2021

Farmer Suicide: Rates, Trends, and Associations to Commodity Production Among States Reporting Violent Deaths, 2003-2017

Paul Norrod
University of Kentucky, paul.norrod@uky.edu

STUDENT AGREEMENT:

I represent that my capstone and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained needed written permission statement(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine) which will be submitted to UKnowledge as Additional File.

I hereby grant to The University of Kentucky and its agents the irrevocable, non-exclusive, and royalty-free license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless an embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's capstone including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Paul Norrod, Student

Wayne Sanderson, Committee Chair

Richard Ingram, Director of Graduate Studies

ABSTRACT OF CAPSTONE

Paul Edward Norrod

The College of Public Health

University of Kentucky

2021

FARMER SUICIDE: RATES, TRENDS, AND ASSOCIATIONS TO COMMODITY PRODCUCTION AMONG STATES REPORTING VIOLENT DEATHS, 2003 – 2017

ABSTRACT OF CAPSONE

A Capstone project submitted in partial fulfillment of the
requirements for the degree of Doctor of Public Health in the
College of Public Health
at the University of Kentucky

By: Paul Edward Norrod

Lexington, Kentucky

Director: Dr. Wayne T. Sanderson
Lexington, Kentucky

Co-Directors: Dr. Steve Browning, Dr. W. Jay Christian, & Dr. Erin Abner
Lexington, Kentucky

ABSTRACT OF CAPSTONE

FARMER SUICIDE: RATES, TRENDS, AND ASSOCIATIONS TO COMMODITY PRODUCTION AMONG STATES REPORTING VIOLENT DEATHS, 2003 - 2017

Occupational studies show that farmers are at higher risk for suicide with rates at least two-fold those of the U.S. population.[2-4] Therefore, the purpose of this study was to (1) determine age- and sex-specific farmer suicide rates, (2) evaluate rate trends, and (3) assess the relationship between commodity production and farmer suicide using the National Violent Death Reporting System (NVDRS) and quinquennial Census of Agriculture. We identified 1,652 farmer suicide cases from the NVDRS. Age-specific rates showed the highest rates among male farmers over 64 at 14.03 per 100,000. Annual rates for the 15-year study period peaked during 2013 at 19.37 per 100,000 persons but were lower than rates for U.S. males. State rates were highest rates in New Mexico (29.149 per 100,000) and California (25.55 per 100,000). No statistically significant Joinpoints were identified, however, the model showed a positive Annual Percent Change of 2.44. The rate of farmer suicide in medium soy production counties was 0.56 times the rate of suicide for low soy production counties. The age-standardized male farmer suicide rates show farmer suicide rates are lower than suicide rates for U.S. males, however, farmer suicide rates continue to rise indicating a shift in farmer suicide risk.

KEYWORDS: suicide, farmer suicide, suicide trends

Student's Signature: Paul E. Norrod

Date: July 6, 2021

FARMER SUICIDE: RATES, TRENDS, AND ASSOCIATIONS TO COMMODITY PRODUCTION AMONG STATES REPORTING VIOLENT DEATHS, 2003- 2017

By
Paul Edward Norrod
2021

Dr. Wayne T. Sanderson
(Capstone Chair)

Dr. Richard Ingram
(Director of Doctoral Studies)

RULES FOR THE USE OF CAPSTONE PROJECTS

Unpublished capstone projects submitted for the Doctor's degree and deposited in the University of Kentucky library are as a rule open for inspection but are to be used only with due regard to the rights of the authors. Bibliographical references may be noted, but quotations or summaries of parts may be published only with the permission of the author, and with the usual scholarly acknowledgements.

Extensive copying or publication of the capstone project in whole or in part also requires the consent of the Dean of the College of Public Health of the University of Kentucky.

A library that borrows this capstone project for use by its patrons is expected to secure the signature of each user.

Name **Date**

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

FARMER SUICIDE: RATES, TRENDS, AND ASSOCIATIONS TO COMMODITY PRODUCTION AMONG STATES REPORTING VIOLENT DEATHS, 2003 – 2017

Paul Edward Norrod

College of Public Health

University of Kentucky

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

My sincerest thanks to my doctoral chair, Dr. Wayne Sanderson, for his patience and guidance during this entire project. I appreciate your commitment to working on a very serious problem facing farmers and your excitement for research and epidemiology. I am blessed to have you as a mentor, colleague, and friend. To our Education and Research team, Ashley, Christin, and Nurlan, you all are wonderful people.

Thank you to Dr. Erin Abner for your help and support when I was struggling to complete the project, and to Dr. Steve Browning and Dr. W. Jay Christian for offering insightful tips and suggestions during this very intensive project. You all believe in my abilities when I struggled to make progress.

To Dr. Brown and Dr. Seals, thank you for providing information and helping me access the data need to conduct this very important study. I am grateful for your ongoing work on such an important topic that is often very difficult to discuss and conduct research on.

Lastly, I want to thank my lovely wife, Stephanie, for all the support and prayers during the last five years. You have been a light in much darkness. To my wonderful children, Destiny, Parker, Carmen, Michael, Hunter, Delaynie, and Haleigh, you are my legacy and can accomplish anything in life. I pray God grant you all the joy in the world!

CHAPTER 1

INTRODUCTION

Suicide is a major public health concern in the U.S. and is defined as a behavioral outcome resulting from an individual engaging in a prospected attempt at self-injurious behavior with the intent to die.[1, 5] The mechanism of injury varies by age, sex, and geographic location; however, firearms, suffocation, and poisoning comprise the three main mechanisms used by decedents.[1, 6] Since 2001, the culmination of suicide behavior in the U.S. resulted in rates rising from 18.2 to 22.4 per 100,000, a 30% increase, by 2017.[1] Likewise, by sex, suicide rates rose from 4.1 to 6.1 per 100,000 among women, a 48% surge, between 2001 and 2017.[1] Male suicide rates also increased during these years, by 20%.[1] Men over the age of 65 have the highest suicide rate at 31 per 100,000, while the highest rate for women is among those between 45 and 6 years of age (9.8 per 100,000).[1] As of 2019, suicide ranks 10th among all leading causes of death over all ages and is the 2nd leading cause of death for persons between 10 and 34 years of age. The economic burden associated with each event is around $1.3 million, while suicide-related deaths account for 24% of fatal injuries costing about $50.8 billion annually. [1, 7]

Suicide rates vary not only by sex and age but also vary by widely recognized risk factors such as aging, depression and anxiety symptoms, family structure, stress, absent social support, substandard socioeconomic status, and chronic health issues.[6, 8-11] Additionally, geospatial variations like rural-urban gradients, proximity to health services, and state and county-level socioeconomic gradients are known to be strongly associated with suicide rates.[12, 13] The association of geospatial variations with suicide rates is evidenced by county-level trends indicating that nearly all U.S. counties experienced a 10% increase in suicide deaths from 2005 to 2015, with the highest rates occurring in Midwestern and Southeastern states peaking at approximately 38 per 100,000 persons.[13] States with the highest county-level rates were those with the most rural areas.

Another important suicide risk factor is occupation. Occupational researchers routinely classify workers according to the Standard Occupational Classification (SOC) system employed by the Bureau of Labor Statistics (BLS). The SOC system groups occupations based on job duties, education, training and job skills.[14] Based on the SOC

classification system, farmers are classified as farming, forestry, and fishing which includes farmers and agriculture workers, agricultural inspectors, loggers, and fishing and hunting workers.[14, 15] While studies of farmer suicide employed SOC codes to estimate rates for farmers, whereas, some farmer suicide studies disaggregate farmers from their respective BLS classification. The classification methods employed to disaggregate farmers from SOC categories results in broadly defining a “farmer.”

In the U.S., farming is an agricultural production occupation comprised of an aging population exposed to multiple potential causes for suicide, including well-known etiologies like rurality, economic pressures, access to care, age, depression, and chronic disease.[16-18] In 2017, there were 3.2 million farmers in the U.S., comprising mostly persons between 35 and 64 years old, with an average age of 58.[19] Additionally, most U.S. farmers are male (64%) and white race (95%).[19] Farming is a somewhat unique occupation in that farmers do not typically retire in their mid-60s but continue to work well into their 70s and 80s.

Thus, the typical demographic characteristics of farmers—and the high prevalence of established risk factors for suicide that tend to coincide in areas where farming is also prevalent—placing them among the highest risk occupational groups.[1] Although known etiologies of suicide, such as depression, are present in farming populations, the presence of diagnosable behavioral health conditions does not clarify their excess risk. Given the documentation of elevated rates among farming populations, it is likely that the processes, practices and culture of farming causally contributes to their suicide mortality compared to similar working populations.[4, 20-24]

Farmer-specific suicide risk factors are multifactorial, with prior research attributing risk to social isolation, physically demanding work-life conditions, chronic health problems, psychosocial and socioeconomic disturbances, and unpredictable forces.[24-26] The culmination of long-term suicide exposures alters neurochemistry and inhibits innate biological coping mechanisms.[27-29] Once innate coping mechanisms falter, adapting to a crisis like spousal loss, poor health, or farm-associated financial problems is hindered, thus increasing suicidal behavior.[27-30] Furthermore, the rurality of farm work, rural culture, place of residence, and proximity to health services compounds farmer suicide risk.[7, 12, 31-33] These various mechanisms of exposure are likely causes of excess risk

In the U.S., the limited research on farmer suicide indicates that farmers have higher suicide rates, at least two times higher than the non-farming population.[2, 34] Likewise, sex and age-group distributions show male farmers incur higher suicide rates, especially under 44 and over age 65. Female farmers remain an understudied group.[2, 4, 35, 36] Geospatial farmer suicide rates vary by state, with higher rates occurring in Western, Midwestern, and Southeastern states and follows national patterns for higher suicide rates in rural areas among non-farmer populations. However, no geospatial analysis of farmer suicides in the U.S. exists.[2, 34, 37, 38]

Problem Statement

Since 1946, national suicide research and prevention efforts have grown, resulting in agencies like the National Institutes of Mental Health (NIMH) and the Substance Abuse and Mental Health Services Administration (SAMHSA). Since the creation of NIMH and SAMHSA, public health efforts have been directed toward research and disseminating evidenced-based suicide prevention strategies.[39, 40] Despite the national emphasis on suicide prevention, there were 1.4 million attempts and over 40,000 deaths in 2018.[1] Similarly, a 2019 survey conducted by SAMHSA documented that approximately 9.8 million adults reported they seriously considered dying by suicide.[41] With the dramatic increase in suicide mortality and its association with substance misuse, prevention efforts shifted toward rural and disenfranchised populations affected by reduced access to mental health practitioners and the opioid epidemic.[7, 42, 43] Accordingly, suicide research tends to focus on suicide risk factors and mortality in the general population, with limited attention on at-risk occupational groups.

