Agriculture Professor	39	Yes
Key Informant	VT Agriculture Staff	23	No
Key Informant	Department of Agriculture & Consumer Services Staff	63	Yes
Stakeholder	Co-operative Extension Agent	17	Yes
Stakeholder	FFA	16	Yes
Stakeholder	FFA	14	Yes
Stakeholder	VDH Health Director	22	No

Note: The order of interviews was randomized for this table and titles have been simplified to provide confidentiality.

Data Analysis Procedures

The process of data analysis included the following steps, each of which will be discussed in further detail:

1. The interview notes were compared to the recordings.
2. The interviews were played while reading the transcripts created by Otter.ai to correct any transcription errors.
3. The interviews were re-read to gain an overview of the major ideas presented in each.
4. A codebook was created using deductive codes based on the interview protocol.
5. The deductive codebook was loaded into Dedoose, and interview excerpts were coded.
6. Inductive codes and categories were added, and excerpts were recoded after more iterative analysis.
7. Themes emerged from the initial coding.
8. The parent and child codes were mapped to the themes to visualize the interrelationships between codes and themes and allow for graphic analysis.

The data analysis process began by reviewing all interview notes and transcripts in detail. During the first read of the interviews, care was taken to correct transcription errors by the software Otter.ai. This was accomplished by re-listening to the interviews and correcting minor errors introduced by the software. During the second review, the interviews were re-read to gain a high-level understanding of the major topics discussed.

Codebook Development

Before loading the interviews into Dedoose for detailed analysis, a codebook was created based on deductive findings from the literature. Because the interview guide was based on research questions, potential categories were created within the context of the research question and the HBM and SEM constructs. As discussed in Chapter 3, the four research questions were created by combining seven HBM constructs. Before developing the codebook, the each research questions was condensed to one word, which then became categories for the codebook: experiences (RQ1), concern (RQ2), impact (RQ3), and actions (RQ4). The SEM constructs were coded to the category barrier in the deductive codebook. Table 9 illustrates how the theoretical framework was applied to develop the potential categories for the codebook.

Table 9

Theoretical Framework Applied to Create Categories for the Codebook

Potential Category	HBM Construct	SEM Construct
1. Experiences (RQ1) a. Awareness b. Barriers	Perceived Susceptibility Perceived Barriers	Influences: • Individual • Interpersonal • Organizational • Community • Public policy
2. Concerns (RQ2) a. Stress b. Isolation c. Farm Viability d. Worry	Perceived Severity	
3. Impact (RQ3) a. Health b. Well-being	Perceived Benefits	
4. Actions (RQ4) a. Protective Behavior b. Work Adaptation	Cues to Action Self-Efficacy	

The categories derived from the theoretical and research question context were then developed into a codebook with parent and child codes. The parent and child codes were deduced from the literature review.

Table 10

Codebook with Deductive Codes

Child Code	Parent Code	Category
Exhaustion	Heat	Awareness
Injuries	Heat	Awareness
Sun Exposure	Heat	Awareness
Dust	Air Quality	Awareness
Wildfire Smoke	Air Quality	Awareness
	Compliance	Barrier
	Time	Barrier
	Work Must go on	Barrier
	Self	Influence
	Interpersonal	Influence
	Organization	Influence
	Community	Influence
	Public Policy	Influence
	Farm Viability	Concern
	Isolation	Concern
	Stress	Concern
	Health (physical)	Impact
	Well-being (mental health)	Impact
	Clothing	Protective Behavior
	Hat	Protective Behavior
	Mask Eye Ear (PPE)	Protective Behavior
Avoid Heat	Adjust Work Time	Work Adaptation
Early or Late	Adjust Work Time	Work Adaptation
Shade	Breaks	Work Adaptation
Water	Breaks	Work Adaptation
Tools	Equipment	Work Adaptation
	Minimize Exposure	Work Adaptation

All of the deductive codes were loaded in the Dedoose codebook. A detailed analysis of the interviews was then conducted, and responses were marked and recorded based on the deductive codebook. During this phase, the interview transcripts were reviewed line by line and phrase by phrase. Significant phrases were marked as excerpts and coded to one of the child or parent codes in Table 10.

After the first round of in-depth coding in Dedoose, additional codes were identified. When a concept was repeated by multiple participants, a new inductive code was created, added to the codebook and the interview transcripts were reviewed again to apply the newly added codes. As analysis continued, the coding process became immersive, and additional codes were added and some categories renamed or shifted to better reflect what the interviewee was communicating. The inductive codes included: *Cold, Drought, Generational Differences, Family, Other Farmers, Co-op, Farm Bureau, FFA, Virginia Tech, Worry, Hacks, Work Less and AC Cab.* The inductive codes were added to the codebook and were bolded in a combined deductive and inductive codebook (Table 11). The category *Influence* was renamed to *Trust* to reflect the fact that when participants were asked who they would look to as a credible source, they repeatedly used the word, *Trust*.

Table 11

Codebook with Deductive and Inductive Codes (Inductive are Bold)

Child Code	**Parent Code**	**Category**
Exhaustion	Heat	Awareness
Injuries	Heat	Awareness
Sun Exposure	Heat	Awareness
Dust	Air Quality	Awareness
Wildfire Smoke	Air Quality	Awareness
	Cold	Awareness
	Drought	Awareness
	Compliance	Barrier
	Generational Differences	Barrier
	Time	Barrier
	Work Must go on	Barrier
	Self	**Trust**
	Family	**Trust**
	Other Farmers	**Trust**
Co-op	Organization	**Trust**
Farm Bureau	Organization	**Trust**
FFA	Organization	**Trust**
Virginia Tech	Organization	**Trust**
	Community	**Trust**
	Public Policy	**Trust**
	Farm Viability	Concern
	Isolation	Concern

	Stress	Concern
	Worry	Concern
	Health (physical)	Impact
	Well-being (mental health)	Impact
	Clothing	Protective Behavior
	Hat	Protective Behavior
	Hacks	Protective Behavior
	Mask Eye Ear (PPE)	Protective Behavior
Avoid Heat	Adjust Work Time	Work Adaptation
Early or Late	Adjust Work Time	Work Adaptation
Work Less	Adjust Work Time	Work Adaptation
Shade	Breaks	Work Adaptation
Water	Breaks	Work Adaptation
Tools	Equipment	Work Adaptation
AC Cab	Equipment	Work Adaptation
	Minimize Exposure	Work Adaptation

After the inductive coding was applied, the interviews were reviewed in detail a second and third time. Dedoose enables dynamic analysis, allowing the code counts and tables to be "drilled down" to view every phrase that comprises the code. This allowed continuous testing to ensure that the codes were applied correctly. Some phrases or excerpts were coded to more than one category. For example, if the interviewee discussed health and well-being in the same excerpt, that excerpt might be coded to both the health and the well-being parent codes. The parent code would only count the unique excerpt. Conversely, if the interviewee discussed *trust,* but did not elaborate on which organization it trusted, there may be more excerpts counted at the trust parent code than there were at the specific child codes such as *Self, Family,* etc.

During the review process in Dedoose, the categories were also subject to review and realignment as the themes emerged. During the project, it became clear that some of the categories should be renamed (for example *Influence* was renamed to *Trust* to better reflect the interview discussion). Some of the categories that were thought to be distinct such as "concerns for" versus "impacts on health" were talked about together so frequently, they were combined to form a new theme that encompassed both. in a single theme. Once the categories were finalized, the information was reviewed again to understand the emergent themes.

During this iterative process, five significant themes were identified: *Farm work continues in extreme weather*, *Compliance is hard, Trust in self, Co-op and the Farm Bureau*, *Impact on health and well-being* and *Changes to the work*. The final codes, categories, and themes are included in Table 12. The themes will be discussed in further detail in the results section.

Table 12

Codebook including Final Codes, Categories and Themes

Child Code	Parent Code	Category	Theme
Exhaustion	Heat	Awareness	Farm work continues in extreme weather
Injuries	Heat	Awareness	
Sun Exposure	Heat	Awareness	
Dust	Air Quality	Awareness	
Wildfire Smoke	Air Quality	Awareness	
	Cold	Awareness	
	Drought	Awareness	
	Compliance	Barrier	Compliance is Hard
	Generational Difference	Barrier	
	Time	Barrier	
	Work Must go on	Barrier	
Self	Influence	Barrier	Trust in self, Co-op and the Farm Bureau
Family	Influence	Barrier	
Other Farmers	Influence	Barrier	
Community	Influence	Barrier	
Public Policy	Influence	Barrier	
	Farm Viability	Concern	Impact on Health & Well-being
	Isolation	Concern	
	Stress	Concern	
	Worry	Concern	
	Health (physical)	Impact	
	Health (mental health)	Impact	
	Clothing	Protective Behavior	Changes in the Work
	Hat	Protective Behavior	
	Hacks	Protective Behavior	
	Mask Eye Ear (PPE)	Protective Behavior	
Avoid Heat	Adjust Work Time	Work Adaptation	
Early or Late	Adjust Work Time	Work Adaptation	
Work Less	Adjust Work Time		
Shade	Breaks	Work Adaptation	
Water	Breaks	Work Adaptation	
Tools	Equipment	Work Adaptation	
AC Cab	Equipment	Work Adaptation	
	Minimize Exposure	Work Adaptation	

Data Analysis Using Dedoose

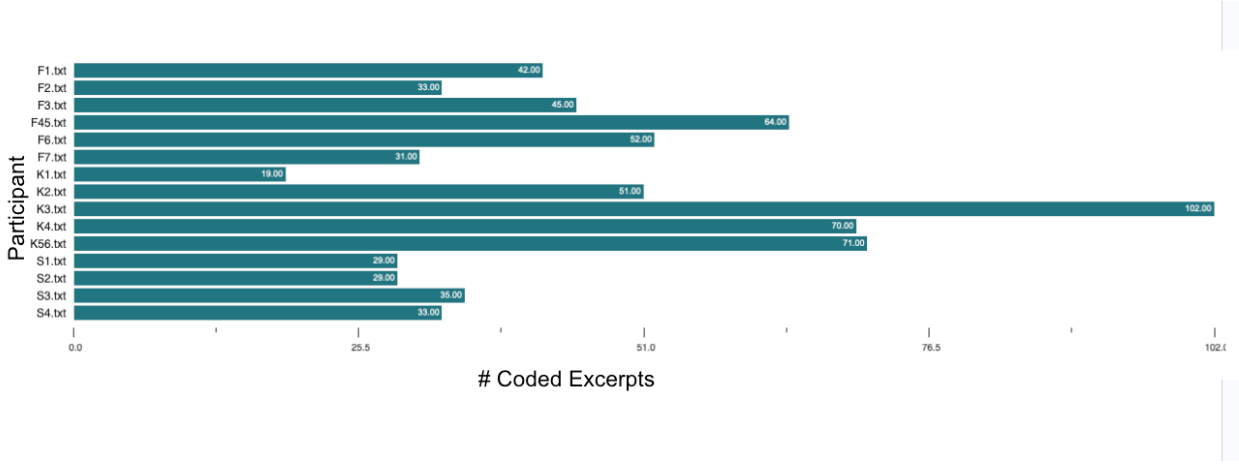
Once the codes, categories and themes were loaded in Dedoose, line-by-line coding was used to organize the data by codes for analysis. Summary information was reported by child code, parent code and category. Beyond the reporting, the primary purpose of reviewing the coded information was to sort, sift, cross-reference and begin to observe themes emerging from the information. There was a total of 44 codes and 475 excerpts once this part of the analysis was complete. An excerpt was a phrase or sentence that was marked and coded to one or more of the 44 codes.

The following six figures are examples of Dedoose analysis outputs used during the thematic analysis process. Each of these six figures is provided within the text for context, with a larger figure available in Appendix D. The figures in Appendix D are identified as D1, D2, etc.

Figure 1 shows the number of times a code was applied to each of the 15 interviews and ranged from 19 codes to 102 codes. Note that interview F45 was one interview that included both farmers 4 & 5, interview K56 was one interview that included both key informants 5 & 6. A larger copy is located in Appendix D and labeled Figure D1.

Figure 1

Code Count by Interview Transcript



An excerpt of the number of code case counts for each of the three roles is displayed in Figure 2. The complete Figure is located in Appendix D and labeled Figure D2. Case count is best thought of as how many times a concept was mentioned. This graphic shows how many times a code was applied to each role. For example, the *Cold* was mentioned eight times by the farmers, 12 times by key informants and two times by the stakeholders.

Figure 2

Code Case Count by Participant Role

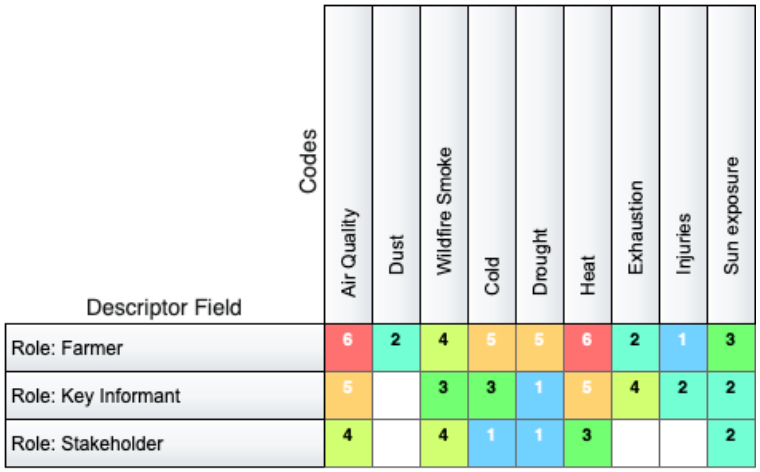
Descriptor Field \ Codes	Air Quality	Dust	Wildfire Smoke	Cold	Drought	Heat	Exhaustion	Injuries	Sun exposure
Role: Farmer	11	3	7	8	10	28	4	2	7
Role: Key Informant	6		4	12	7	28	6	5	9
Role: Stakeholder	11		11	2	1	9			3

An excerpt of the number of code counts for each role, which refers to whether or not the topic came up for each role is displayed in

Figure 3. The complete Figure is located in Appendix D and labeled Figure D3. The total number of code counts will never exceed the number of participants in each category. For example, the *Co-op* was mentioned by three of the farmers, four of the key informants and three of the stakeholders.

Figure 3

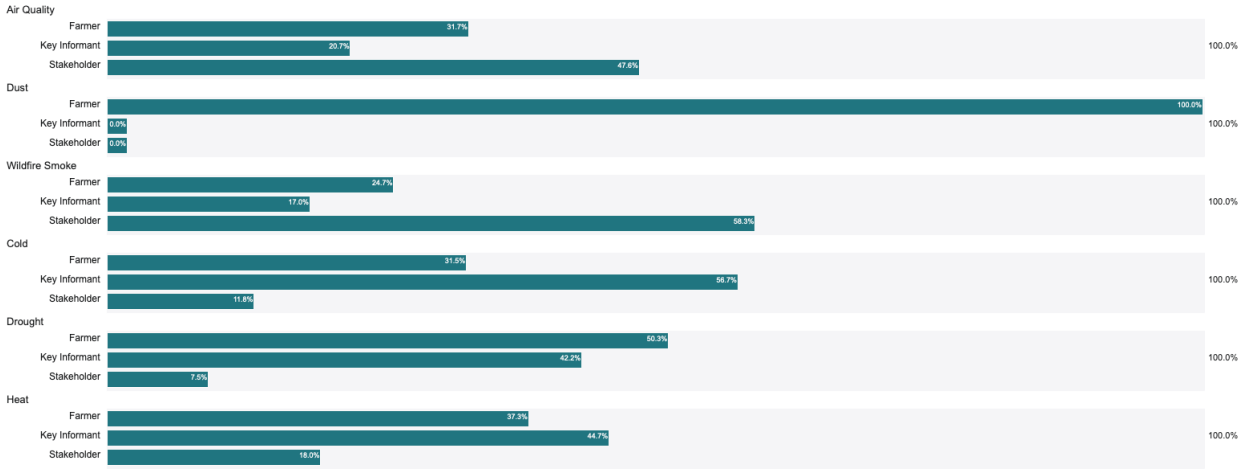
Code Count by Participant Role



The Code Discussion Percentage by Participant Role (Figure 4) is sample of the responses related to extreme weather conditions. The complete Figure is located in Appendix D and labeled Figure D4. This graphic which is provided for all of the codes in the appendix, shows the portion of the role categories by code to provide a visual of which role discussed each code the most. In this excerpt, it is clear there are differences in how often each code was mentioned by participant role. For example, 24.7% of the *Wildfire smoke* codes came from farmers, while 17% were from key informants and 58.3% from stakeholders. While these tools can help in the analysis, it should be noted that all but two of the key informants and stakeholders were also farmers, so the participant descriptors are not mutually exclusive.