Because national efforts prioritize suicide mortality in the general population, knowledge about farmer suicide mortality is minimal, and, consequently, previous studies were limited by confounding, heterogeneity, and restricted sampling frames. Few prevention efforts focus on farmer suicide, and there are no national efforts to track and report farmer suicide. Although Congress recently approved the “Seeding Rural Resilience Act” to improve farmer mental health and strengthen relief efforts associated with disastrous commodity loss, farmer suicide persists as an understudied public health problem.[2, 4, 34]

Purpose of Capstone

The purpose of this capstone is to address limitations of previous studies by estimating farmer suicide rates using nationally representative data spanning a 15-year-period. Special attention will be paid to the accuracy and validity of the numerators and denominators. Data from 2003-2017 was obtained from the National Violent Death Reporting System (NVDRS) and the quinquennial Census of Agriculture to accomplish study aims. The NVDRS is restricted access data collected and abstracted from the CDC from NVDRS participating states. The quinquennial Census of Agriculture comprises data collected, analyzed, and reported by the National Agriculture Statistics Services, housed in the U.S. Department of Agriculture. We will estimate farmer suicide rates by age and sex across each year of the study period and assess trends. Finally, the capstone will evaluate geospatial variations in farmer suicide rates across NVDRS-participating states throughout the study period, focusing on the relationships between commodity production and farmer suicide rates at the county level.

Research Aims

Aim 1: To determine age- and sex-specific farmer suicide rates using the NVDRS and quinquennial Census of Agriculture. **Hypotheses:** Overall, farmers will demonstrate higher suicide rates than the general population for each year in the study period. Suicide rates among male farmers will exceed rates for female farmers in each year of the study period. Additionally, sex and age-specific farmer suicide rates will exceed sex and age-specific rates observed in the general population.

Aim 2: To ascertain age- and sex-specific temporal trends and trend differences among farmer suicide rates. **Hypotheses:** (1) Temporal suicide rates will show a positive trend and follow upward trends observed in the general population from 2003-2017. Furthermore, time-trends will evidence a positive linear relationship between year and suicide rates. (2) Both male and female farmer suicide rates will increase from 2003-2017 and follow sex-specific patterns observed in the general population. Age-specific rates for males will be higher than female age-specific rates.

Aim 3: Evaluate the relationship between commodity production types and farmer suicide. **Hypothesis:** Farmers in counties that produce large quantities of animal and crop commodities will show increased risk for suicide than farmers in counties with lower

production levels. Farmer suicide rates will follow geospatial distributions observed in the general population for Western, Midwestern, and Southeastern states, with the highest suicide rates occurring in Midwestern and Southeastern states.

Significance

Epidemiologic research on farmer suicide in the U.S. is limited, with most studies reporting on farmer suicides at the state level.[2, 3, 30, 35] Most study findings indicate that farmers experienced suicide rates 2.7 to 6 times higher than non-farming occupations, with the highest rates occurring in Western, Midwestern, and Southeastern states.[4, 34] Furthermore, research documents consistently that white male farmers have higher rates of suicide compared to non-farmer populations, especially among males over 65.[2-4, 34] In contrast, female farmers are an understudied population.[2-4, 34]

Most studies of farmer suicide studies grouped farmers into heterogeneous occupations with distinctly different occupational suicide exposures, while those studies focusing on farmers included agricultural workers in the numerator sample. Further, only two studies employed a farmer-specific referent population to calculate rates; however, age and sex-specific confounding were not addressed because those strata did not exist in the denominator during the study period.[2, 34] Moreover, the majority of farmer suicide studies employed regional or single state sampling within a limited study period, which fails to account for demographic, geographic, and commodity production differences leading to a low temporal and national representative sample.[44]

Given previous farmer suicide research, the current study sought to ameliorate prior study limitations while expanding knowledge of farmer suicide in the U.S. by accurately calculating farmer suicide rates using standardized national suicide data and a nationally representative farmer denominator population. Moreover, this study aims to enhance previous research by filling knowledge gaps about female farmer suicide rates while determining age and sex-specific farmer suicide rate differences. This study evaluated temporal trends to determine if farmer suicide rates follow similar rising patterns observed in the general population.

Finally, this study sought to assess spatial patterns in farmer suicide rates at the county level regarding crop and animal production. Farmers are susceptible to the stresses associated with unpredictable weather patterns and commodity markets, which

can adversely affect farm expenses and income. Socioeconomic factors and suicide risk are well-documented, and commodity production indirectly affects the socioeconomic status of farmers. To date, no study has explored the relationship between crop and animal production and farmer suicide rates to determine if levels of crop production are associated with rate shifts in farming populations.

CHAPTER 2

LITERATURE REVIEW

The following literature review details critical aspects of suicide and farmer suicide and provides theoretical and empirical knowledge of suicide etiologies known to impact farmers. The literature cited herein is derived from peer-reviewed sources, including medical and psychological texts, doctoral dissertations, peer-reviewed journals, and government records.

The first two sections of the review detail the historical perspectives on suicide and define suicide and corresponding self-directed violence. The third and fourth sections outline current worldwide and national rates, trends, and geospatial differences as a central factor in suicide research while detailing the economic burden of suicide. Following the fourth section, we summarize our target population and document an overview of existing literature. Lastly, the overview of existing suicide research gives special attention to epidemiologic literature relevant to each specific aim of this study, including the theoretical and empirical basis for investigating farmer suicide.

History of Suicide

Historical understandings of suicide behavior are dissimilar to current knowledge about suicide. Beliefs about suicide in antiquity were attributed to cultural and philosophical understandings of the mind and were rooted in metaphysical understandings of suicide behavior. Cultural perspectives also differed when the suicides of heroes were celebrated, while notable philosophers condemned it.[45] These early cultural and philosophical perspectives continued to influence knowledge about suicide until the emergence of empiricism ushered in scientific research on suicide etiologies and behavior.

The pioneering work of Emile Durkheim (1897) provided groundbreaking scientific evidence on suicide behavior and is one of the first known works to analyze suicide and its relationship to social norms and divisions of labor.[46] Durkheim's work discredited claims that suicide resulted from insanity or mania while connecting suicide to measurable social and environmental factors.[46] Furthermore, Durkheim's work established rationales for spatial and temporal analysis of longitudinal suicide data

because it corresponds to suicide mortality changes.[46] Decades after Durkheim's work, Ruth Cavan advanced knowledge on suicide behavior by postulating that suicide behavior follows from a personal crisis and does not solely result from group norms or severe mental illness.[47] Cavan's work also corroborated findings that suicide becomes feasible in the presence of thwarted coping and maladjustment to a personal crisis.[47] Following Durkheim and Cavan's work, suicide research broadened and revealed that suicide behavior follows complicated motivations and multi-faceted exposures, including environmental, physical, psychosocial, and occupational factors.

Outcome Definition

Self-directed violence (SDV) is a complex phenomenon comprised of behavioral elements that include fatal and nonfatal suicidal behavior and non-suicidal intentional self-harm.[48] Although suicidal ideations (thoughts) are not behaviors, suicidal behavior involves ideations because it consists of communications and actions associated with SDV.[48, 49] Individuals may report thoughts and communications about suicide behavior; however, an intent to die is not always apparent after suicide, which results in authorities relying on psychological autopsies.

The position that suicides are misreported arises from potential misclassification of deaths, by examiners, from an overdose, poisonings, firearms discharge, or undetermined causes where the death intent is unclear.[50, 51] Consequently, there are state-level authority differences regarding who can classify deaths, and in many states, the systems are a mix of elected, untrained coroners and professionally trained medical examiners.[50, 52] The ambiguities associated with mixed professional authorities and difficulties in assessing intent at death signify the need to utilize standardized data sources like the NVDRS. The NVDRS abstracts information from participating states to designate deaths as suicide from coroner reports, death certificates, law enforcement reports, and medical examiner documentation.

The CDC currently defines "violent death as a death that results from the intentional use of physical force or power, threatened or actual, against oneself, another person, or a group or community." [53] For purposes of this work, the authors define suicide as a behavioral outcome resulting from an individual engaging in a prospected attempt at SDV with the intent to die.

Suicide is a Public Health Concern

Suicide is a global and national public health concern and is the 18th leading cause of death worldwide, whereas, in the U.S., suicide is the 10th leading cause of death.[1, 54] In the U.S., suicide is the 2nd leading cause of death for persons between 10 and 34 and is the 8th leading cause of death for persons over 55.[1] There were twice as many U.S. suicides as homicides during 2017, resulting in approximately 47,173 suicides.[55, 56] The alarming frequency of persons using SDV to end their life resulted in a suicide death every 11 minutes, and for every death, about 10.8 million adults over 18 seriously considered suicide.[57] Around 3.3 million persons reported making a suicide plan while approximately 1.4 million had a nonfatal suicide attempt during 2018.[41]

Globally, suicide rates vary by age, sex, and race/ethnicity, with some of the highest global rates observed in industrialized countries, and as of 2017, the U.S. suicide rate (14.0 per 100,000) exceeded the global suicide rate (10.5 per 100,000).[1, 54] Age and sex-specific rates in the U.S. reveal higher suicide rates (31 per 100,000) among males over 65 and females (9.8 per 100,000) between 45 and 54.[1, 58] Consequently, racial/ethnic distributions for both sexes show persons identifying as American Indian/American Native and Non-Hispanic White have the highest rates (>30 per 100,000).[1, 56, 57]

Rocket et al. (2012), in their study of U.S. suicide mortality, reported that suicide surpassed intentional and unintentional injury mortality from 2000 to 2009.[5] Sex-specific distributions for suicide mortality showed males have the highest cause-specific mortality with a rate of 24.10 per 100,000 compared to females with a rate of 13.9 per 100,000.[5] Age-specific suicide rates were highest among persons between the ages of 35 to 54 (25.60 per 100,000), followed by persons 55-74 years old (23.80 per 100,000).[5] The suicide incidence rate ratio for persons between the ages of 35-54 was 29% higher than persons 15 to 24 and was 31% higher for persons over 75.[5] Comparable findings were reported by the CDC with the highest rates observed during 2010 among men (30.7 per 100,000) and women (9.4 per 100,000) between ages 50-54. Overall rates increased among individuals between 55 and 59 (49.1%) and women (59.7%) from 60 to 64 years old.[59] Suicide mortality by racial/ethnic identity was highest among persons who identify as American Indian/American Native (65.5 per 100,000), followed by Whites (40.4 per 100,000).[59]

Research on geospatial differences for suicide shows higher rates in the Western U.S., followed by the Midwest and Southeast, which consist of counties with high rural-urban gradients and reduced access to mental health services.[13,16] Stone et al. (2018) found that suicide rates in Western and Midwestern states increased by more than 30% throughout the study period.[58] North Dakota experienced the most extensive (57.6%) suicide increase over time; whereas, Southeastern states like Kentucky showed lower rates (19%) during the study period.[58] Similar geospatial suicide patterns are documented in other studies with the highest rates observed in Western and Midwestern states followed by those in the Southeast.[5]

Overall, states with a lower ratio of non-white persons between 15 and 24 show lower suicide mortality; whereas, states with a higher proportion of whites, males, and persons in poverty showed higher suicide rates.[60] Moreover, research indicates that temporal suicide patterns do not shift with population size or "urbanicity." [60] These findings are congruent with other studies that report lower suicide mortality among urbanized and metropolitan counties; however, it does not align with other studies reporting higher suicide rates among American Indians/American Natives in the West and Midwest.[5, 61]

From 1970 to 1997, rates among men living in metropolitan counties decreased over time; whereas, female rates decreased in most urban and rural areas.[32] Male suicide rates in rural areas rose (1.08%) annually through the study period.[32] The most rural areas experienced a significant suicide rate increase (26%) while rates in urbanized areas fluctuated over time.[32] Similar trends were observed from 2001 to 2015, with the greatest increase in suicide rates in nonmetropolitan/rural counties. Such findings are consistent with other studies reporting higher suicide mortality in states with considerable rural-urban gradients in the Western, Midwestern, and Southeastern states.[13, 61] Counties in Western and Midwestern states typically exhibit rates above the national average (>22.1 per 100,000). In contrast, states with robust American Indian/American Native populations show the worst suicide rates (>36 per 100,000).[13]

Excess suicide mortality in rural regions is problematic because rural regions are known for pronounced concentrations of suicide risk factors, including poverty, substance misuse, degrading built environments and infrastructures, and healthcare disparities. The presence of SDV behaviors in rural regions emulate geospatial patterns comparable to suicide mortality observed in rural regions. Harp and Borders (2019)

documented a statistically higher mean prevalence of suicide behavior among non-metro residents involving thoughts, plans, and attempts. Consequently, the mean prevalence of SDV behaviors in nonmetropolitan counties was statistically higher over time compared to small and large metropolitan counties.[12] These findings are concerning given that persons who plan or attempt suicide are at greater risk for completing a suicide attempt. Although associations between suicide indicators and outcomes are sparse because of possible underreporting, the elevated prevalence of SDV behaviors and suicides in rural areas indicates the need for an ongoing study of suicide behaviors in rural America.[13]

The economic burden associated with fatal injuries exceeds $200 billion annually, which represents about 33% of the more than $600 billion associated with all injuries in the U.S.[62] In the U.S., suicide accounts for 20% of all fatal injuries and constitutes $50.8 billion associated with fatal injuries while the total indirect cost of suicide is about $56.8 billion. Differences by sex reveal that males have the highest direct cost associated with suicide, totaling $41.7 billion, while the total cost of all suicide events and attempts by males reached $48.1 billion.[62, 63] The total average cost of each suicide event is about $1.3 million; however, cost varies by mechanism of injury and decedent age.[62] Individuals between age 25 and 44 account for the highest proportion of suicide costs because of lost life-years and productivity, whereas persons over 65 incur the lowest cost.[62, 63] Despite the measurable adverse economic impact of suicide, families experience unmeasured economic and psychological burdens detrimental to children and spouses.[64]

Suicide and Agricultural

In the U.S., the term farm is defined by the Census of Agriculture as "any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year," which includes small family farms with only one operator, ranches, experimental farms or Indian Reservations.[19] The U.S. Bureau of Labor Statistics defines persons with primary responsibility for running establishments that produce crops, livestock, and dairy products as farmers, ranchers, or "other" agricultural managers; whereas, the Census of Agriculture defines these individuals as an operator or producer.[15] Individuals defined as a farmer, rancher, manager, or

producer may or may not be directly involved with the work associated with crop or livestock handling.[15, 19]

According to the National Agricultural Statistics Services (NASS), there were 2.04 million farms and ranches operated by over 3.3 million farmers in 2017, with the majority (97%) classified as family farms or ranches.[19] From 2012 to 2017, the number of farms and ranches declined while the number of farmers rose (6.9%). Overall, the average age of farmers also increased to 57.5 years.[19] Most farmers reported their race/ethnicity as white (90%), with the majority of farmers identifying as (64%) were male. Although there was a lower proportion of females reporting themselves as farmers, the number of female farmers rose (27%) between 2012 and 2017.[19] Work distributions among male and female farmers differed, with male farmers reporting involvement in land use and agricultural production decisions while female farmers reported making daily decisions about records and fiscal management.[19] Previous research on farm responsibilities suggests that females contribute to a vast proportion of farming duties but are less likely to describe themselves as a farmer.[65]

Most farmers report living on their farms and consider farming a secondary occupation despite relying on farming for income. For the farmers who worked off the farm, at least 40% reported doing so at least 200 days per year. Although many farmers work off-farm jobs to generate income, this aging group still considers farming a lifestyle instead of a job. Strong emotional connections to family and farmland coincide with farming, and these strong emotional connections to family and land are reasons farmers work into their 70's and 80's.[21, 24] However, the farming lifestyle involves physically hazardous work combined with multi-faceted psychosocial and socioeconomic factors stressors.[22, 24]

Farmers are usually healthier than the general population but are vulnerable to physical, chemical, and environmental hazards. The physical, chemical and environmental dangers of farming originate from multiple sources encompassing machinery operation, providing medical care to livestock, dispersing pesticides, or enduring harsh outdoor environments.[66] The physically demanding nature of farming and its hazards lead to illnesses and musculoskeletal injuries together with chronic diseases like osteoarthritis, certain cancers, or chronic obstructive pulmonary disease (COPD).[66-

[68] Consequently, the adverse physiologic conditions can compound the harmful psychosocial outcomes linked to farming.[16, 69-71]

Farming is an occupation recognized for its detrimental consequences on the psychological well-being of farmers. The existence of psychological strain precipitates deleterious behavioral health outcomes associated with suicide behavior. Likewise, chemicals used in farming, like pesticides, exhibit a dose-response relationship to clinically significant depressive symptoms.[16, 70, 72, 73] Clinically significant behavioral health symptoms may exacerbate or contribute to stress resulting from chronic diseases, physically demanding labor, shifting commodity markets, social isolation, and unpredictable forces.[25, 74, 75]

Booth et al. (2000) found that perceived stressors, like family problems and poor health, were correlated with higher anxiety and depression levels, while stress over finances was associated with higher anxiety levels. Similar studies document farmer stress originates from unpredictable circumstances composed of commodity market uncertainties, livestock and crop problems, family crisis, fear of farm loss, and family transition.[75] Kearney et al. (2014) reported that a large percentage of farmers expressed feeling "very stressed" over the future of their farm, adverse weather impacts, machinery problems, and stress about their livestock and crops. Likewise, a recent study of Georgia farmers and agricultural workers showed the suicide decedents were predominantly married, middle-aged white males whose suicide was attributed to poor health and relationship problems.[30] The culmination and duration of physical, environmental, and psychosocial farm demands can alter neurobiology and thwart coping mechanisms, resulting in coping with ongoing problems or farm crisis. When farmers cannot adapt to physiological and psychological stressors, they experience increased suicidal behavior levels in response to stressors.[76, 77]

Generally speaking, because of the physical demands of the work, farmers are healthier and have lower mortality rates than the general population (the healthy worker effect). During the early 1970s and 80s, mortality research among major occupations showed that farmer suicide mortality increased in the late 80s because of sweeping global economic recessions and the U.S. farm crisis. The adverse socioeconomic condition for agribusiness[78] The combination of global economic events, rural population

shifts, and the emergence of publications from well-known academics like Bedeian and Boxer drew attention to suicides among agricultural occupations[78, 79]

Occupational mortality studies have consistently documented excess suicide mortality in relationship to all-cause mortality among agricultural populations. Although early occupational mortality studies were fraught with limitations associated with study design and bias, they established the groundwork for research on farmer suicide mortality. Saftlas et al. (1987) reported a higher proportionate mortality ratio (23%) for suicide among Wisconsin farmers than leukemia, cardiovascular, and kidney disease. Likewise, mortality patterns among British farm workers showed elevated suicide mortality, while mortality ratios did not exceed unintentional injuries and were not compared to chronic diseases.[80] An evaluation of suicide mortality patterns in Australia showed (22%) higher mortality rates among male farmers and farm managers than the general population; whereas, standardized mortality ratios for suicide exceeded that of chronic pulmonary disease and neoplasms in the lung and bronchus.[81] Consequently, an evaluation of proportionate mortality among British Columbia Farmers documented lower suicide mortality than all other accidents; whereas, SDV and accident mortality exceeded the mortality from all other causes of death.[80]

Outcomes research among Agricultural Health Study (AHS) participants document greater suicide risk (RR=1.45) among chlorpyrifos applicators in the AHS study versus unintentional injuries, circulatory diseases, respiratory diseases, and certain neoplasms.[82] Canadian farmers exposed to pesticides also show an increased risk for suicide among persons with direct contact with mixing and spraying pesticides.[83] Conversely, studies exploring dose-response relationships between all pesticides and suicide among AHS participants show distinctly different results. Beard et al. (2011) document commercial applicators (HR=1.35) and participants over 65 (HR=1.97); whereas, cumulative lifetime pesticide exposures did not demonstrate any association with suicide. Studies of mortality rates among AHS participants reveal that standardized suicide mortality ratios were lower (30%) than all other causes of death among pesticide applicators and their spouses.[84, 85] Likewise, spouses also show lower rates (60%) of suicide mortality.[84, 85]

The differences across study outcomes may be attributed to several epidemiologic factors, including differences in the sampling period, exposure classification, study design, sample size, and outcome misclassification of suicide decedents. Furthermore, there are more male applicators than female applicators with a

more significant proportion of female spouses in the cohort, thus reducing the comparison of sex-specific suicide mortality. In the AHS, outcome misclassification may be attributable to differences between North Carolina and Iowa in ruling a death as a suicide.[86] For example, in the presence of a terminal illness, investigators and medical examiners may not differentiate between an accidental overdose or an intentional death.