Figure 4

Code Discussion Percentage by Participant Role

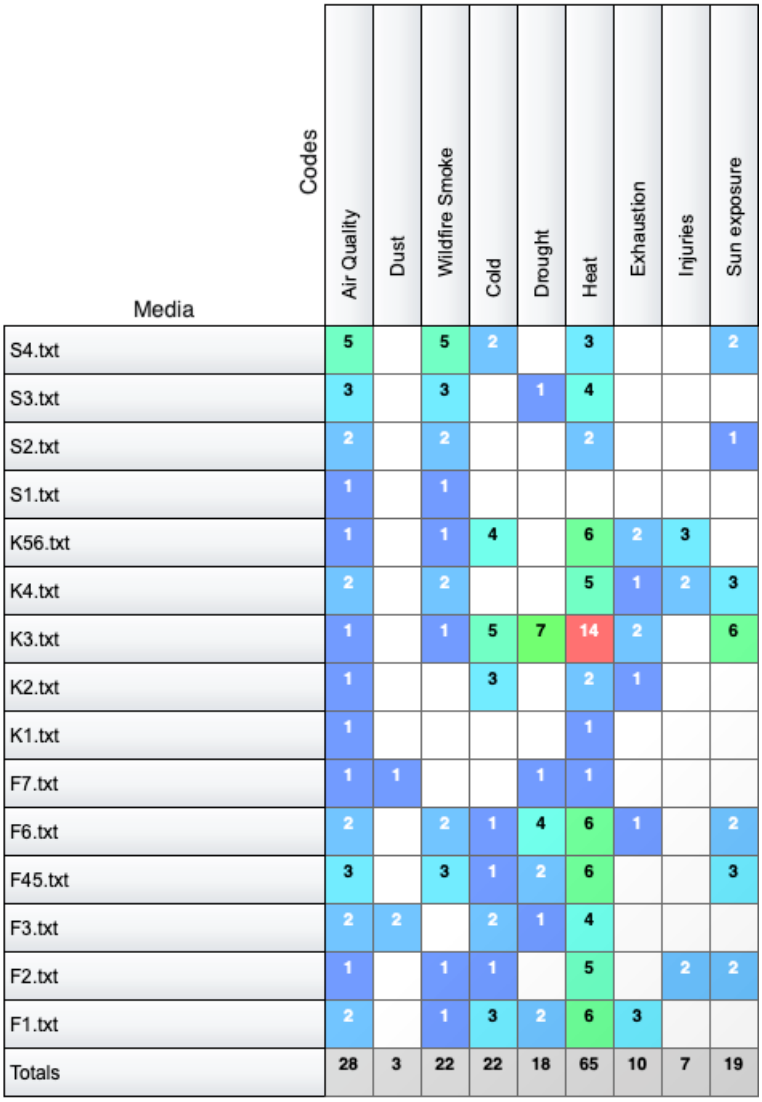


The Code Application by Interview excerpt (

Figure 5) shows how many times each code was applied to an interview for codes related to weather conditions. The complete Figure is located in Appendix D and labeled Figure D5. This was useful to visually depict the codes that were most often applied and brought attention to those codes that were used very little or not at all. For example, every participant mentioned *Air quality*, all but one participant mentioned *Heat*, and a type of action taken (*Adjust Work Time* or *Breaks)*, but not all of the participants mentioned *Health* or *Stress*. None of the 17 participants talked about *Isolation*.

Figure 5

Code Application by Interview

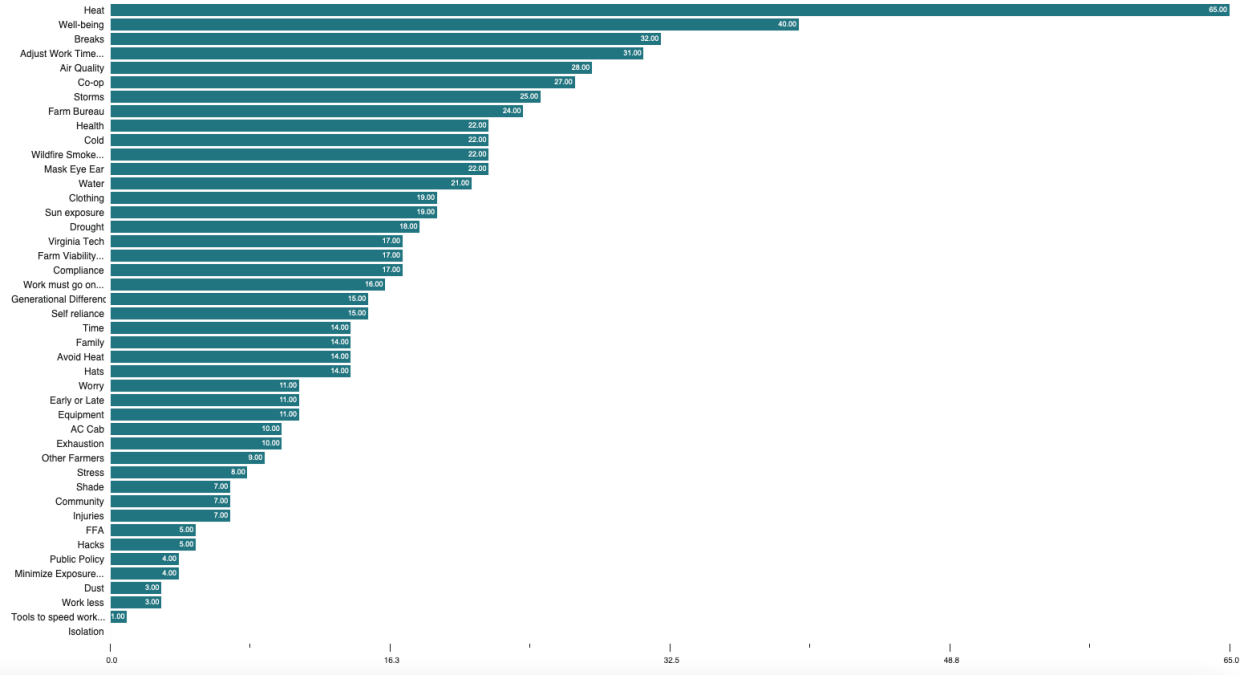


Media \ Codes	Air Quality	Dust	Wildfire Smoke	Cold	Drought	Heat	Exhaustion	Injuries	Sun exposure
S4.txt	5		5	2		3			2
S3.txt	3		3		1	4			
S2.txt	2		2			2			1
S1.txt	1		1						
K56.txt	1		1	4		6	2	3	
K4.txt	2		2			5	1	2	3
K3.txt	1		1	5	7	14	2		6
K2.txt	1			3		2	1		
K1.txt	1					1			
F7.txt	1	1			1	1			
F6.txt	2		2	1	4	6	1		2
F45.txt	3		3	1	2	6			3
F3.txt	2	2		2	1	4			
F2.txt	1		1	1		5		2	2
F1.txt	2		1	3	2	6	3		
Totals	28	3	22	22	18	65	10	7	19

In Figure 6, the code counts were sorted in descending order to determine what topics were discussed the most often by the participants, as well as the least mentioned topics. A larger copy is located in Appendix D and labeled Figure D6. *Heat* was coded most often at 65 times and *Well-being* was coded second most frequently at 40 times, followed by *Breaks* at 20 times, *Adjust Work Time* at 31 times, and *Air Quality* at 28 times.

Figure 6

Code Counts in Descending Order



Results

As previously mentioned, five themes were identified once the data analysis was complete: *Farm work continues in extreme weather, Compliance is hard, Trust in self, Co-op and the Farm Bureau, Nothing we can't handle* and *Changes to the work.* The following will further introduce each theme. Selected differences in coding are presented graphically to provide a visual representation of the differences, though not every line item will be discussed in detail. Where it is meaningful, further discussion of differences between farmers, key informants, and stakeholders are included. As previously noted, the roles are not mutually exclusive, as 15 of the 17 total participants were also experienced in or actively engaged in farming.

Direct quotations are included to allow for participant voice and enable them to tell the story in their own words. The quotations were labeled according to a randomized identifier that

has no relationship with the order of the previous participant figures and tables. Farmers were identified as F1, F2, etc., key informants as K1, K2, etc. and stakeholders as S1, S2, etc. to show the type of participant that was quoted. The quotations were selected because they were the best match for the theme or supporting evidence, although an intentional effort was made to ensure that a farmer's quote was matched to each concept.

Theme 1: Farm work continues in extreme weather

All the farmers acknowledged that the weather is the number one factor in their success, while at the same time acknowledging that farm tasks continued regardless of the extreme conditions. Farmers, key informants and stakeholders all acknowledged that extreme weather was making it harder to work. Most often, the farmers reported the challenges of working in the heat, and all but one of the farmers discussed heat in conjunction with drought.

However, there was not always a direct connection between recent extreme weather conditions and climate change. Only one of the farmers used the term climate change in a sentence, while the terminology was more often used by key informants and stakeholders. All participants acknowledged that the weather was getting more intense in recent years compared to their lifetime of work, stating:

> You're talking about a small farm. So, you know, you are at the mercy at times of the weather. You need rain for hay to grow. You need rain if you're growing corn. You need rain for your pasture should grow. So, you know, you are somewhat at the limitations of Mother Nature in that way. (F7)

A key informant commented on the challenge of continuing to work safely no matter what the weather brings:

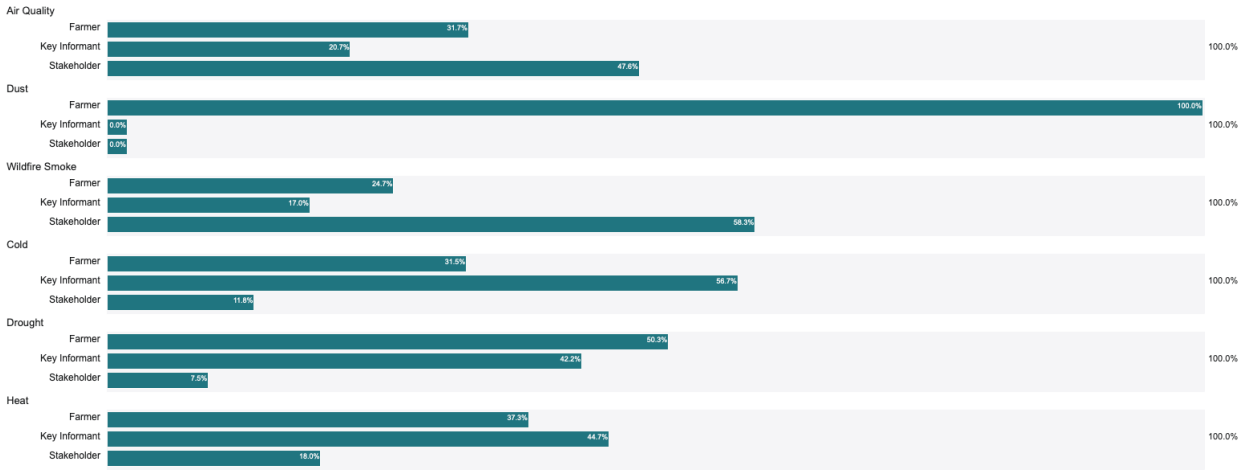
> I think we are seeing more instances of more extremes, and that could be what heat, cold, wind, you know, rain, whatever it might be, drought, we've got to be more in tune with how we prepare ourselves for extremes and the ability to work in them. (K3)

Another key informant commented that people working with farmers need to do more to support the farmer who is working in the weather, “Climate is very much of a concern from, you know, the farm gate to, I think, a larger landscape of, how do we support the people who actually are making the food in which we all rely on” (K4).

Figure 7 illustrates selected codes that contributed to this theme. Stakeholders discussed wildfire smoke more than any other group, and only farmers discussed dust. All of the groups commented on the extreme weather conditions.

Figure 7

Selected code occurrence by participant role within Farm work continues in extreme weather theme



Heat

There was a strong awareness of the challenges of working in the heat. In fact, heat was the most often referenced code. The following quote, which was a response to the very first

question, “what concerns do you have about working in extreme weather?”, is indicative of how all of the farmers discussed heat, “Probably the biggest concern is heat in the summertime” (F2). Even though the interviews were conducted in the dead of winter, heat was repeatedly mentioned as a challenge. The farmers reported being aware that not taking care of themselves during periods of high heat can have personal health consequences, and two shared personal experiences with skin cancer, and one recounted a period of heat exhaustion.

As they discussed the heat, they were quick to offer up their solutions and workarounds which left the impression they had it under control. There was general acknowledgment that the work had to be done, so the heat was part of the job. However, many admitted that the smaller farms in Virginia do not always require constant oversight, so that some of the work can be scheduled. For example, two farmers commented that cattle on a small farm may require daily attention, but the farmer can choose when to perform necessary tasks.

The haying process involving mowing and baling was the most common concern, from a heat perspective, mentioned by five of the six farmers. The farmers commented that harvesting hay has to take place in the dead heat of summer. One of the stakeholders commented that the conditions for the best time to harvest (hot, dry) are often the worst times for human health.

> You know, the farming still has to happen. No matter the temperature, you still have to be out there. And you know, I really worry about some of the farmers who are using some of these open cab tractors who are out there making hay when it's 100 and some odd degrees and 70% humidity. (S3)

Another stakeholder could not talk about heat without also mentioning heat stroke, saying, “Really concerned about the short-term health heat stroke, that would be, something that we

would, we would want to educate about and be concerned with extreme weather events that create different exposures and issues" (S4).

Air Quality & Wildfire Smoke.

There was less awareness about air quality and the dangers of wildfire smoke among farmers. When air quality came up, four of the farmers acknowledged it had been present: however, two of the farmers viewed air quality only as related to the general dust and allergen exposure on the farm. As noted in Figure 7, only the farmers discussed dust. When wildfires were mentioned, it was usually dismissed as being short duration and inconsequential. Wildfire smoke was perceived as something that was a "haze" (F4) and really not a problem for the farmer who had work to do on the ground because it "was organic mostly" (F5).

One farmer acknowledged the risk of inhaling dust during dry conditions when it was more apt to be in the air, saying, "Everything we drive the tractor through, you know, we change air filters out fairly regularly, keeping them cleaned and everything else. But in the same boat, you're breathing all that stuff in at the same time" (F3). If the farmer was concerned about air quality at all, they typically viewed it as a lesser concern than the work that needed to be done.

In a few cases, farmers suggested they would simply try to get their work done faster if there was poor air quality due to wildfire smoke. There did not appear to be a consistent understanding of the health risks associated with inhaling particulate matter from wildfire smoke. Only three of the key informants discussed wildfire smoke, and then only briefly. A stakeholder commented on the risk of wildfire smoke and thought out loud about the challenges:

> Yes, that would be another huge one for sure. Because that's one that you couldn't get away from, even if you're, if you're [sic] in your truck, if you're feeding, you know, it's not practical to wear a K95 or N95 mask. (S3)

Extreme Cold.

There was considerable discussion about the increasing bouts of extreme cold. Farmers recognized that like the heat, the cold spells were getting more intense and more frequent in recent years. Five of the six farmer interviews noted the challenge of working in the cold and keeping their body heat regulated. One farmer noted, “when the cold is there, you have to have the right clothing and bundled up to get out there and do what you have to do anyway” (F1).

While only three of the key informants discussed the cold, the ones that did, talked about it at length. They recognized that cold can also lead to accidents and injuries due to impaired judgement or the need to work faster to stay warm. One of the key informants mentioned that cold could also contribute to more intensified injuries due to how the body experiences cold, “You have to dress appropriately, and you have to make sure that you're taking care of yourself and being safe at all times” (K3).

Drought.

Drought was mentioned in five of the six farmer interviews. The farmers understood that in a period of drought their susceptibility to dehydration may be increased or they may work longer than they should and not realize the effect of the dry heat on their body.

When asked about their concerns about farm viability, one farmer commented that the viability of a small farm can also be more significantly impacted by a period of drought, which may lead the farmer to do more work to preserve what they have during a time that can be dangerous to their own health. Three farmers mentioned a difficult drought in parts of Virginia in 2024 that led to an inability to grow their hay. Two of the farmers remarked how this led to a scramble to purchase hay at above market prices from neighboring areas. This was also affirmed

by one of the key informants, who added, “I think we are seeing some extremes in temperature, but also in drought, in ways that we haven't seen much before” (K3).

Storms.

The direct line between the dangers of a storm and health threats was articulated by several participants. Five of the key informants and two of the stakeholders talked about storms repeatedly. Only two of the farmers raised the issue of storms. It was sometimes difficult to determine whether the farmers were thinking of the risk to their health or that of their animals and crops, as indicated by the following quote, “my brother in law's a produce farmer, and, you know, he has lost entire crops from weather events, hurricanes” (F4).