Evaluating suicide mortality by occupation is an epidemiologic method to assess differences by primary industry and occupation. In the U.S., most occupational suicide research to date consists of longitudinal studies using vital statistics data from state departments of health, the U.S. Census Bureau, and the Bureau of Labor Statistics. Before the inception of the National Violent Death Reporting System (NVDRS) in 2002, suicide studies typically abstracted data from death certificates. The corpus of studies on farmer suicide mortality shows mixed results compared to other vocations with mortality variances by sex, age, state, and geographic region.

Occupational Suicide Mortality

Occupational suicide mortality during the late 1970s and 80s showed crude farmer suicide rates (25 per 100,000) exceeded those of other occupations like coal mining and machine tool operators.[87, 88] Likewise, male farmer suicide rates (30 per 100,000) were higher than that of male physicians and other manual labor occupations.[87] In comparing industrial suicide rates in Alabama, crude farmer suicide rates exceeded national rates while county-level rate ratios were fivefold (aRR=5.7) higher than the public administration referent groups.[88] Consequently, farmer suicide rate ratios did not exceed ratios for mining, construction, and transportation, which may be connected to the bi-vocational nature of farming or unassessed age and gender confounding.[88] A multi-state case-control study of occupational suicide during a similar time frame documented that the odds of suicide among farmer workers (OR=0.69) was less than that of other skilled and semi-skilled labor occupations.[89] Neither study provided results for sex and age suicide risk, and, likewise, temporal patterns were unassessed.

In recent decades, occupational suicide research has modeled previous research showing mixed results for farmer suicide mortality. Studies of suicide occurring at or around the workplace showed a higher suicide risk for farmers (RR=4.67) than other occupations except for military and police personnel.[90] Males over the age of 55 were at

substantial risk for suicide in and around the workplace while reporting female suicide risk is sparse. The lack of reporting on female farmer suicide risk may be related to implicit gender bias and female farm roles. In other instances, farmer suicides were omitted from studies because of a low number of farmer suicide decedents contributing to rate instability.[87, 88, 90] To overcome challenges associated with low farmer suicide decedent counts, several studies grouped farmers into their respective occupational categories defined by the standard occupational classification system established by the Bureau of Labor Statistics.

Farmers are categorized into two major occupational classifications: farm, ranch, and other agricultural managers or farming, forestry, and fishing, which includes agricultural workers. Research employing the standard occupational classification system and the standard census population as the denominator to calculate rates consistently shows farmers sustain excess suicide mortality compared to other occupations. Stallones et al. (2013) reported that Colorado male farmers, forestry, and fishing workers had the highest adjusted rates (475.6 per 100,000) versus all other occupations. Consequently, female farmers, forestry, and fishing suicide rates (22.7 per 100,000) were higher than most female suicide rates in all occupations, although their rates were based on fewer than five decedents.[3]

A study using the NVDRS and the standard occupational classification system found that farmer, forestry, and fishing suicide rates were lower than most skilled and unskilled laborers.[4] Subgroup rates for farm, ranch, and agricultural managers and farming, forestry, and fishing showed rates exceeding adjusted rates for other skilled and non-skilled vocations, with rates peaking at 44.9 per 100,000. Likewise, suicide mortality among Georgia workers was highest among farmers, forestry, and fishing workers. Crude rates peaked at 50.7 per 100,000, while standardized mortality ratios for Georgia workers being highest among farmers, forestry, and fishing workers.[36] As with previous research, female rates were unreported for all standard occupations associate with farming because of the low number of female decedents.[4, 36] Sex and age-specific rates were not reported in the NVDRS or Georgia violent deaths studies.

Worldwide occupational suicide mortality research indicates sex and age variability among farming populations with mixed results for farmer suicide mortality compared to other occupations. Page and Frager (2002) reported farmer suicide rates

exceeded those of the general population (51.4 per 100,000) over ten years; whereas, agricultural laborers' suicide rates were slightly lower (41.9 per 100,000). Evaluation of age-specific trends revealed rates for farm managers (106 per 100,000) over 60 was double that of all farmer managers throughout the ten-year study period.[91] Conversely, suicide studies of Australian farmers show a significant proportion of suicides occur among farmers less than 60 years, with the highest, averaged suicide rates occurring among males less than 34 years old.[37, 92, 93] Female farmer rates (25.15 per 100,000) were highest among females less than 34 years old.[93] Likewise, farmer suicide rates are higher than non-farmer suicide rates across all ages groups for both genders except for females ages 35 – 55.[93] Geospatial differences in Australia farmer suicide show were notably higher for farmers versus non-farmers; however, this may be attributed to population density gradients for farmer and non-farmers in certain regions.[93] In a geographic follow-up study of farmer suicides, there were observable rate differences between Queensland and New South Wales and regional differences within each state.[37] Farmer suicide rates in Queensland regions were double that of rates in New South Wales, indicating geospatial variability in farmer suicide.[37]

Studies of male Canadian farmers document lower suicide rates, overall, compared to males in the general population throughout the study period. Rates for male farmers over 40 increased, with the highest rates (36.4 per 100,00) among farmers between 50 and 59 years.[94] Moreover, the suicide rates for farmers over 70 were higher (6.7%) than rates for non-farmers. Similar results were reported among Ontario farmers, where rates were highest among older farmers while rates throughout the ten-year study period were less for farmers than non-farmers.[95]

Within the U.S., studies consistently show excess farmer suicide mortality compared to non-farming populations. In a study of Kentucky farmer suicides from 1979 to 1985, the highest rates were among white male farmers over 65.[35] The suicide rate for white male farmers (116.1 per 100,000) during the study period was triple that of U.S. white males (34.3 per 100,000) and almost doubled the rate for white males (63.2 per 100,000) in Kentucky.[35] White male farmers under 25 demonstrated the lowest suicide rates (8.5 per 100,000). Pylka et al. (1992) and Gunderson et al. (1993) reported similar findings for farmer suicides in Midwestern states. Rates were prominent for full-time farmers and ranchers (>50.1 per 100,000) compared to farm laborers and females on farms.[96, 97] The average age of farmer suicide decedents was 64, whereas female and

farm labor decedents were middle-aged and younger.[96, 97] Consequently, there were notable geospatial rate differences, with the highest rates occurring in Montana and South Dakota, while the lowest rates were observed in Minnesota, North Dakota, and Wisconsin.[96, 97] Similar findings were reported for farmer suicides in Colorado and Southeastern states.

Stallones and Cook (1992) compared metropolitan, nonmetropolitan, and on-farm suicide rates in Colorado from 1980-1989. Overall, suicide rates were substantially lower (88%) among farm residents than metropolitan and nonmetropolitan residents. Likewise, age-specific suicide rates were the lowest among farm residents.[98] Persons over 65 showed the highest rates of all metropolitan (68.2 per 100,000), nonmetropolitan (69.2 per 100,000), and farm residents (21.8 per 100,000).[98] These findings depart from previous geospatial suicide and farmer suicide studies and show that residing on a farm may be a protective factor for suicide.

Browning et al. (2008) reported elevated farmer suicide rates for Kentucky, North Carolina, and South Carolina with heightened rates for white male farmers in North Carolina (48.09 per 100,000) compared to Kentucky and South Carolina. The widest rate difference for excess suicide mortality was observed between North Carolina and Kentucky, whereas the total number of suicide decedents was highest in Kentucky. Calendar-time adjusted rates peaked among white male farmers over 64 exceeded rates (>50 per 100,000) among middle-aged and younger farmers. Suicide trends throughout the study period showed an overall downward trend from 1990 to 1998. Female and non-white suicide rates were undocumented because of low decedent counts, which follows similar accounts from previous farmer suicide research. Nationwide research on farmer suicide rates in recent decades is limited; however, recent research documents higher violent death rates for farmers and agricultural workers than other occupations.

Ringgenberg et al. (2017) reported higher rates of suicide for farmers and agricultural workers (0.36 to 0.95 per 100,000) compared to other occupations (0.13 to 0.19 per 100,000). Suicide trends throughout the study period varied, with an upward trend occurring between 2004 and 2008, while rates for 2010 were not plotted.[34] Gender and age differences were unreported except for a statistical chi-square test noting independence between these variables.[34] The highest proportion of suicides occurred among decedents between the ages of 25 and 44, with most decedents being white and

male.[34] Regional variations indicated that the largest percentage of suicides occurred in the West and Midwestern regions of the U.S.[34] Although rates were not calculated, the average decedent age was 53. The highest proportion of factors contributing to suicide were health and relationship issues.[30]

Public Health Implications

Conventional public health efforts to reduce suicide regularly target suicide risk factors in the general population, increasing awareness about behavioral health, increasing systems level treatment access,, reducing substance misuse, and improving delivery of evidence-based interventions. Despite national public health efforts, though, research consistently confirms rising suicide mortality in the U.S.[3, 4, 7, 88, 89, 99-102] Furthermore, national trends clearly illustrate variability over time with distinct differences by gender, age, and geography. Older males incur the highest suicide mortality, followed by younger females, while racial/ethnic trends show persons identifying as American Indians/American Natives and as White have the highest racial/ethnic suicide mortality. Geospatial suicide patterns demonstrate that rural regions demonstrate excess suicide morbidity and mortality because of risk factor prevalence and SDV behaviors. Moreover, suicide mortality is worse in rural counties and regions than urban and metropolitan areas, especially in the West, Midwest, and Southeastern regions of the U.S., which may be attributed to proximity to health services and social isolation.