Two of the key informants cited the recent tragedy where a farmer in Southwest Virginia was killed by a piece of his barn during Hurricane Helene. The key informants also pointed out that farmers are often under more pressure to get out as the storm is coming and secure their animals and property so may be less apt to heed public health warnings to stay indoors. Two key informants who work in farm safety education shared the challenges of reaching the farmers and changing their behaviors to stay out of harm’s way during a storm. They lamented how farmers often do not heed the warnings, stating, “We gave them the situation: You're under severe thunderstorm warning or something. What do you do differently? And the universal answer was not a daggum [*sic*] thing” (K5).

Throughout all the comments and codes compiled into this theme, it was apparent that farm work continues in extreme weather conditions.

Theme 2: Compliance is hard

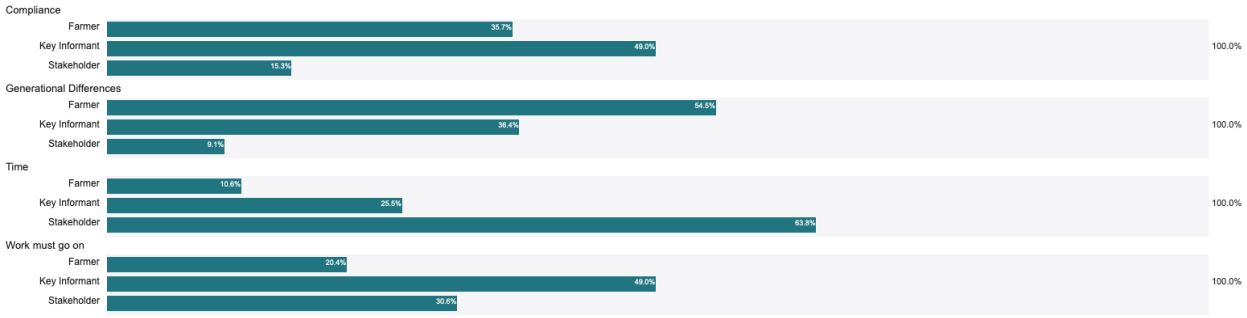
As the farmers discussed their experiences, a second theme emerged: *Compliance is hard.* Significant impediments to safe behavior included generational differences, compliance

challenges with PPE and protective clothing, the time necessary to slow down and comply and the challenge that the work continues to go on. The key informants and stakeholders appear to be more concerned about *time* and the *work must go on* than the farmers (

Figure 8).

Figure 8

Selected code occurrence by participant role within Compliance is hard theme



Generational Differences.

Several farmers and key informants conveyed that one challenge lies in reaching the older generation of farmers. Convincing someone to change their work pattern when they have been doing something a certain way for 50 years was often cited as an uphill battle. At least one of each of the roles, farmer, key informant, and stakeholder, admitted it would be tough. A key informant commented: “Many of them will not use PPE because they did not witness their elders wearing it, saying: No, my uncle, my grandpa, they have been working on the farms. Nothing happened.” (K6). A stakeholder stated: “I think that traditional farmers think they're invincible, and so it's very hard to get them to take some of this seriously, whereas some of the newer farmers, they are more receptive to some of this information.” (S3)

Two farmers mused that younger or beginning farmers may be more receptive to the message, stating:

> If you look at how many farmers are, newer generations are college educated, gone to Virginia Tech or Penn State, you know, some of the bigger, ag schools, I bet you find a holistically different approach to the things that you're thinking about here than the ones that are like, you know, Daddy was the farmer, and I got out of high school, if I did, and I just went straight to the farm, and that's what it was. (F4)

One key informant and two stakeholders who work closely with high school students echoed that the way to make significant change would be to start with FFA in the high schools, so the next generation would be safer. The two stakeholders were hopeful that perhaps by reaching the younger people in the family, they might, in turn, bring up the issue with their parents and grandparents.

Compliance.

Compliance was shared as an issue with farmers in Virginia. When the farmers brought up the challenges with compliance, they were often acknowledging the things they should be doing while at the same time admitting they did not do them. Two farmers mentioned that they rarely wear protective clothing and sunscreen in the heat even though they had experienced skin cancer. Two other farmers mentioned the challenge of wearing eye and ear protection on top of a mask when working with heavy equipment even though they knew they should.

Two of the farmers and three of the key informants shared that the reality for most farmers is that more intense PPE, such as masks, is seldom used or, when used, does not stay on for long due to discomfort or a lack of time to stop and protect oneself. Thus, compliance is not an act of defiance or disbelief for the two farmers who mentioned it. Rather, it was viewed as an acknowledgement that discomfort or the pace of the work outweighed the need to protect. One of the key informants summarized the compliance issue in this quotation:

> Many, many, many [*sic*] of them will not use PPE. And the reason is because all is, you know, the gloves we're handling pesticides are the clothes are really annoying. If they are itchy or it's too hot, I cannot breathe with this mask on. It's really uncomfortable. (K6)

Time.

Farmers mentioned they do not have the time to stop working and comply with protective behavior such as PPE or take care of their own health. Two of the farmers commented that the workload can prevent the farmer from having the time to even consider their own safety, let alone practice protective behavior. They shared that time was particularly precious to the small farmer as they often do not have farmworkers to assist with their daily activities, as remarked by one of the farmers: "They've already got 11 things on their list, and where's this going to fall, so trying to figure out where it can fall into something they're already doing or already going to" (F3).

Time challenges can also get in the way of public health education efforts as the farmer is unlikely to leave the farm to go and attend a course. The key informants shared the challenge of trying to reach the farmer when the farmer is focused on their farm activities and livelihood. Three key informants commented that during the main growing and harvesting seasons, the farmer has their hands full, so any training needs to be brought to the farmer or scheduled in the wintertime. Aside from public health education, access to health care was also raised as an issue by one stakeholder, particularly in rural areas where the farmer simply could not afford to take the time away from the farm to take care of their own health saying:

> I'm not sure where, for a farmer, where that falls on the priority of, I need to go out and fertilize my field, or I've got to spend the next four days harvesting crops. But you know, when do I go and get a health and wellness checkup? (S4)

Work must go on.

The fact that work must go on every day to protect the animals, crops and the land was mentioned by five of the key informants, two of the farmers and two stakeholders. This was slightly different than the time issue as the work is continuous and never ending. Two farmers remarked that even though the small farmer may be in control of their day and scheduling, there were tasks that needed to occur each day. There were periods of time, such as planting, harvesting, and keeping the cattle in feed and water, that had to happen regardless of the weather on a given day as was indicated by one farmer: "You gotta [*sic*] be out no matter what the weather is, whether it's hot, whether it's cold, there's always something's going on" (F3).

When the key informants and stakeholders discussed this code, there was acknowledgement that the most significant and intense work often had to occur in the most uncomfortable conditions (hot, dry). The life of their crops and animals needed attention on a daily basis, and the crops and animals came first. The individual farmer's health was far less consequential than losing a crop or an animal that the farmer had so much invested in, as evidenced by this quote:

> And you know, the farming still has to happen. No matter the temperature, you still have to be out there. And you know, I really worry about some of the farmers who are using some of these open cab tractors who are out there making hay when it's 100 and some odd degrees and 70% humidity. (S3)

A key informant commented, "Yeah, it's not even about their personal safety. It's about the value of the crop or the work, and what happens to that if they don't finish because of weather" (K5).

Theme 3: Trust in Self, Co-op, and the Farm Bureau

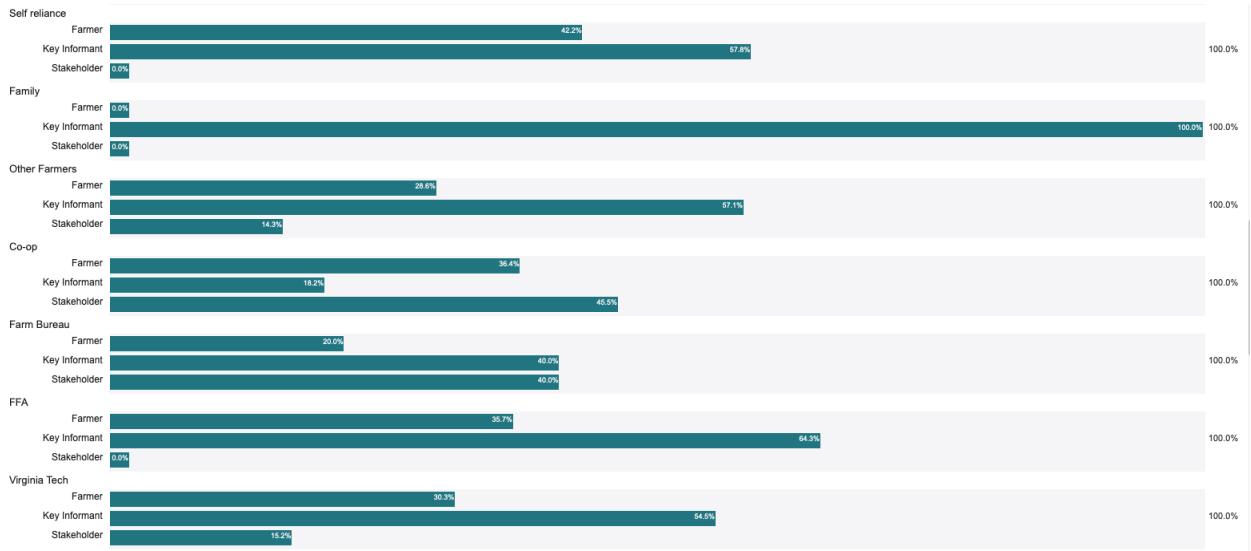
As the participants discussed their experiences, they were asked how they would like to receive public health information and training in the future. This conversation quickly turned to an issue of trust, with each of the farmer participants discussing who they would look to and the key informants and stakeholders also commenting about who farmers consider credible. Some of the responses related to socio-ecological model constructs and the differences are displayed in

Figure 9. The construct levels were not specifically asked in the question or prompts; they all came out organically in the discussion.

The farmers reported a high degree of self-reliance and tended to live in the individual construct. For the farmers, it was almost universally stated that I trust myself, then the Co-op and Farm Bureau for information. Three of the key informants suggested using family and interpersonal relations to influence the farmers to be more concerned about their own health. There was also significant discussion of the trust and credibility of organizations that deal directly with farmers. Community organizations were occasionally mentioned with the caveat that community alone would not be sufficient as an influence unless there were other relational elements such as interpersonal or organizational engagement at the community level. Public policy/federal influencers were not mentioned in a positive light. Each of these levels will be discussed in additional detail.

Figure 9

Selected code occurrence by participant role within Trust in self, Co-op and the Farm Bureau theme



Self-reliance.

Along with their experiences, there was a general acknowledgement that there are lots of barriers to a farmer being concerned about the issue enough to take action to protect themselves. Self-reliance and the tough persona of a farmer were among the most frequently mentioned challenges. One of the farmers commented that it would be tough to get past the attitude that: “If your neck is not leather and your hands aren’t rough, you are not a farmer” (F5).

Two of the farmers admitted their attitudes of self-reliance could stand in the way of listening to new ideas about safety. One of the farmers commented that the self-reliance crossed generations as he had been taught by their parents to be self-reliant and ready for anything, stating, “I've always taught, you know, my boys, when they're out doing stuff like that, is, you know you, you've got to be able to take care of yourself” (F2). There is a consistent attitude voiced by the farmers that it’s up to them to solve the problems they face on their own.

Interpersonal Influencers.

Family was the most frequently referenced interpersonal idea. While the farmers did not tend to talk directly about family, they did mention the issue of generational control over the work sometimes, even when the farmer was of a mature age:

> Ag [*sic*] is dominated by the older generations being the ones that like make the rules, because, I mean, generally, the family farm, you don't get the family farm, even if you are our age, like your dad's still there telling you what to do on the family farm. (F4)

Three of the key informants were the ones who mentioned family as part of the key to making the change happen because they were the ones who could convince the farmer to be safe: "Reaching out to spouses and children can be helpful as well. Those are sometimes the big persuaders with farmers" (K3). The children of the farmer were most often mentioned as the next generation who would raise the issue with elder farmers and convince them to be more careful. The spouses were also mentioned by a key informant as a means to get the farmer to listen, though not quite as often:

> Invoking the spouse, the grandparents and the kids is that is the pathway in a lot of cases, because you're not going to get the 55-year-old guy or the 65-year-old guy to be safer when he has been climbing into the hay loft every day since he's 14. (K5)

In addition to family, a few of the farmers and key informants mentioned that having another farmer from the nearby community either delivering or endorsing the message would be helpful. Farmers and informants commented that farmers have long established networked with one another. More than one farmer mentioned that if they saw a fellow farmer adapting safety or adaptive practices, they would be more apt to consider doing the same as noted in the following quote: "A fellow farmer would be trustworthy" (F7). A few farmers also mentioned getting the

veterinarian to assist would be useful as they are looked to for advice and often make house calls to the farm.

Trusted Organizations.

The co-operative extension, often referred to as the "extension" or "co-op" was the most mentioned source of credible information and training with 27 mentions throughout the interviews. The Farm Bureau was also mentioned quite frequently with 24 comments. Virginia Tech, the land grant university in Virginia, was mentioned 17 times (Virginia Tech houses the co-operative extension in Virginia). The FFA was seen as a pathway to ensure safety awareness for younger and beginning farmers, and perhaps even to bring the message home to older generations.

The farmers interviewed seemed to have limited interest going beyond the organizational level for information and educational training. The co-operative extension, Farm Bureau and Virginia Tech are already interfacing with the farmer for other farm education, so there was little interest in receiving the message from an outside expert. These were the type of organizations the farmer considered to be in their trusted circle. One key informant summarized the importance of sticking to organizations the farmer typically interacts with: "As a general rule, agriculturalists are very loyal to their own and they don't trust outsiders" (K2).

Community.

The community was only discussed by key informants and stakeholders. When a community group was mentioned, it was often a faith-based organization, an unincorporated rural area, or the area around a rescue squad. When community was introduced, it was more from the perspective of the difficulty in using it as an engagement channel unless an

organizational or interpersonal relationship had already been activated in that community as indicated by this key informant:

> The 500 people that live closest to the fire station that's the level of community, the 150 people that go to the same church. Those are the level at which we saw either success or failure as we talk training. (K5)

Public Policy.

When public policy/federal government was mentioned, it was always as a negative source. During one of the interviews that had two farmers present, they acknowledged receiving farm assistance programs from the federal government, but they would not look to the federal or state government for protection of their health commenting, “A lot of your farmers have a healthy distrust of the federal government due to the regulations and bureaucracy and would be less likely to receive messaging from that source” (F4). Further, the government was the last place farmers interviewed would look for help even if it was to protect health and safety. One farmer commented, “I think the regulations that are put on farmers now probably make it harder to farm than Mother Nature does” (F6).

Theme 4: Nothing we can’t handle

When it the participants were asked if they were concerned about the impact working in extreme weather conditions would have on their health and well-being, there was acknowledgement of the health and well-being risks, yet there was a repeated attitude that many of the farmers were confident that they had the situation under control as long as they used “common sense”, as evidenced by this comment:

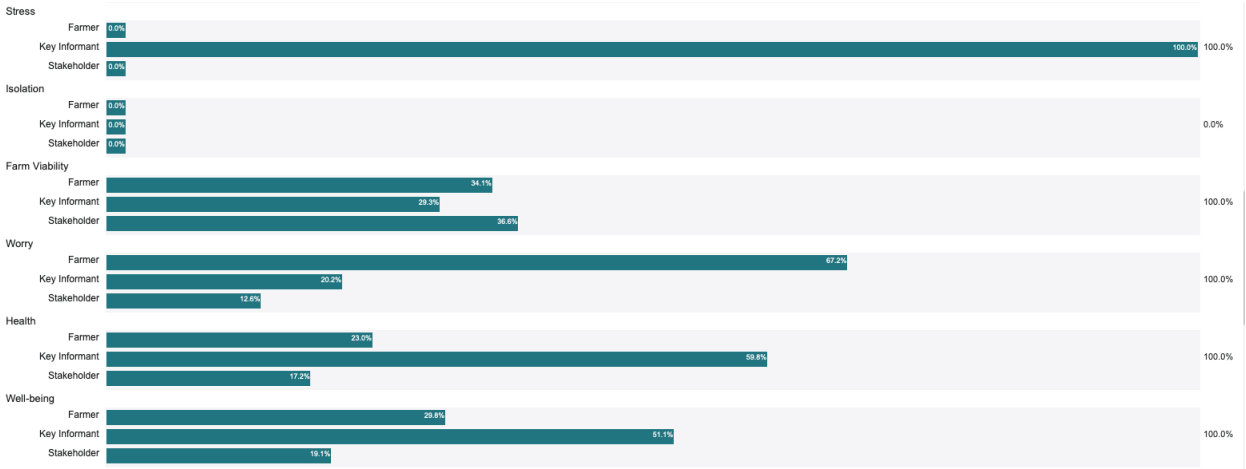
> I believe in climate change 100% so I know that our extremes are getting more extreme, but I don't think they're anything that seasoned farmers who know what they're doing

can't handle. You just use common sense with it to make sure you could deal with the elements. (F7)

Most of the farmers, key informants, and stakeholders acknowledged that working in extreme weather conditions could be taking a toll on their health and well-being, even if they may not fully recognize the extent of the impact. The impact on health and well-being was discussed in almost all of the interviews with health discussed in four of the six farmer interviews, four of the five key informant interviews, and two of the four stakeholder interviews. Well-being was discussed in four of the six farmer interviews, four of the five key informant interviews and three of the four stakeholder interviews. There were wide differences in which participant role mentioned each code that was considered for this theme as indicated in Figure 10. When health and well-being were discussed, the discussion did not last very long, and this theme had the lowest number of codes applied compared to the other themes.