Prior studies of farmer suicide in the US consistently document heightened farmer suicide rates for all farmers and male farmers with rates exceeding the suicide rates of the general population and similar manual labor occupations like construction. Overall, reported rates for all farmers, male farmers and occupations that include farmers show substantial variability with rates ranging between 30 to 475 per 100,000 persons. By contrast, there is scant research reporting female farmer suicide rates because of the low number of female farmers or possibly because of how females residing on farms self-identify. However, studies reporting female farmer suicide rates show suicide rates among female farmers exceed the rates of all other occupations and the general female population in the US. Accordingly, close examination of prior farmer suicide research suggests distorted methodological problems in how farmers are classified and discordance in the denominator populations utilized to estimate rates.

Prior studies were fraught with limitations including occupational misclassification, lack of generalization to farming populations, age and gender confounding, and sampling differences in selection of a population that best represent suicide background risk among farmers.. Heterogeneity is an appreciable concern in study design because of variations in background exposures when comparing farmers to other occupations. Consequently, utilizing non-farmer referent groups in rate calculations induces bias because suicide risk factors in farmers are distinctly different from those in non-farming populations. Although it is essential to compare farmer suicide to all occupational suicides, examining farming-specific populations is vital to improving knowledge of suicide mortality among farmers.

The body of farmer suicide research follows similar patterns observed in the general U.S. population suggesting higher suicide mortality in older white male farmers. Higher suicide mortality among older farmers is relevant, given that the average age of U.S. farmers reported in the last Census of Agriculture was 57.[19] Documentation of female farmer suicide mortality is inadequate; however, evidence suggests that females between 35 and 55 are at greater risk for suicide. Several studies have reported increasing suicide trends over time; however, these studies did not analyze farmer suicide time-trends. Likewise, geospatial patterns follow national suicide patterns where Western, Midwestern, and Southeastern states experience considerable suicide mortality; however, it is unclear whether farm-specific, mental health, socioeconomic, or geospatial suicide etiologies contribute to the excess mortality in these U.S. regions. To date, there is no documented geospatial analysis of farmer suicides in the U.S. or worldwide.

The burden of suicide mortality in farmers leads organizations like the CDC to prioritize farmer mental health and suicide reduction as part of the National Occupational Research Agenda (NORA). Since 2008, NORA consistently acknowledges the stressful work conditions and mental health needs of farmers. Other nationwide efforts targeting farmers include the "Seeding Rural Resilience Act," which designated funds toward farmer mental health and improves financial relief efforts associated with unpredictable commodity loss. However, it is unclear how states will employ funds to reduce farmer suicide and prioritize mental health services. Besides acknowledging farmer suicide through NORA, there are no national efforts to track and reduce farmer suicide, with current efforts posited solely within universities and state departments of agriculture.

This study can provide valuable information about current farmer suicide mortality in the U.S. while contributing better knowledge on sex and age-specific differences as well as time-trends and geospatial patterns. Moreover, results from this study can be used to inform targeted suicide interventions at national and state levels.

CHAPTER 3

METHODOLOGY

Research Aims 1 and 2

Background

The multifaceted nature of suicide has gained considerable interest with growing attention on suicide mortality among farming populations. In the US, farmers are an aging population of predominately white males.[19] Most farmers view farming as a lifestyle enmeshed with strong emotional connections to the profession and their land, even though it is a hazardous and stressful occupation.[19, 21] The hazards of farming are well-documented and are linked to handling livestock, dispersing pesticides and herbicides, operating equipment, and exposure to harsh work environments.[66, 67, 103] Exposure to farming's physical hazards increases the risk for developing chronic respiratory diseases, musculoskeletal disorders, certain cancers, and depression.[18, 68, 84, 104, 105] Farmers report high levels of stress associated with agriculture production's physical and mental demands attributed to inclement weather patterns, fluctuating commodity markets, machinery breakdown, social isolation, aging, and relationship problems.[24, 74, 106] The combination of hazards and stress associated with farming result in inhibited neurobiological and psychosocial coping mechanisms that precipitate increased SDV behaviors and suicide.[26, 28, 30]

Worldwide, research consistently documents elevated farmer suicide rates in Australia, England, Wales, and the U.S.[2, 34, 91, 93, 94] In the US, studies show elevated farmer suicide rates are higher when compared to other occupations and the general population with geospatial grouping in Western, Midwestern, and Southeastern states.[3, 4, 34, 91, 96, 97] From 1970 to 1980, suicide mortality studies documented high crude rates for farmers (25 per 100,000) that exceeded rates for manual labor occupations like machinery operators and mining.[87, 88] Stallones (1990) reported white male suicide rates for Kentucky farmers (116.1 per 100,000) were double that of white males in Kentucky and three-fold higher than the general population.[35] Similar findings were reported in a study of farmer suicides in three Southeastern states, with the highest rates occurring among white farmers over age 64 in North Carolina.[2] In recent decades, farmer suicide

mortality remains an ongoing concern with researchers using standardized data sets such as the Census of Fatal Occupational Injuries (CFOI) and the National Violent Death Reporting System (NVDRS). A study of occupational suicide from the Bureau of Labor Statistics (BLS) showed the majority of on-the-job suicide decedents were males (94%), with agriculture, forestry, and fishing jobs incurring the highest risk (RR=3.21) of all occupations.[90] In a study of Georgia worker violent deaths, Lavender et al. (2016) documented that suicide mortality (SMR=2.9) for farmers, forestry, and fishing workers was double that of any other occupation.[36] Consequently, geospatial distributions of farmer suicide mortality show higher distributions among Western, Midwestern, and Southeastern states known for farming.[4, 96, 97] However, a comparison of suicide rates among on-farm residents to metropolitan and nonmetropolitan geographies revealed lower rates among on-farm residents.[98]

Data Sources

We conducted an ecological study to determine sex and age-specific farmer suicide rates in the US from 2003 to 2017. Numerator data were obtained from the NVDRS, with the total sample representing data from 36 participating states. The NVDRS is a national population-based active surveillance system created in 2002 and published by the National Center for Injury Prevention and Control (NCIPC), part of the Centers for Disease Control and Prevention (CDC).[107] The NCIPC collects incident violent death data from funded states through multiple data sources, including death certificates, coroner and medical examiner reports, and law enforcement reports.[107] The information about the violent deaths and contributing circumstances, including physical, mental, and relationship problems and toxicological reports, are abstracted, standardized, and entered in the NVDRS restricted access database by CDC-trained abstractors.[107]

Denominator data for farmers were obtained from the quinquennial Census of Agriculture to estimate the total number of farmers for each NVDRS participating state throughout the study period.[108] Data for the Census of Agriculture is collected and reported by the National Agricultural Statistics Service (NASS), a United States Department of Agriculture (USDA) division. The NASS surveys and reports on the multitudinous aspects of farms, ranches, and commodity production in the US and the persons who engage in commodity production through the Census of Agriculture. The NASS mails the census questionnaires to farm and ranch operators every five years, resulting in survey surveillance of US farms and ranches as the best source for

consistent and comprehensive agricultural information for every state.[109] Farm and ranch operators can respond online or submit completed surveys via mail. Farms and ranches and the persons who operate them are included in the Census of Agriculture counts "if $1,000 or more of agricultural products were produced and sold, or would normally have been sold, during the census year."[110] The NASS maintains confidentiality of information and aggregates and analyzes survey information for statistical purposes only.[110] The authors of this study obtained census data for 2002, 2007, 2012, and 2017.[108]

Variables

Adult (18 years and older) suicide decedents were selected from the 271,699 violent death cases reported in the NVDRS from 2003-2017. Criteria for case selection were based on the total number of cases whose "death manner per abstractor" was reported and coded as a suicide. The "death manner per abstractor" is an NVDRS variable indicating the manner of death determined by the NVDRS abstractor derived from information reported on the death certificate, coroner and medical examiner reports, and law enforcement reports. The NVDRS abstractor manner of death must be consistent with at least one manner of death reported on the death certificate, coroner and medical examiner, or law enforcement reports. A total of 196,747 suicide cases were identified from the NVDRS data set.

We created an initial list of 32 terms derived from the Bureau of Labor Statistics Standardized Occupational Codes and major commodity types listed in the Census of Agriculture to search the industry and occupation text variables fields in the NVDRS. Industry and occupation are entered as free text variables for the victim's usual industry and occupation reported on their death certificate. Additional sampling utilized a snowball technique resulting in the final creation of 72 farming-specific terms used to systematically code the industry and occupation text variables into a binary "farmer" variable. We identified approximately 2,883 farming occupations among NVDRS decedents and excluded decedents without a farming occupation or where both industry and occupation text fields were missing.

To delineate farmers from non-farmers, the author employed the NASS definition for operators and producers, which defines those persons as the individuals primarily responsible for day-to-day decision-making for farm operations and management.[19, 65, 109-111] From there, the author classified the 2,883 decedents as a farmer (*N=1490*), non-farmer (*N=1,127*), or uncertain (*N=266*). To improve decedent classification, an expert interrater panel of occupational and agricultural researchers was convened and blinded

to further classify the 2,883 decedents with farming occupations. Raters were provided the NASS definition used to define a famer for this study and instructed to use it to classify the decedents as a farmer or non-farmer. Once the interrater's classified the cases, coding of cases were compared across raters to assess reliability and validity. Interrater disagree on case coding was debated until raters reached consensus.

Case classification distributions resulted in 188 of those occupations classified as "uncertain" being coded as a farmer. By contrast, only ten of the cases coded as a "non-farmer" were classified as a farmer while all 1,490 cases originally classified as a farmer retained the farmer designation. The interrater classification of decedents resulted in identification of 1,652 farmer suicide decedents. Occupations excluded from our case counts included those whose occupational text was designated as a "cowboy", "landscaper", "logger" "tree expert/serviceman/remover/trimmer", and "farmer/ranch hand or laborer." Industry and occupational titles accepted by the interrater panel include "agricultural supervisor", "retired farmer", "agriculture rancher" and "agriculture farmer." Sociodemographic NVDRS decedent variables included incident year, reporting state, age at death in years, sex, marital and education status, and occupation and industry text reported on the death certificate. The decedent's age is measured as a continuous variable, and sex (male=1 and female=0) is a categorical variable while the state was coded using the American National Standards Institute (ANSI) Codes for States. Because of a low number of decedents in categories for race, education and relationship status, we created the following categorical variables: race (white=1 and non-white=0); education status (no degree/diploma=0; high school diploma/GED=1; some college/associates degree=2; and bachelor's degree and above=3); and relationship status (married/civil union/domestic partnership=0; single/never married=1; widowed=2; and divorced/separated=3). Likewise, we created three broad age categories (18-34, 35-64, and >64 years). The three age categories were created based on age categories employed by the NVDRS for age-standardization. However, we broadened the age categories because of low decedents counts thus allowing for estimation of age-standardized rates.

Denominator data were obtained from the Census of Agriculture for 2002, 2007, and 2012. Data elements included year, state, age group, and the total number of females and the total number of operators per state, while variables for the 2017 data also included male and female producers age groups. The Census of Agriculture for 2002, 2007, 2012 defines operators as the person(s) primarily responsible for farm and

ranch operations and day-to-day decision making.[109-111] For the 2017 Census of Agriculture, the NASS changed the term for an operator to producer to accommodate the vast range of commodity production and operations while defining producers as the person(s) responsible for day-to-day farm decisions.[19] Examples of operator and producer responsibilities include breeding and feeding livestock or poultry, planting or harvesting crops or trees, and fiscal decisions like marketing and commodity sales.[109-111] For 2002, 2007, and 2012 Census of Agriculture, the NASS collected demographic information for a maximum of three operators per farm or ranch, including sex, age, race, occupation, and place of residence; whereas, the 2017 Census of Agriculture collected demographics for up to four producers per farm or ranch.[19, 93, 109-111]

To generate state-specific denominators for each calendar year from the Census of Agriculture, we chose the demographic sector followed by the operator and producer group and commodity levels. Every year, age groups were collapsed to align with our farmer suicide decedents' age groups for 2002, 2007, 2012, and 2017. In 2002, the NASS did not report the total number of male operators by age group; however, the total number of operators by race/ethnicity was reported. To obtain the total number of male and female operators and corresponding age groups, we created a binary variable to denote female versus “other” operators. We summed all racial/ethnic groups from the “other” operator variable to obtain a “total” number of operators across each age group. The totals obtained from the summed “total” variable were then subtracted from the female operators to obtain the number of “male” operators by age group. For 2007 and 2012, the total number of operators and female operators by age group were present; therefore, we subtracted the female operators from the total, thus ascertaining an overall number of male operators. We used PROC EXPAND to interpolate the demographic denominators for each age, gender, and race group for each NVDRS participating state for intercensal years.

The United States 2010 population and intercensal population estimates were used for standardization.[112] Variables obtained from the US Census population estimates were age in years, sex, and state for each NVDRS participating state. Age groups were created from the US Census population estimates to match our numerator and denominator age groupings.

Statistical Analysis

We conducted bivariate statistics for male and female farmer suicide decedents. Female farmer suicide decedents were excluded from rate calculations because of low

decedent counts across years and states. Direct standardization was employed to calculate annual age-adjusted rates for males using the United States 2010 population and intercensal population estimates for direct standardization.[112] Aggregated age-adjusted rates for states and US regions were calculated for the entire study period except for states reporting <20 decedents throughout the study period. Because of shifts in the total number of decedents for Kentucky each year, we only aggregated the Kentucky rate to include 2011 - 2017. Regional rate calculations included states with >20 decedents throughout the study period.

We used the Joinpoint Regression Software to analyze farmer suicide rates for points of inflection and assess for a change in annual rates. Joinpoint Regression software was initially developed by the National Cancer Institute to assess cancer trends, however, numerous other studies utilized Joinpoint Regression to assess suicide trends.[113-115] Regression analysis is a log-linear Poisson regression with application of a Monte-Carlo permutation test to sample the rate data and identify trends line (points) changes both in direction and magnitude.[113, 116] The regression analysis begins with the least number of joinpoints, which is initially zero, and statistically tests if one or more joinpoints are significant and adds them to them to the model. If statistically significant joinpoints are indicated in the model, then results indicate a statistically significant shift in the slope.[113, 116] Further, the regression process statistically assess the annual percent change (APC) and delivers and precise mortality trend estimate compared to non-probability analysis.[113, 116] For the permutation test and APC, we applied an alpha of 0.05.

Research Aim 3

Background

Most US farmers live and work on their farms with locations in rural communities known for disadvantageous socioeconomic circumstances and poor mental and physical health outcomes. Although farmers are usually healthier than the general population, farmers incur unique suicide exposures associated with commodity production. Most of the risk for suicide among farmers is attributable to multifactorial exposures associated with physically demanding labor, musculoskeletal injuries, environmental hazards, chronic diseases, and mental health conditions such as depression. However, excessive stress and maladaptive coping skills place farmers at risk for SDV behaviors.

The unique stressors of farming associated with suicide are linked to uncontrollable factors and unpredictable forces that include farm operation pressures, crop, and livestock loss, and commodity market patterns that reduce operation gains. Although most of the research supports the relationship between unique farm stressors and suicide, most studies focus on contextual psychosocial stressors like poor health, relationship problems, mental illness, and access to means. Consequently, research has overlooked circumstantial factors associated with changes in commodity production and sales and the relationship to farmer suicide. For purposes of this aim, we conducted an exploratory analysis of commodity production and evaluated the risk associated with farmer suicide.

Data Sources

We selected a sub-sample of farmer suicide decedents in the NVDRS from only Kentucky along with the Kentucky sub-sample of operators and producers from the quinquennial Census of Agriculture to assess the risk of suicide by selected commodity production factors. Kentucky farmer suicide decedents from the NVDRS were selected for each year Kentucky participated in the NVDRS, while commodity production variables, operators, and producers were selected from the Census of Agriculture by Kentucky county for 2007, 2012, and 2017. We employed the same methodology from AIM 1 to obtain the total number of male and female farmers for each Kentucky county for 2007, 2012, and 2017. Further, we obtained county-level American National Standards Institute (ANSI) codes from the US Census Bureau for each Kentucky county.

Exposure Assessment

Commodity production assessment utilized four major commodity groups, which included the total inventory of dairy cattle and hogs, total inventory of broilers and layers, total acres harvested for corn grain and silage, and total acres of soy harvested. We created a summary variable for broilers and layers (poultry) and acres harvested for grain and silage (corn_acres). To assess production by county, we created dichotomous and categorical production groups based on univariate distributions for dairy, hogs, poultry, corn, and soy production.

First, we averaged production variable across all census years using tercile ranks based on “medium” rank included the median. However, creating tercile ranks for dairy

and hog production induced small cell counts and restricted our ability to estimate rates for each county. Likewise, ranking commodity production for corn, soy and poultry created low decedent counts in small categories of commodity production. Therefore, commodity production variables were structured to prevent a low number of decedent counts for each commodity production category. Dichotomous variables for the head of dairy cattle and hogs are represented as “low-medium (0 – 1,000 head)” and “high” (>1,000 head)”. Categorical variables for poultry are represented as “low (0 – 10,000 chickens)”, “medium (>10,000 – 900,000 chickens)”, and “high (>900,000 chickens)” while corn and soy acres harvested were represented as “low (0 – 10,000 acres)”, “medium (>10,000 – 30,000 acres)”, and “high (>30,000 acres)”. Because county-level commodity data was not available in the Census of Agriculture for each NVDRS reporting year for Kentucky, we averaged commodity production for dairy, hogs, poultry, and corn and soy acres across decennial census years to obtain a county-level commodity production average and created similar dichotomous and categorical production variables. The average number of soy acres was recategorized based on distributions to prevent low decedent counts resulting in the following categories “low (0 – 10,000 acres)”, “medium (>10,000 – 40,000 acres)”, and “high (>40,000 acres).”

Outcome Assessment

The total number of farmer suicide decedents was identified for Kentucky from the NVDRS data employed in our Aim 1 analysis. We excluded decedents if records were missing ANSI and Federal Information Processing Standards (FIPS) data, and female farmer decedents were excluded because of small cell sizes. Decedents were aggregated in counts to estimate the total number of farmer suicide decedents for each Kentucky county. To obtain our denominator, we obtained county-level operator data for 2007 and 2012 and county-level producer data for 2017. We generated the number of male operators for 2007 and 2012 by subtracting female operators from the total number of operators in each Kentucky county, while county-level data for male producers were available for 2017. Age group data were not available at the county level for 2007 and 2012; therefore, to assess cumulative background risk we calculated the sum of total male farmers for 2007, 2012, and 2017 by Kentucky county. County-level commodity production and our male farmer denominator data were merged with FIPS data to obtain the total number of farmers by commodity production type for each Kentucky county. Likewise, commodity production and FIPS data were combined then merged with

decedent data in the NVDRS data to obtain the total number of Kentucky farmer suicide decedents for commodity production type by county.

Statistical Analysis

Univariate statistics were used to estimate mean production for dairy, hogs, poultry, corn, and soy and to explore distributions of commodity production by year among all Kentucky counties. We calculated a percent change for mean commodity production between decennial census years to determine negative or positive production gains in Kentucky. Further, we obtained decedent characteristics and the total number of suicide decedents and farmers for each commodity production type. We estimated the relative risk for farmer suicide by commodity production type for dairy, hogs, corn, soy, and poultry and employed the “low-medium” and “low” categories as the referent. All statistical analyses were conducted using SAS 9.4 software for windows.[117]

CHAPTER 4

RESULTS

Research Aim 1 and 2 Results

From a total of 271,699 suicide decedents, 1,652 farmer suicide cases were identified through the NVDRS between 2003 to 2017 (Figure 1). Throughout the 15-year study period, there were 1,575 male and 77 female farmer suicide deaths (Table 1). The mean age of male decedents was 61.25 (SD=19.62) and 54.17 (SD=17.5) for female decedents. The proportion of male suicide deaths was highest in the oldest age groups: males over 65 (47%), those between 46 and 64 (31.6%), and between 18-44 years old (21.5%). Age distributions for female farmer suicide deaths indicated that females between 45 and 64 (50.65%) years old accounted for the majority of female decedents. Racial distributions showed that most male (93.84%) and female (96.1%) farmer decedents were white. Over 40% of male and female decedents had some post-high school education. Conversely, a smaller proportion of deaths (<20%) for male and female farmers occurred among decedents with less than a high school diploma (N=288). A higher proportion of male (43.6%) and female (42.9%) farmer decedents were married, while nearly a quarter of male farmer decedents (23.54%) were either single or never married. Comparatively, nearly a quarter of female (22.1%) decedents were widowed.