Figure 10

Selected code occurrence by participant role within the Nothing we can't handle theme.



When discussing the impact on health and well-being, the answers can be divided into two categories: the perception of impact on health and the impact on well-being. The number of

codes applied to the health code was only 22 across all of the participants and the key informants talked about health a great deal more than the farmers did, as shown in Figure 10. Some of the farmers acknowledged they had some concerns about how working in conditions might lead to negative impacts on their health and safety, but their comments revealed that perhaps they do not believe the threat is anything they can't handle.

The long-term impact of working in extreme weather conditions on their physical health was not directly acknowledged by farmers. There were occasional references to sun exposure, infrequent concerns about skin cancer, and some discussions about storms and the additional physical dangers. Stakeholders and key informant participants were more vocal than the farmers about the impact on health. As noted by one stakeholder:

> Farmers work very hard and are very hard on their bodies. I mean, there's always concerns for health, just because there's a large inherent risk in being a farmer, no matter what the circumstances are, and extreme weather would certainly be an instance where there would be a cause for concern. (S1)

The comments about working when wildfire smoke was present indicated a lower level of concern about health impacts. The interview included prompts to remind the farmers and key informants of the wildfire smoke in recent history. Farmers did comment on the smoke, but the impact on anything other than immediate health was not vocalized. Two of the farmers did not appear concerned about the link between wildfire smoke inhalation and long-term consequences to their health as noted in the following comments: "I've never really been sensitive to little bits of smoke" (F4), "I mean, you could smell it, but little bit of haze. But I wasn't too concerned" (F5) and "You could tell the difference in the way you were trying to breathe" (F6).

There was often immediate concern for the animals and the crops before the people's health. In fact, for three of the farmers, it sounded more like they were talking about the health impact on their crops and animals rather than themselves. These three farmers had to be gently reminded that the study was about the impact on *human* health.

The concerns that could be attributed to mental health and well-being included codes for farm viability, isolation, stress, well-being, and worry. None of the participants brought up the issue of isolation. The viability of the farm was the most frequently cited reason for concern. None of the farmers and only three of the key informants discussed stress. One of the key informants acknowledged the stress that working in extreme weather can add stating, "When you add that on, it definitely adds an extra element of stress and challenge" (K1).

Among two of the farmers, there was an acknowledgement of some worry, "Yeah, I was always worried about something like heat" (F1), and "As I've gotten older, yeah, I tend to kind of, you know, I guess I worry more about getting overheated, heat stroke, that kind of thing" (F6). A key informant cited recent statewide efforts to provide a mental health helpline staffed by people familiar with farming:

> We have tried to open up spaces to think about health and safety and rationally, using the words wellness, being very purposeful about wellness, and you have to take care of your body and your mind. This is all connected. (K4)

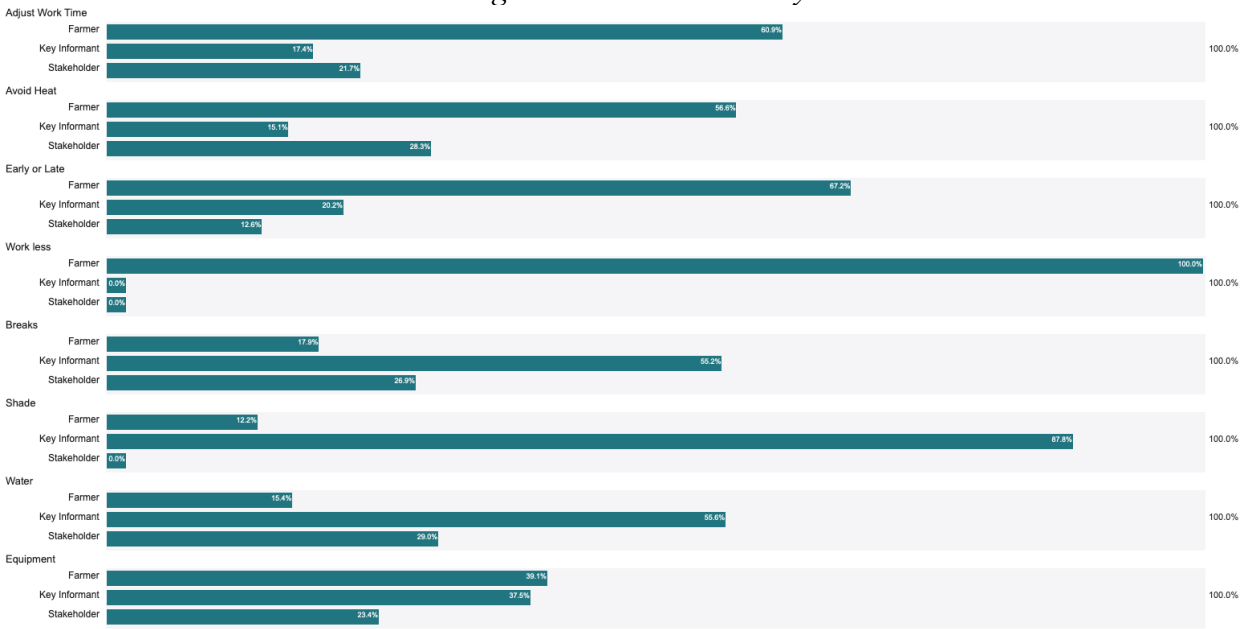
Theme 5: Changes to the work

The theme *Changes to the work* includes all of the actions that farmers are taking to change how they protect themselves from the dangers of extreme weather conditions or adapt the workday to minimize the impact. The actions farmers were taking were discussed almost as much as their experiences with the weather itself. When farmers discussed weather exposure, the

next sentence was usually what they were doing to protect themselves. Several farmers and key informants indicated that it was simply "common sense" that farmers needed to protect themselves with clothing, PPE, and equipment or adapt their work times to avoid the most extreme hours of exposure. The farmers talked a lot about altering their work time, avoiding the heat, and working less while the key informants talked more about breaks, shade, and water, than the farmers did, as evidenced in Figure 11.

Figure 11

Selected code occurrence within Changes to the work theme by role



All of the farmer participants indicated they were confident that they had taken necessary actions to protect themselves. One of the key informants who was also a multi-generational farmer, talked about how farmers need to be prepared for anything:

> The climate is remarkably different, because it's 2300 feet different in elevation, and Virginia both has change from north to south in latitude but also change in elevation. And so, you know, we have cooler weather, colder seasons, more snow in the western part of

> the state, west of the Blue Ridge, west of the Alleghenies, in particular, in our higher elevations. But we also have more extreme heat in the south side, and that has to be part of your planning and preparedness for farming, whether or not, whether whatever your opinions are about climate change, and is it anthropomorphic or natural, or whatever it might be, I think it's always fair to say we need to be prepared for any contingency, and we need to be resilient, and I think we need to build up more resilience. (K3)

One stakeholder who is also a farmer indicated the need for farmers to be adaptive, “I think that's a cornerstone of being involved in agriculture, is being adaptable, and being able to make change” (S1).

The adaptations farmers are making can be categorized into protective behaviors, such as going out and still doing the work, and adaptations to scheduling, which aim to minimize the impact of exposure or even avoid it altogether. Each of these will be discussed in further detail.

Protective Behavior (PPE and Equipment).

Farmers were quick to point out that they wear hats, long pants and long-sleeve clothing when working in the sun. When it comes to protective clothing, all of the farmers discussed that they are compliant to protect themselves from skin cancer and other effects of working in the sun.

The farmers admitted they are less reliable when it comes to other PPE. Several admitted that they should apply sunscreen, wear masks and other protective equipment such as ear and eye protection, though many admit challenges with compliance in the same sentence. Three of the key informants mentioned past efforts to hand out dual purpose PPE such as sunglasses that are also safety glasses, in order to try and make it second nature for the farmers to protect themselves.

> We're handing out, you know, safety glasses that are also sunglasses. You know, we're giving them earplugs and, you know, showing them ways that they can hook them on their hats, or showing, you know, giving them in in plastic cases that they can stick them in their pockets and in their trucks and their tractors and everywhere. (K2)

Several farmers shared their own "hacks" for dealing with the heat, such as soaking their shirts in water throughout the day and then putting them back on, using cooling towels, or clever ways to ensure cold water was available. Earplugs that connect to hats, so they are more likely to be used, was another suggestion. Cooling towels are another intervention that has been well received, and the farmer is taught to dunk them in the creek, water trough, etc. to help them cool down in extreme heat. One farmer remarked:

> Usually, I was trying to soak down my shirt and put it on, dripping wet before I go out into that and then in about an hour, it would, it would evaporate and be dried out and soak it down again, so that that was kind of my way of trying to adapt to the heat. (F1)

Others shared their tricks to make sure they stayed hydrated. Hydration was mentioned by many of the farmers without any prompt, "I do, you know, try to always have cooler full of water or something which a little bit better for you to drink" (F6). A key informant, who is also a farmer shared this:

> I would take a gallon, an empty gallon jug, fill it halfway up with water, and put it in the freezer. Morning, when I went out to work, I would fill it up to the top with water. So, all day I was drinking something that was that was cold, and as the water, as the ice melted, had that as a supply and I will guarantee you, if you get it on a hot enough day, all of that ice, would become water. (K3)

Work Adaptation.

Many farmers indicated they are adapting their workday to the weather conditions. One of the key informants summarized this by saying, “People do, I think, have some awareness that they're needing to adapt to that reality” (K1). The most cited adjustment was moving the work to the time of day when it was coolest to avoid the main heat of the day. To accomplish this, the farmer reported getting up early or working in the evening when the weather is cooler. In some cases, farmers even indicated that they would work less on the days with extreme conditions and make up for it the next day. A farmer commented, “We tend to, alter schedule, get up and work, you know, a few hours, early morning, take the middle of the day off and get back, you know, late evening” (F2). Another farmer echoed that comment, “I mean, you didn't stay out if it was 100 degrees. You wouldn't stay out at it all the time” (F7).

Many discussed taking *breaks* and looking for *shade*. *Breaks* were expressed either as breaks in the workday where shade or air-conditioned cover was sought or by taking water breaks. One farmer commented, “I’m trying to listen to my body and tell me when you've gotten too hot now, get out of the sun and, you know, try to stop what you're doing” (F1). Another stated, “I probably shortened my days up and try not to push myself” (F6). There was also significant discussion about whether or not the tractor or truck had an enclosed cab that allowed for climate control. This was cited as an issue both in the summer and winter. There was a lot of reflection about the days before they had equipment such as a tractor or truck with an enclosed cab with climate control. When non-protected equipment is used, care was taken to use it in a limited fashion or ensure that the younger generation uses it, allowing the older generation access to climate-controlled equipment.

Summary

Farmers in Virginia along with the key informants and stakeholders who participated in this study, many of whom were also farmers, were very forthcoming on most of the questions asked during the interview process. The participants discussed all of the deductive topics and expanded by discussing other topics which resulted in the creation of additional codes, categories and themes. The topics that were discussed are shown visually in a word cloud that represents code frequency (Figure 12):

Figure 12

Word Cloud showing magnitude of code discussion

The results have been presented in the context of five themes: *Farm work continues in extreme weather, Compliance is hard, Trust in self, Co-op and the Farm Bureau, Nothing we*

can't handle and Changes to the work. The research questions will be revisited in Chapter 5 to discuss these findings and suggest the insights this study has to contribute.

Chapter 5: Discussion

Introduction and Summary of Study

This study sought to explore where farmers in Virginia currently are in their understanding and preparedness to work in extreme weather conditions. This included considering four research questions: What are the experiences of farmers in Virginia with working in extreme conditions? What are their concerns? Do they think it is impacting their health & well-being? What actions are they taking to protect themselves? Data was analyzed based on the seven HBM constructs and how the farmers' lived experience falls within the SEM levels. Before any public health readiness initiative is undertaken, it is useful to understand the lived experience of the farmers. The perspectives of key informants and stakeholders who are already involved with farmers' health and safety can inform future efforts.

Natural disasters are happening three times as often as they did 50 years ago, and new disasters are predicted to impact the agriculture industry most heavily (United Nations, 2021). The planet is getting warmer, and weather patterns are getting more extreme across the globe. The results of this study will inform people working in farm safety to help farmers in Virginia to remain resilient. Farmers in Virginia have experience with heat, but they need to start preparing for increasing heat intensity and other extreme weather conditions, such as wildfire smoke, flooding, and storms. This chapter will interpret the results in the context of these research questions.

Summary of Findings and Conclusion

To examine the findings, the five identified themes were mapped back to the research questions. Table 13 shows how each theme can be interpreted as an answer to one or more research questions. Each theme will be interpreted in the context of the research question(s).

Table 13

Research Questions Matched with Themes

Research Question	**Themes**
RQ1: What experiences do farmers in Virginia have regarding extreme weather conditions (such as high heat and poor air quality)?	*Theme 1: Farm work continues in extreme weather* *Theme 2: Compliance is hard* *Theme 3: Trust in self, Co-op and the Farm Bureau*
RQ2: What concerns do farmers in Virginia have about working outside within extreme weather conditions (such as high heat and poor air quality)?	*Theme 4: Nothing we can't handle*
RQ3: How is working in extreme weather conditions impacting farmers health and well-being?	
RQ4: What actions are farmers in Virginia taking to protect themselves from the impacts of extreme weather conditions?	*Theme 5: Changes to the work*

Research Question 1: Lived Experiences

As this was a study of the lived experiences of farmers in Virginia, most codes and three of the five themes were all linked to Research Question 1: What experiences do farmers in Virginia have regarding extreme weather conditions? The themes of *Farm work continues in extreme weather, Compliance is hard, and Trust in self, Co-op, and the Farm Bureau* can all be considered as expressions of the lived experience.

Farm work continues.

The results indicated that weather is seen as just part of the job. Farmers indicated that they were aware of difficult weather, and they were ready for it because they were already wearing protective clothing or hats, or were adjusting the amount of time or time of day that they

were working when extreme conditions were present. While the farmers in Virginia appear to be ready for heat, a previous study of farmworkers showed they thought they were ready for HRI but had an incorrect understanding of related risks (Smith et al., 2021). Previous studies of farmworkers have shown that they thought they were protecting themselves from heat but were actually experiencing signs of heat exhaustion (Luque et al., 2020). It was difficult to know if the farmers in this study are resilient or perhaps do not fully understand the risks. Studies in the past have found that by embracing rather than challenging a resilient attitude, farmers are more likely to receive a public health message (Liu et al., 2018)..

Farmers in Virginia have a deep awareness of the dangers of heat but less of other weather-related risks. This was evidenced by the fact that heat was the most frequently discussed concern. There is a strong understanding of the potential dangers of heat, and farmers are making adjustments to protect themselves consistent with previous work with farmworkers in the Southeast (Smith et al., 2021). Air quality was an afterthought, if it was even considered. The acknowledgment of the heat risk with less emphasis on the air quality is consistent with previous studies that interviewed farmers on the West Coast (Riden et al., 2020). Wildfire smoke was not seen as a significant danger to farm operations, with farmers recalling that WFS events have been historically infrequent and not of lasting duration in Virginia. There is limited understanding of wildfire smoke exposure, and even a couple of farmers indicated that they thought it was fine because WFS is *natural*. They did not appear to understand that working in agriculture, could be subject them to the dangers of other toxic substances in the smoke from burned structures and vehicles, a concern that was been previously raised by researchers in California who found that agriculture workers across California had been subjected to toxic chemicals in wildfire smoke (Marlier et al., 2022). Further education on the dangers of inhaling

particulates during a wildfire smoke event or even on bad air quality days would be beneficial to farmers.

The farmers, key informants, and stakeholders discussed increasing cold, drought, and storms as other potential threats to farm viability and their health. All participants noted they were concerned that cold brought its own risks to health and safety. Drought was a significant concern and the intensity of storms in Virginia was recognized as a threat, including hurricanes. Farmers admitted that they had no choice but to dress for the weather and get the job done even in bitter cold or as storms approached. The recent heat and drought events, Hurricane Helene, and the cold spells were top of mind for the farmers at the time of the interviews, and they admitted they had worked in and around all of them. These three types of potential health risks related to working in extreme weather conditions have not been explored with this population in the literature. The impact of cold, drought, and storms on the physical health of farmers may be just as significant as heat in this region and may call for an additional focus of public health efforts in the future.

Compliance.

One of the most significant challenges for farmers was their compliance with safety precautions to protect themselves from the weather, often citing time, generational resistance, and the fact that the work must go on as reasons for noncompliance. When farmers talked about compliance, they conveyed an understanding of the appropriate safety action, but did not comply due to discomfort or the time necessary to stop working and locate and put on appropriate protection. This sentiment was consistent with previous dialogue in the West, where farmers and farmworkers talked about how PPE was uncomfortable or made them sweaty when it was hot outside (Riden et al., 2020). The fact that farmers acknowledged the need for PPE such as hats,

clothing, and masks while talking about the challenges of wearing them all the time indicates an awareness of the protective value while at the same time recognizing compliance is a continuing issue.

Time is a precious resource for farmers, and they commented that there is often little time within their long list of other chores to take time out for safe practices. As every minute off the farm or away from farming on the farm itself can have economic consequences, it can be difficult for the farmer to take time out for their health. There is also the issue and feeling that the work must go on. As found previously among farm workers in Idaho (Hyland et al., 2024), there are other life demands that require their attention. Whether it is an animal or a crop, the farmer must continue to ensure food and water needs are taken care of, regardless of the weather. The animals and crops often take priority over the farmer's needs, a sentiment consistent with a previous qualitative study in Ireland, where farmers admitted their own health needs were secondary to that of the farm (Hammersley et al., 2021).

Many farmers cited generational resistance as an issue when talking about potential barriers to change. As one farmer pointed out, it is not unusual for the older generation of farmers to still be on the farm so that the younger generation has fewer opportunities to change behavior. Small family farms have had practices handed down for many generations, and the new generation learns by example and may even come into conflict with elders when proposing new ideas (Freeman et al., 2024). To make changes, the older generations need to be influenced to change or at least accept the new practices their children have learned.

Trust.

The SEM model was especially apparent at the intrapersonal and interpersonal levels as the farmers discussed who they would trust as a source of information, education, and

intervention. The key informants and stakeholders mentioned that family was a significant influence; however, but farmers did not mention family. Farmers indicated they trusted themselves the most, with the co-op, farm bureau, and Virginia Tech also holding a high degree of credibility. This was similar to previous studies that found the farmers valued the ties to co-operative extensions (Freeman et al., 2024; Liang et al., 2022). Community organizations outside of farming were not acknowledged, other than occasional mention of a church or volunteer fire department district event.

There was outright distrust of the government as a source of farm safety education. Farmers indicated they had little appetite for further regulation, consistent with previous work that indicated farmers want support, not regulation from the government (Liu et al., 2018). Passing a state regulation to protect farmers, such as the previous legislation in California or Washington, would likely have little effect, as most farms in Virginia are small family farms that would be exempt from any OSHA regulation (OSHA, 2007).

Research Questions 2 and 3: Concerns and Impacts

When farmers were asked whether they were concerned or saw an impact on their health, about half of both farmers and key informants acknowledged that they were worried about farm viability in light of extreme weather conditions. The farmers did not talk about their mental health or whether they experienced stress or isolation. However, farmers who work off the farm have been shown to have lower levels of stress (Brennan et al., 2022), and all farmers who participated also had jobs off the farm allowing them to feel more well-connected with others. Connectedness has been shown to reduce depression for farmers who were well connected with others, such as farmers who went to farmers' markets (Durant et al., 2023), farmers who worked off the farm (Freeman et al., 2024), farmers involved with the co-operative extension (Liang et

al., 2022), and farmworkers who were involved with family and schools (Raymond-Flesch et al., 2021).

The farmers did not articulate that they thought working in extreme weather conditions was impacting their physical and mental health. The only potential long-term physical impact recognized was the occasional reference to skin cancer, and nothing was explicitly mentioned about mental health. The challenges of the elusive understanding of farmer mental health have been encountered by previous key informant research (Henning-Smith et al., 2022). The inclusion of indirect mental health questions was not as effective as previous studies that used more direct questions or using a validated instrument to assess the mental health of farmers (Keeney et al., 2023). As the discussions on physical and mental health occurred, the farmers often went directly from awareness to discussions to what they were doing. The lack of connection to long-term health impact may be a byproduct of what previous authors called farming masculinity, where the "good farmer" is self-reliant, able to deal with adversity, and suppresses emotions (Burton, 2004; Hammersley et al., 2021).

Research Question 4: Actions Taken

When participants were asked how they act when extreme conditions are present, many took a "common sense" approach and either protected themselves or got out of the weather. Farmers shared that they wear appropriate clothing, hats, and even sunscreen to protect themselves from the sun. Some shared clever hacks they use to keep their body cool while working, like soaking their shirt in cold water or carrying bottles of ice water they froze the night before and pouring water on their neck. There is room for improvement on more "intense" forms of PPE, such as masks which farmers admitted they used less often. Embracing the clothing but not the masks and gloves is consistent with previous studies of farmer use of PPE during wildfire

smoke events (Riden et al., 2020) or when handling pesticides (Sapbamrer & Thammachai, 2020). Participants also talked about various methods of staying hydrated; however, past research has found inconsistencies when farmers and farmworkers thought they were hydrating appropriately, and their actual liquid consumption was lower than recommended levels (Smith et al., 2021).

When extreme weather conditions were present, farmers were adapting their work schedule, which is consistent with a previous study in California where farmers indicated they adapted their work schedule to avoid high heat and WFS (Wadsworth et al., 2022). Farmers indicate they work earlier or later in the day to avoid the heat, or in the winter, doing the opposite and completing chores during the warmest part of the day. When the conditions cannot be avoided, farmers noted they take breaks from the sun and ensure they have water on hand to stay hydrated. Some prioritized their tasks so they do less high-impact work during the part of the day when the weather is most extreme. All of these comments are consistent with findings in the California study (Wadsworth et al., 2022). A few of the farmers suggested they worked less on days with high risk, particularly on days with high heat. Using a climate-conditioned cab either in the truck or tractor was mentioned often as a means of staying safe by altering their own environment, even if they could not change the weather. The discussion of working less or using air condition are adaptive activities that have not previously been documented by farmers in the literature.

In summary, the farmers in Virginia are aware of extreme weather conditions and believe they are taking steps to protect themselves, though it was not clear whether they universally realize working in extreme weather may be taking a long-term toll on their health and well-being. While the study opens the door to understanding the lived experience of farmers in

Virginia, there is still very little known about the toll that working in extreme weather conditions has on long-term physical health and well-being.

Theoretical Implications

This study demonstrates that the HBM can be insightful when applied to farmers in addition to previous research studies that focused almost exclusively on farmworkers (Arcury et al., 2002; Brock et al., 2012; Chavez Santos et al., 2022; Luque et al., 2020). For example, in this study, farmers discussed several perceived barriers to wearing PPE or avoiding working in extreme conditions, including lack of time, the need to continue to work, and generational differences. Farmers did not indicate they perceived susceptibility to their long-term physical and mental health. Most of the farmers in this study did not perceive wildfire smoke as a serious threat to their health. Farmers indicate they have self-efficacy when it comes to heat conditions and that they are taking action to avoid severe hazards, but further research could explore whether the farmers' efficacy and actions are effective.

The farmers, key informants and stakeholders in this study were very vocal about which levels of influence from the SEM they would consider as credible. The farmers were very clear that they rely mostly on individual level of SEM, although they did acknowledge they trusted other farmers as mentors, which would indicate an interpersonal level as well. Some key informants and stakeholders mentioned family members as key levels of influence at the interpersonal level. Farmers did comment they trusted the organization level (Co-op, and the Farm Bureau) for further information about farm health and safety. The farmers did not trust the community or public policy levels of influence; however, many of the key informants and stakeholders included these levels in their discussion of potential interventions. This gap underscores the need to continue to consider the different SEM levels prior to launching public

health interventions. Previous studies of farmworkers (Liang et al., 2022; Nguyen-Thi-Lan et al., 2021; Vamos et al., 2022), have utilized the SEM model to understand farmworker behavior, but this study provides insight into the levels farmers rely on, and farmers as owners, may have more influence on the safety of the overall farm.

Practical Implications

This study demonstrated that farmers in Virginia are willing to talk about the weather and that they believe they have working in extreme weather conditions under control, the latter of which will have to be carefully considered by future efforts to assist farmers. If the farmers don't perceive the weather changes as serious and weather is "nothing they can't handle," the packaging of interventions will need to be seen as supporting the level of preparedness the farmer already thinks they have (Liu et al., 2018). Public health interventions and support should carefully consider the language of the intervention, so it is supportive of what the farmer is currently doing, thus supporting rather than regulating. Future education activities will be more successful if farmer representatives are recruited who can attest to the intervention to create better buy-in and get the attention of the farmers. Generational differences are a significant factor in farmer attitudes, so interventions will need to ensure they are not only reaching the younger generations, but also the generation of established farmers that may have their own outlook on what precautions are necessary. Different generations may have different health risks to consider.

Farmers are making adaptations on their own to mitigate the impact of working in extreme weather including reducing the work that is done in hazardous weather, which is consistent with previous recommendations (Vega-Arroyo et al., 2019). Farmers in this study were clear that they do not want any additional regulations, even if they are to help protect their own health, which aligns with sentiments found in previous studies (Courville et al., 2016; Liu et

al., 2018; Wadsworth et al., 2022). Before policymakers consider imitating the regulations for working in heat and wildfire smoke that were passed in the West, they might consider working through organizations that the farmers trust, such as the Co-operative Extension or the Farm Bureau. Building dedicated resources for farmer safety, such as dangers of HRI, wildfire smoke, and stress, into existing programs would be beneficial for farmers, especially if they can be delivered through channels that are known and trusted.

Future Implications

This is one of the only known studies of farmers in Virginia's lived experience in recent years. Farmers, key informants, and stakeholders in this study were vocal about their lived experience but spent less time discussing their concerns and impressions of the impact of working in extreme conditions on their own health. Additional studies are warranted to add to the understanding of how this population experiences working in extreme weather. Future studies could add additional emphasis to the concern and impact research questions to determine whether farmers are truly prepared for the extreme weather conditions in Virginia.

All of the farmers in this study were middle-aged males which is reflective of the majority of farmers in Virginia (National Agriculture Statistics Service, 2022). This was a byproduct of the goal to interview established farmers and the fact that those farmers were known to the researcher. As some respondents mentioned, it may be instructive for future studies to understand if there are differences in awareness and compliance by younger generations or farms owned by women. Perhaps a special effort could be considered for the older farmers to improve their understanding of the risks. In addition, the focus of this study was on rural farmers, yet most participants were farming in suburban adjacent areas. It would be useful to determine whether similar findings occur in farmers who are in rural or even in urban farming locations.

Farmers were reserved in their responses. They were forthcoming, but not gregarious. Understanding the efficient nature of farmers' conversational styles and developing further methods to get the farmer talking may inform future study design.

This study showed that farmers interviewed did not vocalize issues with social isolation, perhaps because they all had jobs “off the farm” and were socially connected in other ways. Future studies should attempt to replicate this study in more remote areas of Virginia to determine if social isolation is present in some of the more remote communities. Even if the study had included more geographic representation, it could be possible that farmers in Virginia feel well supported by organizations such as the Co-op and Farm Bureau and isolation is not as significant a concern as it may be in other areas of the country.

Strengths and Weaknesses

A major strength of this study was that farmers were able to speak freely and share their experiences, thus providing a baseline understanding of their lived experience. At the same time, limitations such as the amount of time available to interview, the timing of the interviews, potential selection bias, and geographic and demographic distribution of participants were present. Each of these will be considered briefly.

Strengths of the Study

The qualitative semi-structured interview approach was well received by farmers and useful to explore the mindset of a previously unexplored population. Once the study was explained, farmers were happy to participate and share their individual experiences. The study questions followed a progressive logic that started with the farmers talking about their experiences, then commenting on which level of influence has the most impact on them and culminating with a discussion about the actions they would likely take in the future to protect

their health and well-being. The semi-structured questions allowed key informants to provide a range of helpful perspectives and advice for future efforts. The key informants were happy to engage and discuss what had worked in the past and what might work in the future.

By introducing the study as an exploratory study to understand their lived experience, participants felt non-threatened and were willing to participate. Delivering the interview questions in an apolitical fashion intentionally kept the answers focused on the awareness, concerns, and actions taken to protect the health of farmers. This was especially important given the timing of the interviews just after the inauguration of a new presidential administration. A wide variety of perspectives were included by including key informants and stakeholders at the local and state level as well as from private sector organizations such as the Farm Bureau.

Limitations

The study used a purposeful sample in order to ensure representation from key organizations that work with farming and to ensure that farmers were recruited from areas of Virginia that had experienced wildfire smoke in recent years. Because the sample was geared toward small family farms, and it is difficult to make a living just on farming, the respondents were engaged in other work and social relationships and were potentially less likely to experience isolation.

An additional limitation of the study was the small sample size. While the goal of 15 interviews was met and 17 people participated, future efforts should include more farmers to capture the opinions of farmers in different areas of Virginia. Farmers were difficult to recruit and schedule, even though this was a purposeful sample, and the researcher knew several potential participants. The study benefited from that eight of the 10 key informants who were

actively engaged in farming, which resulted in 15 of the 17 interviewees being familiar with farming.

Research bias was an additional limitation of this study. The interviewer is a beginning farmer with ties to the farming community as the owner and operator of a farm in Virginia. This dual role of researcher and farmer may have introduced some bias in implementing and interpreting the interviews. On the other hand, this dual role was useful and may have helped to establish rapport with the farmer participants.

The timing of the interviews was in the first few weeks of a new presidential term. The interviews were conducted within February of 2025 at a time when daily changes were being made to government agencies including the USDA, CDC and NIH. Given the state of the nation and the impending layoffs of federal employees, there may have been some reluctance to participate on the record. This was noticeable in that no federal employees responded to invitations to respond. In a few cases, the websites and contact information of USDA employees identified as potential participants disappeared between the time the IRB was approved and the time the invitations were released.

Interviews were intentionally scheduled in February to maximize the participation of farmers at a time of year when they were less busy. While the timing helped with recruitment and participation, the interviews were conducted during an extreme cold spell in Virginia. This led to much discussion about working in the cold that may not have occurred if the study had been conducted in another season. Further, the damage from Hurricane Helene was still fresh in the interviewees' minds, leading to considerable discussion about storms which may have distracted the farmers who might have discussed heat and WFS had the study been conducted in the summer. However, the discussions of cold and storms provided interesting insights about

other issues that farmers in Virginia are experiencing throughout the year that has not previously been published in the literature.

Analysis of Study Design

The farmers were asked nine questions to maximize potential information gain, and the key informants and stakeholders had eleven questions. Future research should reduce the number of questions to four that directly map to the research questions. Then, within each research question, probes could be added. With a shorter list of interview questions, the discussion could focus on key themes the interviewee presented. The shorter length could also boost participation rates and allow the interviews to be done quickly in a breakout room or outside an existing meeting of farmers.

The questions were not specific enough about climate change. While the original study was conceptualized as a climate change study, the term climate change was replaced with extreme weather conditions before submitting the study to the IRB. This was done to increase the participation rate by avoiding alienation due to potential participant not agreeing that extreme weather was due to climate change. The loss of attribution to the extreme weather to climate changes by some participants in this study may have limited the conclusions. A previous study in Iowa found that farmers were more apt to act if they attributed the weather to climate change (Arbuckle et al., 2013).

Questions were not as direct as they could have been regarding mental health. Participants were asked if they were “concerned” and later if they were “worried” about extreme weather. These questions were intended to get the farmer talking about their worries and anxieties. In practice, further discussion of the farmer’s state of mind did not materialize.

The farmer interviews did not last very long. While farmers were willing to participate and talk, getting them to elaborate on their answers was challenging. Future studies could keep the overall question list short but contain a number of probes to bolster conversation and get the farmer to talk further. It did not appear that farmers were uncomfortable with the topic; they just had very little to say after answering the questions. The key informants, in contrast, were conversant and more apt to explain their experiences in detail.

By design, the questions were not consistent between the farmers and key informants. In the case of the eight key informants who were also farmers, it would have been better if time had allowed further exploration of their impressions as a farmer. This was accomplished through further inquiries, but the time limitations did not allow a key informant or stakeholder interviewee who was also farming to answer all key informant and farmer questions. It was clear that key informants who were also farmers allowed their experience as a farmer to enlighten their responses.