The number of farmer suicides by year and the years in which each state first started reported suicide data to the NVDRS is presented in Table 2. Only 17 of the 36 states had reported suicide data to the NVDRS for more than four years. The total number of farmers as estimated using the NASS Census Data is provided for each participating state by year the state was providing suicide data to the NVDRS is provided in Table 3. Given the small number of female farmer decedents, the numbers presented in Table 3 and the subsequent rate calculations were restricted to male farmers. Figure 2 depicts aggregated farmer suicide rates by age group, which shows that the oldest farmers have the highest suicide mortality rate. By contrast, rates for middle-aged farmers were less than half the rates of older farmers.

The crude and age-adjusted male farmer suicide rates are presented by year in Table 4. The rates appeared to fluctuate throughout the study period, with the highest age-adjusted suicide rates peaking in 2013 (19.37 per 100,000), while the lowest suicide rates occurred during 2005 (8.81 per 100,000). These fluctuations in rates may partially reflect the varying number of states providing data over time, with the corresponding number of farmers in the denominator varying over time.

Table 5 shows the comparison between male farmers and US male suicide rates. US male suicide rates were obtained by year from the CDC and included the same age range, year, and states reporting to the NVDRS. Suicide rates between farmers and US males varied, with the most remarkable rate difference occurring in 2005 and 2008. Figure 2 visually depicts the farmer suicide rate fluctuations and shows farmer suicide rates fluctuated dramatically with a gradual rise after 2009. By contrast, suicide rates for US males during the same period steadily rose. Table 6 presents aggregated crude and age-adjusted rates for each NVDRS participating state. The state rates are difficult to compare because of varying numbers of years of reporting and widely varying numbers of farmers in each state. The results indicate regional variation in suicide rates related to types of farming, farmer demographics, and economic factors. Figure 4 exhibits the regional comparison of rates with the highest rates observed in the Western (19.56 per 100,000) and Southeastern (16.66 per 100,000) regions, whereas the lowest rates were in the Southwest.

In Table 7 the Joinpoint regression analysis of suicide rates across years shows a statistically significant increasing slope ($p<0.05$) from 2003 to 2017. Although data visualization depicted potential joints in the farmer suicide rates, the model did not detect statistically significant Joinpoints (Table 8). A positive Annual Percent Change (APC) of 2.44 ($p<0.05$) in farmer suicide rates was indicated throughout the entire study period (Table 9). Further, the model demonstrated the presence of a statistically significant APC of 3.5 ($p<0.05$) from 2005 to 2017, suggesting a more recent underlying shift in farmer suicide rate trends (Table 10). Figure 5 depicts the upward trend in farmer suicide rates for the entire study period while the statistically significant rate increase beginning in 2005 is show in Figure 6. Lastly, the rate fluctuations observed by plotting farmer suicide rates were not present in our Joinpoint regression graphs (Figure 6).

Summary of Findings

Farmer suicide decedents are generally older males who hold at least a high school education or GED and are married. Estimating farmer suicide rates showed that rates fluctuated throughout the entire study, with age-adjusted rates peaking in 2013. Suicide rates were highest among males over 64 years and lowest among middle-aged farmers. State rates were aggregated because of low counts in several NVDRS participants, and results showed differences by region, with the highest regional rates occurring in Western and Southeastern states. A comparison of farmer suicide rates to suicide rates of US males showed rate differences between the two populations while visualization an overall upward trend in both populations. The results from our Joinpoint regression analysis confirmed a statistically significant upward trend in farmer suicide rates. Interpretations and implications of findings along with strengths and limitations are in the *Discussion* chapter below.

Research Aim 3 Results

Decedent Characteristics

Table 11 shows the demographic characteristics for the 109 male farmer suicide decedents in Kentucky. The mean age for decedents was about 60 years old (SD=18.81), and almost half the decedents were over 64 (44.04%). Most decedents held a high school diploma or GED (46.79%) and reported being married or living in a civil union or domestic partnership (35.78%).

Commodity Characteristics

Table 12 displays the commodity characteristics for 2007, 2012, and 2017 for all, 120 Kentucky counties. The highest mean number of dairy cattle (mean=747.28, SD=1,346.85) and hogs (mean=314.78 (SD=7,141.60) occurred in 2007, while the largest average of soy acres harvested (mean=15,712.39, SD=22,117.381) occurred during 2017. Most Kentucky counties for every commodity production fell within the “low-medium” for dairy and hogs and “low” for soy, corn, and poultry production. The average head of dairy cattle decreased by almost 20% throughout the study period, and hog production decreased by almost 50% from 2007 to 2012. By contrast, hog production increase by 1.4% increase during 2017. Soy production showed the greatest production increase with a 35% rise in average acres harvested between 2007 and 2012. The total

number of counties for each production category varied from census to census, with the overall number of low hog-producing counties rose from 93 to 111 (Table 12).

Risk Assessment

Table 13 presents the total number of counties reporting farmer suicides and risk ratios for farmer suicide mortality by commodity production type. A total of 63 Kentucky counties throughout the study period reported 109 male farmer suicide decedents. The largest portion of suicides occurred in counties classified as either “low-medium” for dairy and hogs or “low” for corn, soy, and poultry. Low-medium hog production counties (N=85) showed the highest number of suicide decedents followed by low-medium production dairy counties (N=79). Rate ratios for each commodity production type were obtained using the lowest production categories for the referent. The rate of farmer suicide in the medium soy producing group was 0.56 times (p=0.02) the rate of suicide low levels soy production. Comparatively, the rate of farmer suicide in the high soy production was 1.6 times (p=0.7) the rate of farmer suicide in low soy production. The rate of farmers suicide in the medium corn production group (RR=0.66, p=0.09) was elevated compared to low production. The risk of farmer suicide among poultry production groups indicated lower rates among those farmers in the medium producing group while rates were slightly elevated in the high producing groups; however, rate ratios were not statistically different than the low production referent group. Interpretations and implications of findings along with strengths and limitations are in the *Discussion* chapter below.

Table 1. Total farmer suicide decedent demographics by sex – National Violent Death Reporting System, 36 states, 2003-2017.		
Variable	**Males** (*N=1,575)*	**Females** *(N=77)*
Age (±SD)	61.25 (19.62)	54.17 (17.35)
Age Group, N (%)		
18-44	338 (21.46)	20 (25.97)
45-64	497 (31.56)	39 (50.65)
>64	740 (46.98)	18 (23.38)
Race, N (%)		
White	1478 (93.84)	74 (96.1)
Non-White	97 (3.9)	NR
Education Level, N (%)		
No Degree/Diploma	280 (18.42)	8 (10.67)
High School Diploma or GED	558 (36.71)	34 (45.33)
Some college/Associates Degree	222(14.61)	16 (21.33)
Bachelor's degree and above	460 (30.26)	17 (22.67)
Marital Status, N (%)		
Married/Civil Union/Domestic Partnership	681 (43.57)	33 (42.86)
Single/Never Married	368 (23.54)	13 (16.88)
Widowed	231 (14.78)	17 (22.08)
Divorced/Separated	283 (18.11)	14 (18.18)
Abbreviation: NR: not reported due to small cell size. Missing values not included in the percentage for the table. SD: Standard Deviation		

Table 2. Total number of farmer suicide decedents by year and state - National Violent Death Reporting System, 36 states, 2003-2017.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Alaska	NR	0	0	NR	0	0	0	NR	NR	0	NR	0	0	0	0	NR
Arizona													NR	7	NR	**15**
California															25	**25**
Colorado		11	5	11	12	7	6	6	8	9	9	10	7	6	11	**118**
Connecticut													0	0	NR	NR
Delaware															NR	NR
Georgia		6	6	6	13	8	9	8	9	9	10	9	8	7	7	**115**
Hawaii													NR	NR		NR
Illinois														NR	NR	NR
Indiana														12	7	**19**
Iowa														14	14	**28**
Kansas													12	8	11	**31**
Kentucky			NR	NR	0	NR	0	NR	18	13	14	16	11	15	13	**111**
Maine													NR	NR	NR	NR
Maryland	6	NR	NR	NR	NR	NR	0	NR	NR	NR	0	NR	NR	NR	NR	**38**
Mass	0	0	NR	0	NR	NR	NR	NR	0	NR	NR	NR	NR	NR	NR	**15**
Michigan												11	9	13	9	**42**
Minnesota													11	16	19	**46**
Nevada															NR	NR
NH													0	NR	NR	NR
NJ	NR	NR	0	NR	NR	NR	0	NR	0	0	0	NR	0	NR	NR	**18**
NM			NR	NR	7	NR	10	NR	NR	6	NR	7	9	NR	NR	**64**
NY													10	9	7	**26**
NC		14	14	11	8	13	15	16	15	10	8	13	12	9	10	**168**
Ohio									7	8	17	7	6	10	7	**62**
Oklahoma		9	4	17	14	11	7	10	12	8	9	9	16	14	6	**146**
Oregon	3	6	7	5	5	6	10	7	10	10	8	13	7	5	8	**110**
Pennsylvania														NR	NR	NR
RI		0	0	0	NR	0	NR	0	0	0	0	0	0	0	0	NR
SC	6	NR	NR	NR	7	NR	NR	NR	NR	NR	NR	0	NR	NR	NR	**51**
Utah			NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	**29**
Vermont													NR	7	NR	**13**
Virginia	9	10	NR	NR	11	7	7	6	9	11	9	8	7	7	NR	**115**
Washington														NR	NR	NR
WV															NR	NR
Wisconsin		15	13	11	18	8	15	19	14	11	12	10	17	12	20	**195**
Total	**27**	**82**	**67**	**82**	**105**	**76**	**84**	**89**	**111**	**106**	**109**	**126**	**159**	**203**	**226**	***1,652***

Abbreviation: NR: not reported due to small cell size.