Recommendations for Future Research

One of the stakeholders who was also a farmer summarized the challenge of reaching farmers now and in the future by noting, “You got to meet them where they are” (S2). Future research with farmers should be easy and accessible for the farmers. Conducting shorter interviews at an event where farmers are present may be preferred over individual recruitment efforts. The winter months are the least busy time for most farmers, so more in-depth studies should be scheduled during this time. However, there is some temporal awareness, and care should be taken to inquire about heat and air quality in the months when they are most likely to be recognized and understood. Scheduling subsequent studies around events where farmers are

present in the summer, such as farmers markets and equipment shows, may help further understand the impressions of working in the heat.

The co-operative extension, Farm Bureau, and Virginia Tech were the most often mentioned credible sources of information. Partnering with one of these organizations may add to better response rates. Several farmers mentioned the importance of having a local farmer to serve as a mentor or liaison to boost acceptance of interventions and indicated they would be more likely to participate in if a local farmer was involved in the education delivery.

Younger and beginning farmers were not included in this study. Future efforts may wish to compare the attitudes and experiences of experienced farmers with those who are just starting out or are of a younger generation. Levels of influence may vary for different cohorts of farmers.

Adding more definitive language that attributes the weather to climate change in the question may be illuminating. In the informed consent document, climate change was mentioned, but it was perhaps not overt that the study was interested in viewpoints on working in extreme weather conditions related to climate change. While there was general understanding and agreement that recent weather had been worsening, the attribution of the extreme weather was not explored. A similar approach was taken in a previous study (Wadsworth et al., 2022) that observed varying reactions from farmer participants regarding whether the extreme weather was due to climate change. Future research could explore whether this impacts the perceived severity of the problem.

Additional emphasis on the dangers of working in high heat and the inhalation of wildfire smoke could be added to existing and future programs for farmers. While the farmers in this study indicated they were aware of and coping with heat, the message needs to continue to be reinforced so that is on the forefront of their minds. The farmers in this study expressed limited

concern regarding the impact of working in wildfire smoke and other poor air quality conditions. Further efforts to share the long-term impact of breathing in particulate matter could be very helpful to protect farmers in Virginia.

To further explore the impact of isolation on farmer mental health, additional care could be taken to ensure that the sample includes farmers from geographically isolated areas of Virginia. Before developing interventions regarding mental health of farmers, perhaps a definition of social isolation could be shared with farmers, and further efforts could be made to include farmers from the more geographic and socially isolated areas of the state. For example, the focus could be on a group of farmers that do not have employment off the farm as going to a workplace is a means of social contact. Another potential criteria for participant selection could be the amount of contact the farmer has with known organizations such as the co-operative extension or the Farm Bureau.

Conclusions

Farmers in Virginia are critical to the future of all Virginians, and this research opened the door to a better understanding of the lived experiences of these farmers as it relates to changing weather conditions and their well-being. As stated by one key informant who is also a farmer:

> We are seeing more instances of more extremes, and that could be heat, cold, wind, you know, rain, whatever it might be, drought, we have got to be more in tune with how we prepare ourselves for extremes and the ability to not only work in them, but be productive in them and produce crops and livestock that that we all need. (K3)

By asking about the lived experience of farmers in Virginia, three themes were clear *Farm work continues in extreme weather, Compliance is hard, and Trust in self, Co-op and the*

Farm Bureau. Farmers acknowledged that, in most cases, the work must go on, a sentiment echoing previous comments by farmworkers in the Midwest (Hyland et al., 2024). Farmers do not have the luxury of working indoors when the weather is bad. Attribution of the extreme weather to climate change was not always forthcoming, consistent with similar studies in the West (Wadsworth et al., 2022). The farmers admitted that they want to be compliant with safety precautions, until they get in the way of the work or personal comfort, consistent with comments made by farmers in a previous study in California (Riden et al., 2020; Wadsworth et al., 2022). The farmers made it clear they trust in their abilities, the cooperative extension, the Farm Bureau, or Virginia Tech. Future messaging should be delivered in coordination with one of these organizations or delivered from a farmer known by participants who can attest to the value of the intervention based on their own experience to improve the level of acceptance.

At the same time, farmers gave the impression that working in extreme weather conditions is "*Nothing they can't handle".* Further study is necessary to explore if farmers need additional support to protect their health and well-being during extreme weather conditions. Farmers are accustomed to living with and in the weather, but do they truly appreciate the impact it is having on their health? Or is the confidence a byproduct of "farming masculinity", a theme identified by Hammersley et al. (2021)? Additional emphasis of the dangers of wildfire smoke inhalation would be helpful to farmers. Future studies should delve further to explore how the stress and worry of climate change-related weather is affecting the well-being of farmers in Virginia. Previous studies of farmer stress and mental health have documented the difficulty in reaching farmers on this issue (Kohlbeck et al., 2022; Younker & Radunovich, 2021). It would be interesting to explore more remote areas of Virginia to see if there were differences in the feeling of stress and isolation. More needs to be done to understand if Virginia farmers are truly

resilient or if they are suppressing their anxieties and fears and causing unseen damage to their well-being.

The farmers in this study indicated that they are making "*Changes to the work".* Wearing protective items, adding an air-conditioned cab to their tractor or vehicle, moving work to the time of day when the conditions are least intense, or simply not working on extreme weather days are reasonable precautions they are already taking. Perhaps, in the words of farmers in this study, "common sense" steps are enough for now. As one key informant who also farms noted:

> We just can't naturally be out there when it's miserable. I know that even a lot of farmers have switched when they're bailing hay, they'll go ahead and bail it on one afternoon and then wait to the next morning to put it in the barn, just to try to keep everybody healthy and working with mother nature instead of against it. (K5)

It is too early to know if common-sense steps such as this are adequate or if additional protection or avoidance measures are necessary.

This is the first study in recent years that has systematically asked farmers in Virginia whether they are prepared for heat, wildfire smoke exposure and the risks of working in storms, all extreme weather conditions that are likely to continue to intensify. Further, researchers have only recently begun to explore whether the stress of working outside in extreme weather affects the health and well-being of farmers. To be ready for these weather conditions, the farmers will need to first acknowledge their susceptibility to adverse health and well-being impacts (Alyafei & Easton-Carr, 2024). Then, they can begin to understand the potential severity and act to protect themselves (Alyafei & Easton-Carr, 2024; McKenzie et al., 2023). This study provided a beginning understanding of how this unique segment of the population, that is so critical to the food supply, natural resources and economy, is coping with climate change.

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Appendix A Interview Protocol

Introductory passage (researcher will read):

Hi, thank you for agreeing to participate in this interview. The purpose of this research is to better understand the current experiences of farmers in Virginia regarding extreme working conditions due to weather.

I would like to record this to be able to capture your thoughts completely and focus more on the discussion. Your answers will be deidentified and only be used for this study. Do you consent to recording? (Yes, No)

Thank you, now we will go ahead and get started.

Questions for Key Informants &Stakeholders:

1. **Please start by sharing your role, your organization and a little about the mission of your organization.**
2. **If you have personal or professional experience with farming, please share.**
3. **Have you had any experience with farm safety education? Please elaborate.**
4. **What concerns do you have about protecting farmers and farmworkers from the impacts of worsening weather conditions such as high heat and poor air quality?**
5. **On days of high heat or poor air quality, what do you think the farmer should do to protect themselves and their farmworkers?**
6. **Are you concerned about the impact of changing weather conditions on farm viability within the Commonwealth of Virginia?**
7. **What do you think would be some of the challenges of reaching farm owners with an education program or interventions to help protect them?**
8. **What suggestions do you have for making sure interventions are effective?**
9. **What do you recommend to make sure the maximum number of farmers can be reached with education and interventions?**
10. **Do you have any other thoughts or suggestions that we did not get to talk about?**
11. **Is there anyone else you recommend I speak to as part of this project?**

Questions for Farmers:

1. **Please start by sharing the size of your farm, the type of farming you do, and the number of years you have been involved in the farm operations. (**Introductory background question to help establish rapport).
2. **What concerns do you have about protecting yourself from the impacts of worsening weather conditions?**
    a. Probe: What types of changes have you seen in the conditions on your farm in your lifetime?
    b. Probe: What types of changes do you anticipate?
    c. Probe: Tell me about any concerns about working in high heat?
    d. Probe: Tell me about any concerns about working on days with poor air quality?

   e. Probe: Do you have similar concerns for your family?
   f. Probe: Do you have similar concerns for people you hire to work on the farm?
3. **On days with high heat or poor air quality, what do you do?**
   a. Probe: What types of changes have you made under these conditions?
   b. Probe: What types of preventive measures have you taken?
4. **Have you ever been concerned about the impact of climate change on the viability of your farm operations? What are some of your concerns/actions?**
   a. Probe: Do you have any examples of actions taken to adjust your crops/animals, etc.?
   b. Probe: Do you have any examples or anticipate an economic impact to your own farm due to climate change?
5. **Have you ever been worried about the impact of climate change on your own health and well-being? What is it that you worry about?**
   a. Probe: Have you ever worried about the health of your family? Workers?
   b. Probe: Have you ever worried about the viability of your farm if climate change dramatically impacts the weather conditions?
6. **How likely are you to take protective measures in the future? What would help encourage you to do so? What about other farmers in Virginia?**
7. **If trainings were offered in the future related to protecting yourself and your farm from the changing conditions related to climate change, what would be the best way to design them so you would want to attend?**
   a. Probe: Time of year, online vs. in-person, which topics, who would you trust to do the training.
8. **Are there any other thoughts or suggestions you have regarding farm safety while working outdoors that we did not have the chance to talk about?** (For example, is there anything you would want to share with a beginning farmer?)
9. **Is there anyone else you recommend I speak to as part of this project?**

Thank you for sharing your experiences and thoughts today. Please do not hesitate to contact me in the future if further thoughts come to you or if you have further questions. I will now stop the recording.

Appendix B Institutional Review Board Approval Letter

Radford University | Research Compliance Office

Institutional Review Board

January 06, 2025

TO:	Jenny Hall
RE:	Initial Expedited Approval
STUDY TITLE:	Preparing Virginia farmers to protect their physical and mental health while working in extreme weather related to climate change: A key informant study
IRB REFERENCE #:	2024-171
SUBMISSION TYPE:	IRB Initial Submission
ACTION:	Approved
APPROVAL PERIOD:	January 06, 2025 – January 05, 2028

The above-referenced study has been approved by Radford University's Institutional Review Board (IRB). Your study has been approved under **Expedited Category 7: Research is on individual or group characteristics of behavior (including, but not limited to research on perception, cognition, motivation, identity, communication, cultural beliefs or practices, and social behavior) or the research employs survey, interviews, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies).**

Please note that if your research includes stamped materials, they will be provided with this letter and must be used when conducting your research. A copy of your approved IRB protocol is available for your records in IRBManager under your dashboard of active protocols.

You are approved for the enrollment or review of 75 participants/charts.

Note: The number approved is the number of study participants is defined as the number who enroll in the project and NOT the number of subjects with usable data for analysis. If this should change, you must submit an amendment to increase the number of study subjects.

Your IRB approval period ends on January 05, 2028. If the study remains ongoing after the project end date, you must submit a three-year check-in application no later than ten (10) days prior to the expiration of this approval. If the project is no longer being pursued, a closure report must be submitted.

Should you need to make changes in your protocol, you must submit a request for amendment for review and approval before implementing the changes. Amendments must be submitted via the IRBManager system.

As the principal investigator for this project, you are ultimately responsible for ensuring that your study is conducted in an ethical manner. You are also responsible for filing all reports related to this project.

If you have any questions, please contact the Research Compliance Office at 540.831.5290 or irb-iacuc@radford.edu. Please include your study title and reference number in all correspondence with this office.

Good luck with this project!

Radford University Institutional Review Board (IRB)
Research Compliance Office
540.831.5290

Radford University IRB
Approval Date: January 06, 2025

Appendix C Informed Consent Document

Radford University | Department of Public Health and Healthcare Leadership

Informed Consent

Title of Research: Understanding the perceptions and experiences of farmers in Virginia regarding the impact of working in extreme weather conditions on their health and well-being: A key informant study.

You are invited to participate in a research interview, entitled: Understanding the perceptions and experiences of farmers in Virginia regarding the impact of working in extreme weather conditions on their health and well-being: A key informant study. The study is being conducted by Bradley Daniel and Jenny Hall, PhD (principal investigator) in the Department of Public Health and Healthcare Leadership of Radford University 101 Elm Street SE, Room 102, Roanoke, VA 24013.

You were selected as a possible participant because you are a farmer in Virginia or someone who works in an official capacity with farmers in Virginia. We ask that you read this document and ask any questions you may have before agreeing to be in the study. Participation is completely voluntary.

Purpose:
The purpose of this study is to understand the perceptions and experiences of farmers in Virginia regarding the impact of working in extreme weather conditions on their health and well-being.

Procedures:
The study consists of qualitative interviews of farmers, key informants and stakeholders.

If you decide to be in the study, you will be scheduled for an interview. The interview is estimated to take about 30 minutes of your time to complete. You are free to contact the investigator at the above address and phone number to discuss the interview. Participation is completely voluntary.

In order to facilitate data recording and transcription, the video and audio from the interview will be recorded through an online software such as Zoom for video and Otter.ai for audio. The recordings will not be shared with other researchers or the general public. During the study time period, the data will be stored on the researcher's laptop and cloud storage, both of which are password protected. Once the study is complete, all study data including interview recordings, word documents of handwritten notes, and the transcript data will be stored for a minimum of 3 years on a password-protected laptop or in a locked cabinet in the locked office of the principal investigator. You do not need to agree to be recorded in order to participate in this study. If you prefer not to be recorded, the researcher will type up notes immediately following the discussion.

If you give the research team permission to quote you directly, the researchers will give you a pseudonym and will generalize your quote to remove any information that could be personally identifying.

Radford University IRB
Approval Date: January 06, 2025

Confidentiality:
The data collected in this research study will be kept confidential. Participation in research may involve some loss of privacy. We will do our best to make sure that the information about you is kept confidential, but we cannot guarantee total confidentiality. Your personal information may be viewed by individuals involved in the research and may be seen by people including those collaborating and regulating the study. We will share only the minimum necessary information in order to conduct the research. Your personal information may also be given out if required by law, such as pursuant to a court order.
While the information and data resulting from this study may be presented at scientific meetings or published in a scientific journal, your name or other personal information will not be revealed.

Risks:
This study has no more risk than you may find in daily life. You may decline to answer any or all questions and may terminate your involvement at any time if you choose. The research team will work to protect your data to the extent permitted by technology. It is possible, although unlikely, that an unauthorized individual could gain access to your responses because you are responding online. This risk is similar to your everyday use of the internet.
If, for any reason, the interview raises stress or concerns for you, the interview will be stopped, and you are encouraged to contact your healthcare provider or dial 988, the suicide and crisis hotline.

Compensation to You:
There is no compensation for you to participate in this research.

Benefits:
Your participation in the research interview will contribute to a better understanding of the current health and well-being of farmers in Virginia and assist in future health planning efforts to address their needs.

Questions about Your Rights as a Research Participant:
Your participation in this study is voluntary. You may decline to answer any question, and you have the right to withdraw from participation at any time without penalty. If you wish to withdraw from the study or have any questions, contact the investigator listed above. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you have any questions or wish to update your email address, please email Bradley Daniel at badaniel1@radford.edu or you may contact the principal investigator Jenny Hall, EdD at Jhall2@radford.edu or 540-831-2562. You may also request a hard copy of the interview questions.
This study was approved by the Radford University Committee for the Review of Human Subjects Research. If you have questions or concerns about your rights as a research subject or have complaints about this study, you should contact Dr. Jeanne Mekolichick, Institutional Official and Associate Provost for Research, Faculty Success, and Strategic Initiatives, jmekolic@radford.edu, 540.831.6504.

By proceeding to schedule the interview, you voluntarily agree to participate in the study. Further, you agree to allow direct quotation if the research team removes identifying information and uses a pseudonym. You will have another opportunity to provide verbal consent at the beginning of the interview. By proceeding, you acknowledge that you understand you participation is voluntary and that you may withdraw at any time. Please retain a copy of this for your records.
Thank you.

Appendix D Dedoose Figures

Figure D1

Code Count by Interview Transcript

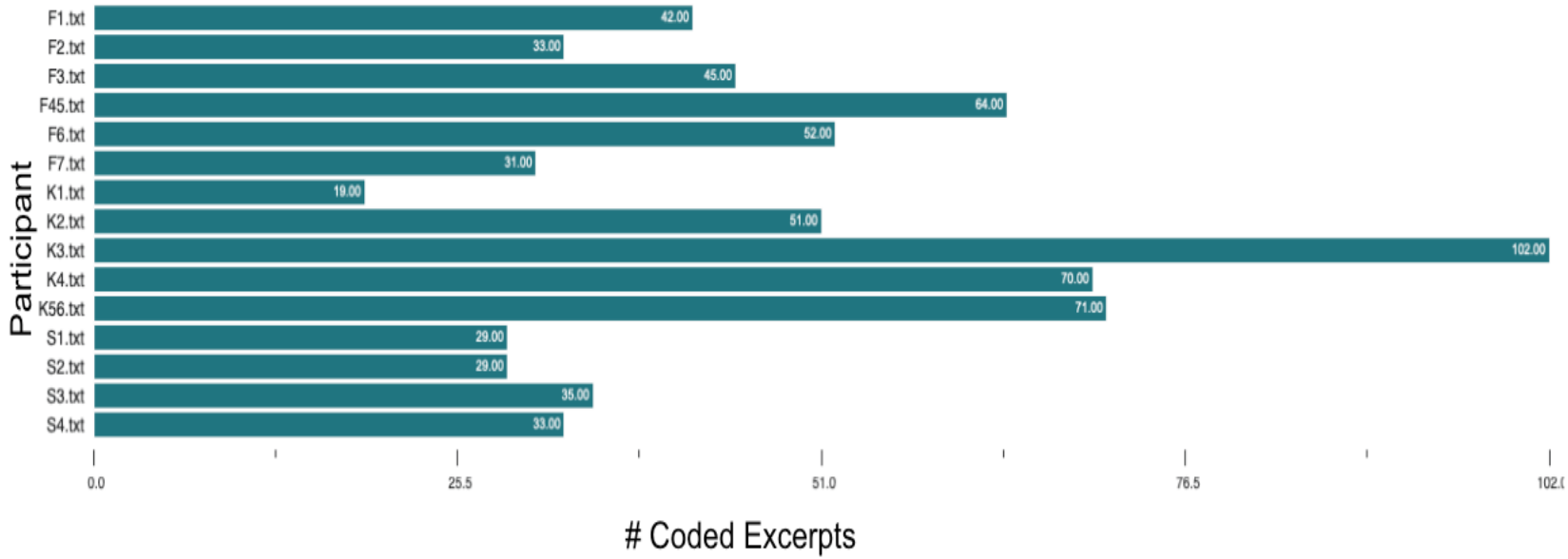


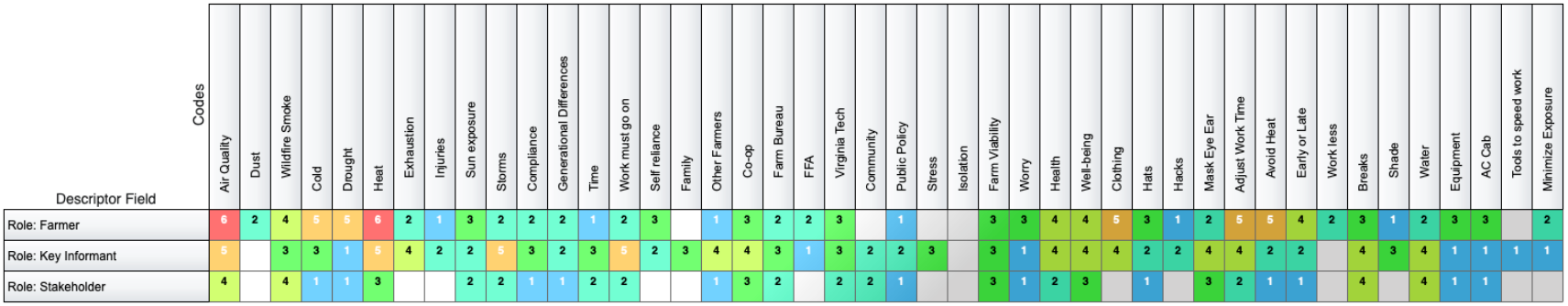
Figure D2

Code Case Count by Participant Role

Descriptor Field	Air Quality	Dust	Wildfire Smoke	Cold	Drought	Heat	Exhaustion	Injuries	Sun exposure	Storms	Compliance	Generational Differences	Time	Work must go on	Self reliance	Family	Other Farmers	Co-op	Farm Bureau	FFA	Virginia Tech	Community	Public Policy	Stress	Isolation	Farm Viability	Worry	Health	Well-being	Clothing	Hats	Hacks	Mask Eye Ear	Adjust Work Time	Avoid Heat	Early or Late	Work less	Breaks	Shade	Water	Equipment	AC Cab	Tools to speed work	Minimize Exposure
Role: Farmer	11	3	7	8	10	28	4	2	7	2	7	9	2	4	7		3	12	6	2	6		1			7	8	6	14	10	8	2	5	21	9	8	3	7	1	4	5	5		3
Role: Key Informant	6		4	12	7	28	6	5	9	19	8	5	4	8	8	14	5	5	10	3	9	5	2	8		5	2	13	20	9	5	3	12	5	2	2		18	6	12	4	3	1	1
Role: Stakeholder	11		11	2	1	9			3	4	2	1	8	4			1	10	8		2	2	1			5	1	3	6		1		5	5	3	1		7		5	2	2		

Figure D3

Code Count by Participant Role



Descriptor Field	Air Quality	Dust	Wildfire Smoke	Cold	Drought	Heat	Exhaustion	Injuries	Sun exposure	Storms	Compliance	Generational Differences	Time	Work must go on	Self reliance	Family	Other Farmers	Co-op	Farm Bureau	FFA	Virginia Tech	Community	Public Policy	Stress	Isolation	Farm Viability	Worry	Health	Well-being	Clothing	Hats	Hacks	Mask Eye Ear	Adjust Work Time	Avoid Heat	Early or Late	Work less	Breaks	Shade	Water	Equipment	AC Cab	Tools to speed work	Minimize Exposure
Role: Farmer	6	2	4	5	5	6	2	1	3	2	2	2	1	2	3		1	3	2	2	3		1			3	3	4	4	5	3	1	2	5	5	4	2	3	1	2	3	3		2
Role: Key Informant	5		3	3	1	5	4	2	2	5	3	2	3	5	2	3	4	4	3	1	3	2	2	3		3	1	4	4	4	2	2	4	4	2	2		4	3	4	1	1	1	1
Role: Stakeholder	4		4	1	1	3			2	2	1	1	2	2			1	3	2		2	2	1			3	1	2	3		1		3	2	1	1		4		4	1	1		

Figure D4

Code Discussion Percentage by Participant Role

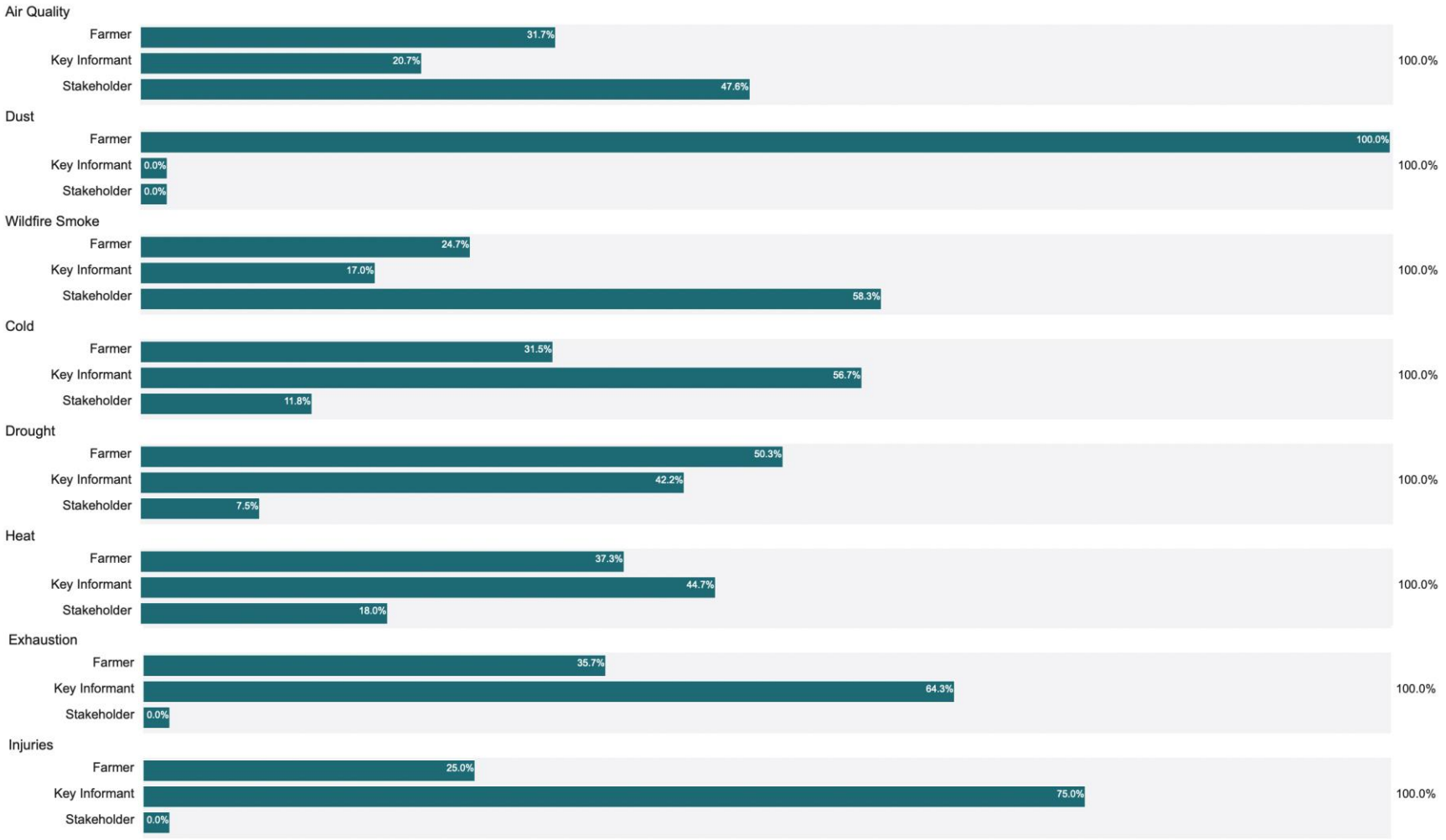


Figure D4

Code Discussion Percentage by Participant Role (Continued)

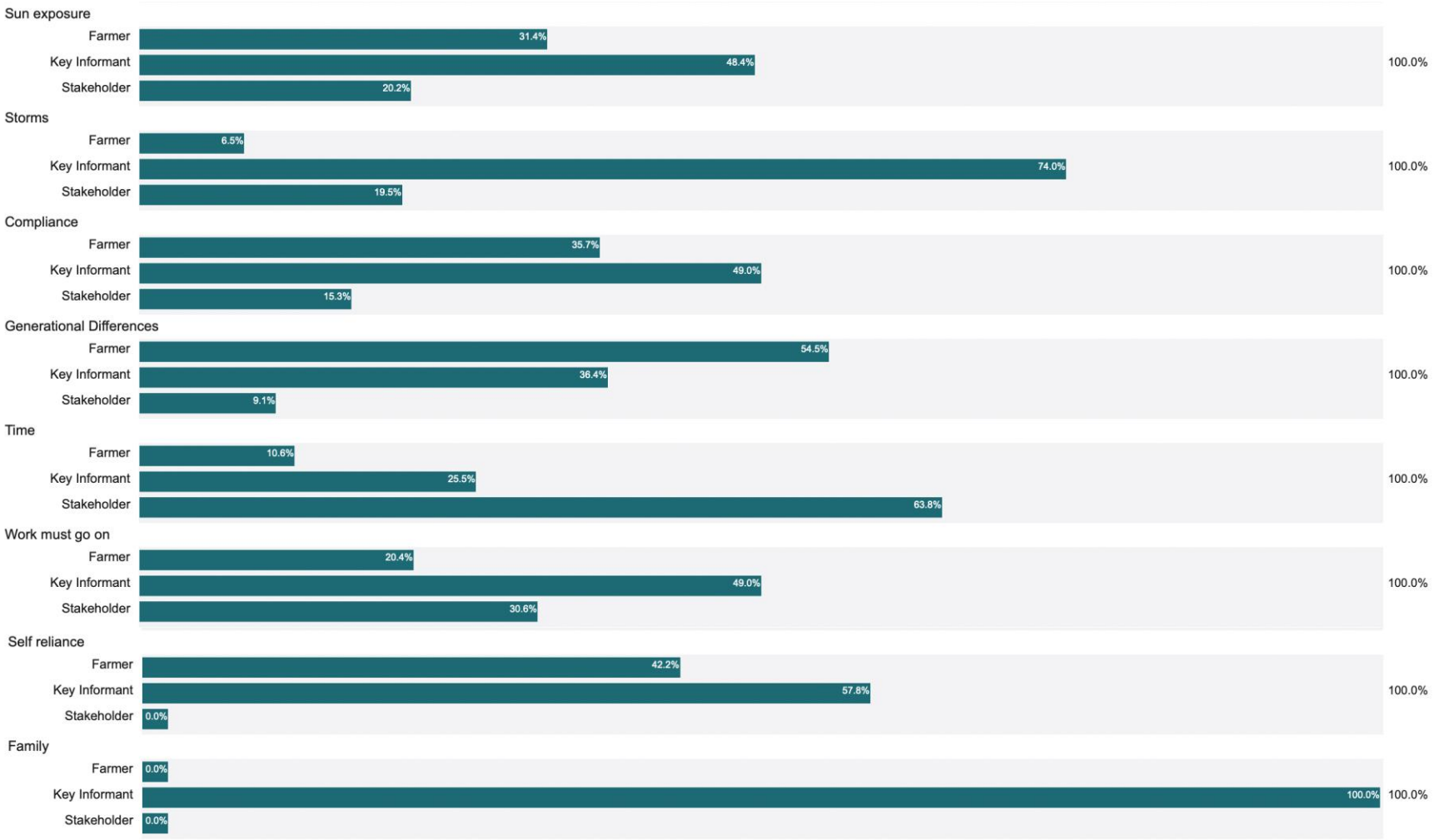


Figure D4

Code Discussion Percentage by Participant Role (Continued)

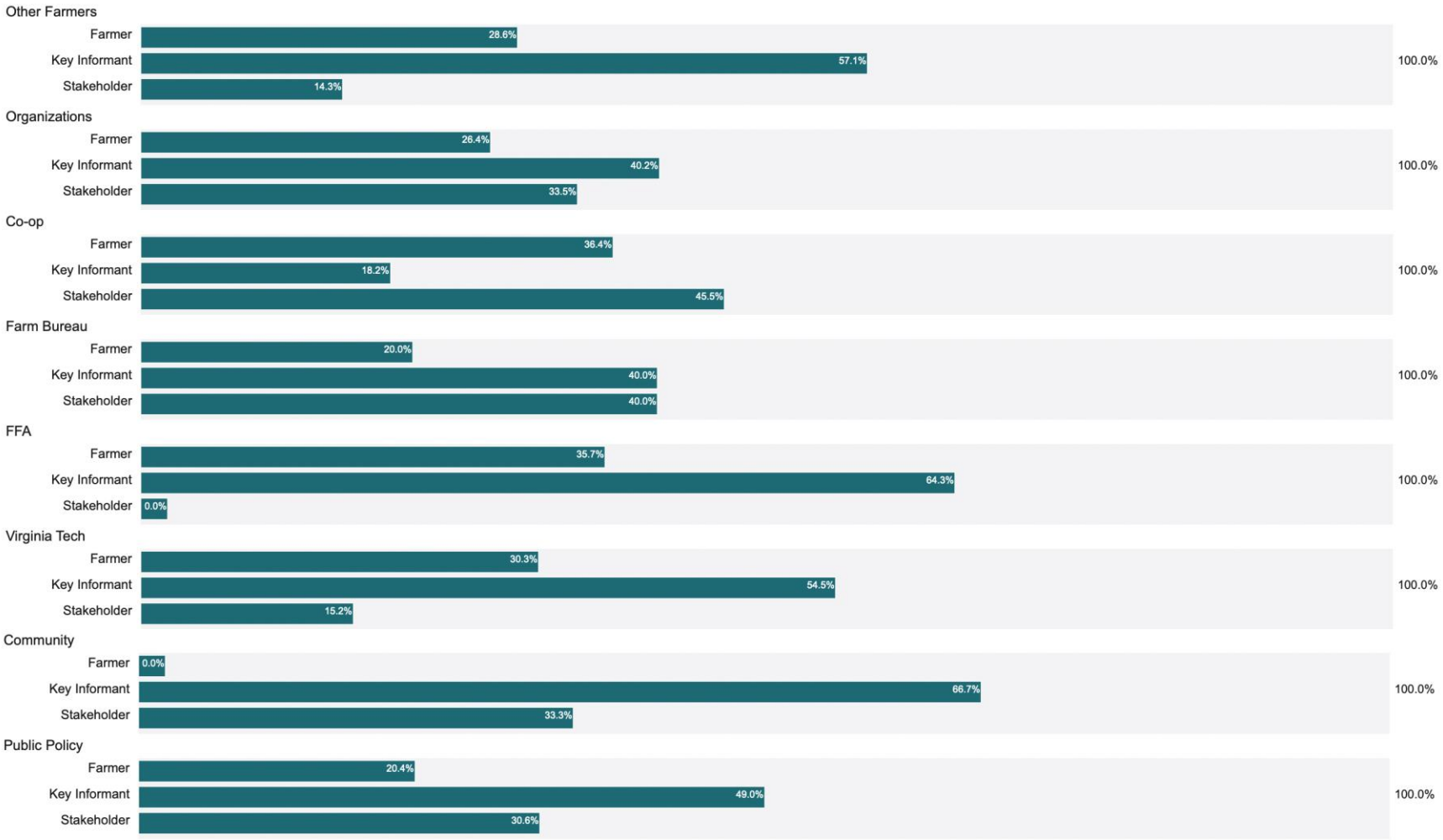


Figure D4

Code Discussion Percentage by Participant Role (Continued)

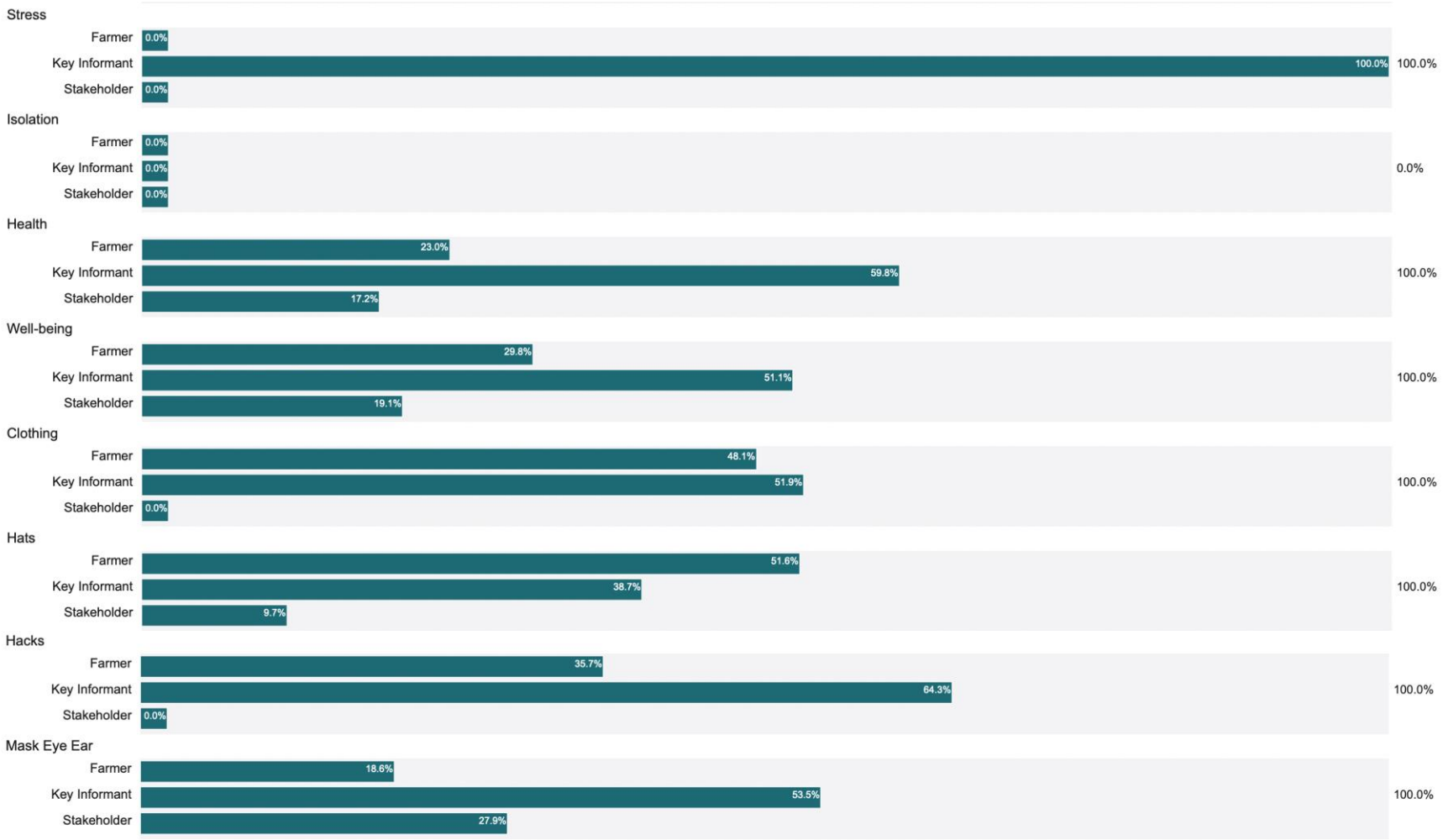


Figure D4

Code Discussion Percentage by Participant Role (Continued)

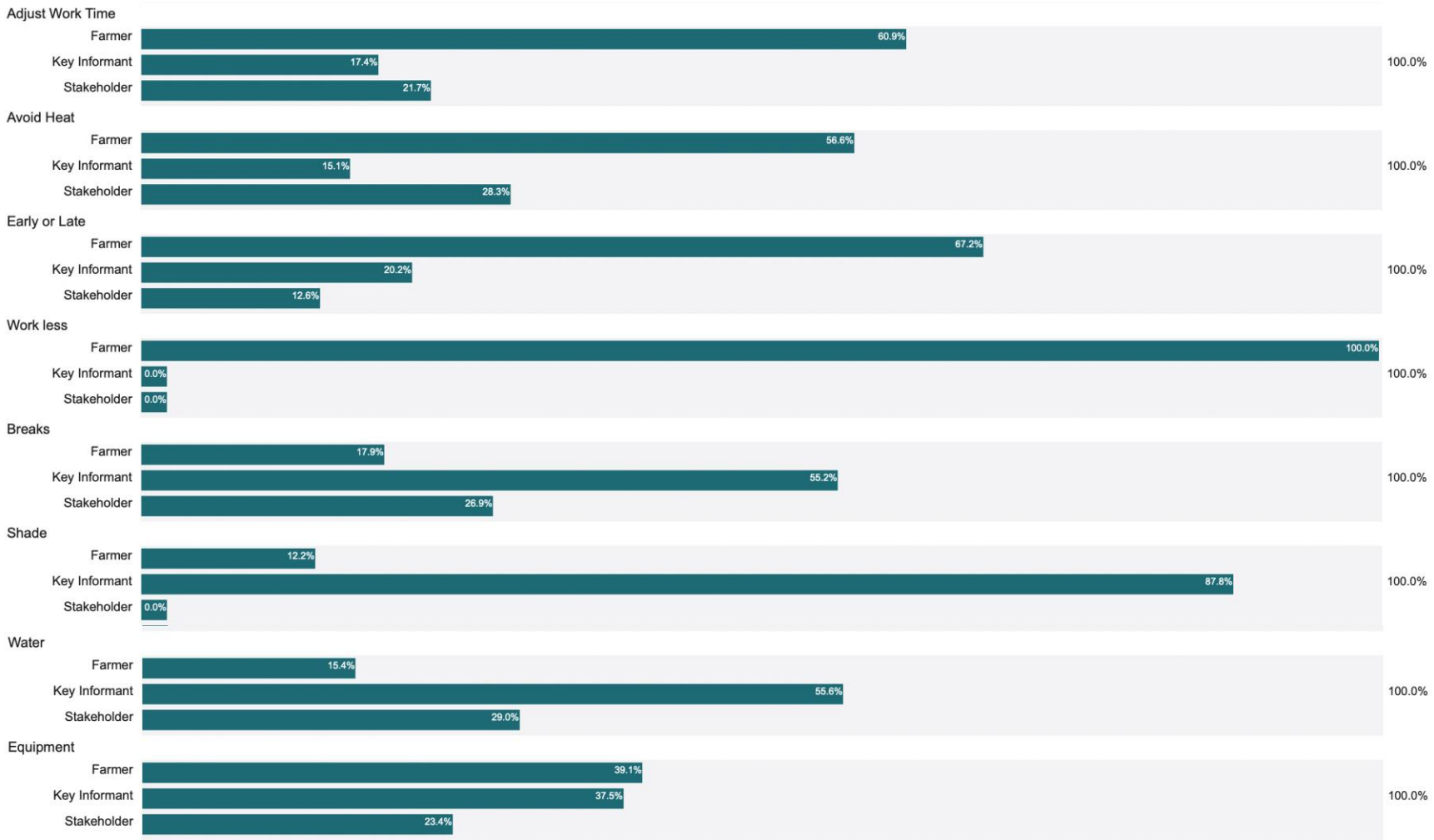


Figure D4

Code Discussion Percentage by Participant Role (Continued)

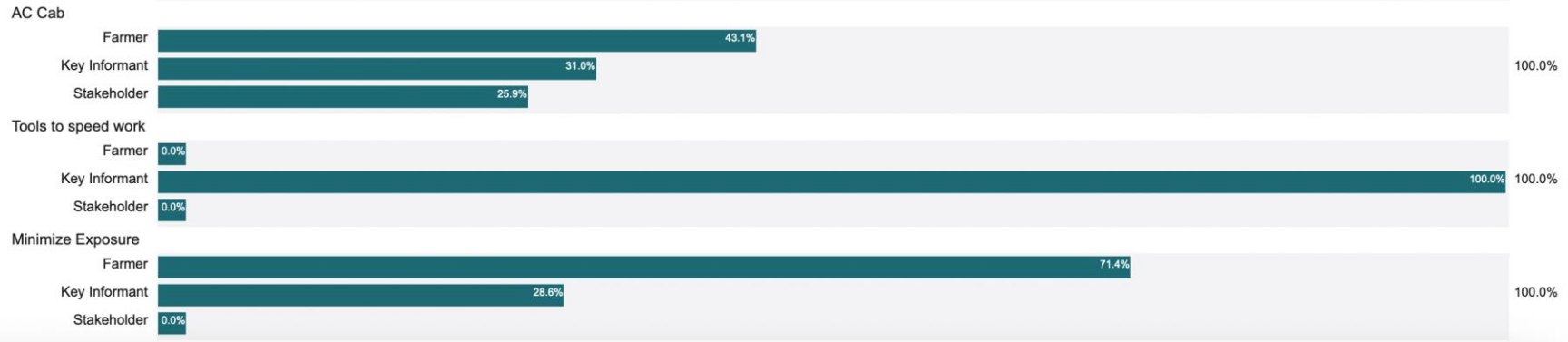
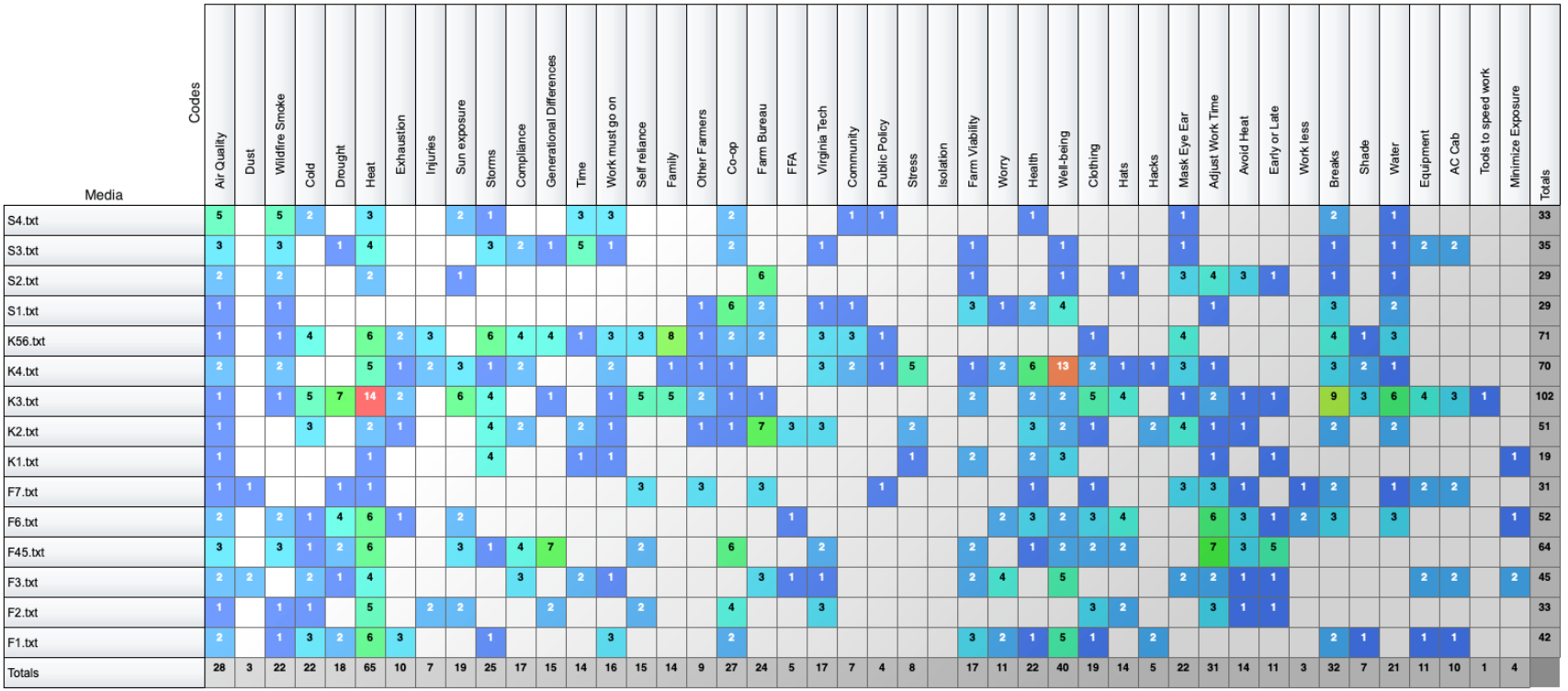


Figure D5

Code Application by Interview



Media \ Codes	Air Quality	Dust	Wildfire Smoke	Cold	Drought	Heat	Exhaustion	Injuries	Sun exposure	Storms	Compliance	Generational Differences	Time	Work must go on	Self reliance	Family	Other Farmers	Co-op	Farm Bureau	FFA	Virginia Tech	Community	Public Policy	Stress	Isolation	Farm Viability	Worry	Health	Well-being	Clothing	Hats	Hacks	Mask Eye Ear	Adjust Work Time	Avoid Heat	Early or Late	Work less	Breaks	Shade	Water	Equipment	AC Cab	Tools to speed work	Minimize Exposure	Totals
S4.txt	5		5	2		3			2	1			3	3				2				1	1				1					1				2		1					33
S3.txt	3		3		1	4				3	2	1	5	1				2			1					1			1				1				1		1	2	2			35
S2.txt	2		2			2			1										6							1			1		1		3	4	3	1		1		1				29
S1.txt	1		1														1	6	2		1	1				3	1	2	4				1				3		2					29
K56.txt	1		1	4		6	2	3		6	4	4	1	3	3	8	1	2	2		3	3	1							1			4				4	1	3					71
K4.txt	2		2			5	1	2	3	1	2			2		1	1	1			3	2	1	5		1	2	6	13	2	1	1	3	1			3	2	1					70
K3.txt	1		1	5	7	14	2		6	4		1		1	5	5	2	1	1							2		2	2	5	4		1	2	1	1		9	3	6	4	3	1		102
K2.txt	1			3		2	1			4	2		2	1			1	1	7	3	3			2				3	2	1		2	4	1	1		2		2					51
K1.txt	1					1				4			1	1										1		2		2	3					1		1							1	19
F7.txt	1	1			1	1									3		3		3				1					1		1			3	3	1		1	2		1	2	2			31
F6.txt	2		2	1	4	6	1		2											1							2	3	2	3	4			6	3	1	2	3		3				1	52
F45.txt	3		3	1	2	6			3	1	4	7			2			6			2					2		1	2	2	2			7	3	5								64
F3.txt	2	2		2	1	4					3		2	1					3	1	1					2	4		5				2	2	1	1				2	2		2	45
F2.txt	1		1	1		5		2	2			2			2			4			3									3	2			3	1	1								33
F1.txt	2		1	3	2	6	3			1				3				2								3	2	1	5	1		2					2	1		1	1			42
Totals	28	3	22	22	18	65	10	7	19	25	17	15	14	16	15	14	9	27	24	5	17	7	4	8		17	11	22	40	19	14	5	22	31	14	11	3	32	7	21	11	10	1	4	

Figure D6

Code Counts in Descending Order