Table 3. Total number of farmers by year and state – Census of Agriculture, 36 states, 2003-2017.																
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Alaska	933	975	1,014	1,056	1,098	1,117	1,138	1,157	1,178	1,197	1,301	1,406	1,509	1,614	1,718	**18,411**
Arizona													32,714	32,755	32,796	**98,265**
California															124,405	**124,405**
Colorado		54,786	56,352	57,915	59,479	59,222	58,963	58,705	58,446	58,189	60,357	62,525	64,696	66,864	69,032	**845,531**
Connecticut													9,552	9,539	9,526	**28,617**
Delaware															3,907	**3,907**
Georgia		67,336	67,634	67,933	68,232	66,797	65,360	63,925	62,488	61,053	62,460	63,866	65,274	66,680	68,087	**917,125**
Hawaii													11,564	11,867		**23,431**
Illinois														114,591	116,417	**231,008**
Indiana														93,071	94,350	**187,421**
Iowa														140,687	143,447	**284,134**
Kansas													94,474	95,412	96,352	**286,238**
Kentucky			122,520	122,647	120,725	118,803	116,881	114,959	113,037	115,229	117,421	119,611	121,803	123,995	122,393	**1,550,024**
Maine													13,315	13,365	13,414	**40,094**
Maryland	18,661	18,939	19,217	19,495	19,773	19,629	19,486	1,9342	19,199	19,055	19,500	19,945	20,389	20,834	21,279	**294,743**
Mass	10,171	10,625	11,076	11,530	11,983	12,041	12,100	12,158	12,217	12,275	12,376	12,476	12,577	12,677	12,778	**179,060**
Michigan												79,131	79,221	79,314	79,404	**317,070**
Minnesota													110,795	111,278	111,760	**333,833**
Nevada															5,957	**5,957**
N.H.													7,197	7,198	7,198	**21,593**
N.J.	15,388	15,524	15,663	15,799	15,936	15,579	15,221	1,4867	14,509	14,152	14,633	15,113	15,595	16,075	16,556	**230,610**
N.M.			2,9975	30,588	31,201	32,394	33,588	34,779	35,973	37,166	37,903	38,639	39,377	40,113	40,850	**462,546**
N.Y.													57,108	57,486	57,865	**172,459**
N.C.		75,271	75,403	75,533	75,665	75,114	7,4562	74,008	73,456	72,905	73,137	73,368	73,599	73,830	74,062	**1,039,913**
Ohio									113,283	113,624	116,637	119,649	122,661	125,673	128,686	**840,213**
Oklahoma		124,787	126,393	127,996	129,602	127,772	125,940	124,110	122,278	120,448	122,282	124,116	125,951	127,785	129,619	**1,759,079**
Oregon	65,246	64,714	64,177	63,645	63,110	62,092	61,074	60,056	59,038	58,020	59,934	6,1849	63,766	65,681	67,595	**939,997**
Pennsylvania														90,489	90,461	**180,950**
R.I.		1,528	1,643	1,757	1,872	1,902	1,932	1,960	1,990	2,020	1,975	1,929	1,885	1,839	1,794	**26,026**
S.C.	33,872	34,546	3,5218	35,892	36,563	36,568	36,573	36,578	36,583	36,588	37,064	37,540	38,018	38,494	38,970	**549,067**
Utah			24,888	25,307	25,726	26,207	26,688	27,168	27,649	28,130	29,003	29,877	30,748	31,622	32,495	**365,508**

Vermont													12,191	12,250	12,309	**36,750**

Table 4. Crude and age-adjusted, male farmer suicide rates per 100,000 persons by year – National Violent Death Reporting System – Census of Agriculture, 2003-2017.

Year	Crude Rates (95% CI)	Adjusted Rate (95% CI)
2003	18.45 (12.16 – 26.85)	17.91 (9.49 – 26.33)
2004	17.61 (13.98 – 21.89)	15.19 (11.11 – 19.27)
2005	11.35 (8.80 – 14.42)	8.81 (6.22 – 11.40)
2006	12.73 (10.01 – 15.96)	10.78 (7.69 – 13.86)
2007	17.51 (14.29 – 21.23)	16.67 (12.62 – 20.72)
2008	12.54 (9.83 – 15.77)	9.56 (6.85 – 12.28)
2009	13.72 10.86 – 17.10)	13.63 (9.81 – 17.46)
2010	14.75 (11.77 – 18.26)	14.39 (10.45 – 18.34)
2011	16.89 (13.87 – 20.38)	16.18 (12.31 – 20.05)
2012	15.96 (13.02 – 19.38)	17.03 (12.82 – 21.24)
2013	16.43 (13.44 – 19.89)	19.37 (14.73 – 24.00)
2014	17.19 (14.24 – 20.57)	16.67 (12.87 – 20.47)
2015	16.51 (13.99 – 19.36)	17.34 (13.91 – 20.76)
2016	15.52 (13.42 – 17.87)	15.29 (12.67 – 17.92)
2017	15.08 (13.08 – 17.29)	16.52 (13.72 – 19.32)

Rates are per 100,000 persons. Rates use Census of Agriculture denominator data.
Age-adjusted rates are directly adjusted to the US male population for each year as the referent.

Table 5. Comparison of Male Farmer to US Male Suicide Age-Adjusted rates by year – National Violent Death Reporting System – Census of Agriculture – CDC WISQARS, 2003-2017.

Year	Farmer Rate	US Rate	Rate Difference
2003	17.9	20.6	2.7
2004	15.2	23.3	8.1
2005	8.8	23.6	14.8
2006	10.8	23.9	13.1
2007	16.7	24.5	7.8
2008	9.6	24.5	14.9
2009	13.6	25.5	11.9
2010	14.4	25.7	11.3
2011	16.2	26.1	9.9
2012	17.0	26.4	9.4
2013	19.4	26.7	7.3
2014	16.7	26.8	10.1
2015	17.3	25.9	8.6
2016	15.3	26.3	11.0
2017	16.5	27.0	10.5

Rates are per 100,000 persons. Farmer rates are estimated annual age-adjusted rates. US male rates were obtained from CDC's WISQARS™ — Web-based Injury Statistics Query and Reporting System: National Violent Death Reporting System (NVDRS) (cdc.gov)

Table 6. Aggregated Age-Adjusted Farmer Suicide rates per 100,000 persons by State – National Violent Death Reporting System – Census of Agriculture, 2003-2017.

State	Crude Rate (95% CI)	Adjusted Rate (95% CI)	NVDRS Years Reported
Alaska	NR	NR	2003 – 2017
Arizona	NR	NR	2015 – 2017
California	24.31 (14.63 – 37.96)	25.55 (9.07 – 42.03)	2017
Colorado	21.20 (17.46 – 25.51)	22.45 (16.95 – 27.94)	2004 – 2017
Connecticut	NR	NR	2015 – 2017
Delaware	NR	NR	2017
Georgia	17.41 (14.33 – 20.95)	17.09 (12.77 – 21.41)	2004 – 2017
Hawaii	NR	NR	2015 – 2016
Illinois	NR	NR	2016 – 2017
Indiana	NR	NR	2016 – 2017
Iowa	14.26 (9.40 – 20.74)	14.32 (7.93 – 20.70)	2016 – 2017
Kansas	15.59 (10.52 – 22.26)	10.01 (5.72 – 14.30	2015 – 2017
Kentucky	17.33 (14.08 – 21.10_	17.82 (13.58 – 22.06)	2005 – 2017
Maine	NR	NR	2015 – 2017
Maryland	19.23 (13.61 – 23.39)	17.34 (10.18 – 24.50)	2003 – 2017
Massachusetts	NR	NR	2003 – 2017
Michigan	19.06 (13.61 – 25.95)	22.40 (14.23 – 30.58)	2014 – 2017
Minnesota	18.35 (13.28 – 24.72)	19.37 (12.45 – 26.28)	2015 – 2017
Nevada	NR	NR	2017
New Hampshire	NR	NR	2015 – 2017
New Jersey	NR	NR	2003 – 2017
New Mexico	20.75 (15.91 – 26.60)	28.19 (19.32 – 37.06)	2005 – 2017
New York	21.16 (13.41 – 31.75)	22.61 (11.57 – 33.65)	2015 – 2017
North Carolina	21.93 (18.81 – 25.54	19.48 (15.63 – 23.33)	2004 – 2017
Ohio	10.26 (7.83 – 13.20)	9.18 (6.51 – 11.84)	2011 – 2017
Oklahoma	11.94 (10.04 – 14.09)	10.45 (8.33 – 12.57)	2004 – 2017
Oregon	17.92 (14.60 – 21.77)	20.16 (15.16 – 25.16)	2003 – 2017
Pennsylvania	NR	NR	2016 – 2017
Rhode Island	NR	NR	2004 – 2017
South Carolina	12.68 (9.38 – 16.77)	13.35 (8.47 – 18.24)	2003 – 2017
Utah	10.56 (6.96 – 15.36)	11.02 (5.47 – 16.58)	2005 – 2017
Vermont	NR	NR	2015 – 2017
Virginia	15.66 (12.89 – 18.84)	14.08 (10.56 – 17.61)	2003 – 2017
Washington	NR	NR	2016 – 2017
West Virginia	NR	NR	2017
Wisconsin	16.52 (14.20 – 19.11)	16.28(13.56 – 18.99)	2004 – 2017

Abbreviation: NR = no calculated due to small cells. Missing values not included in the percentage for the table.

Table 7. Joinpoint Regression for Trends Analysis of Farmer Suicide Rates, 2003 – 2017.

Model Statistics						
Number of Joinpoints	**Number of Observations**	**Number of Parameters**	**Degrees of Freedom**	**Sum of Squared Errors**	**Mean Squared Error**	**Autocorrelation Parameter**
0	15	2	13	28.31182	2.17783	Uncorrelated
Estimated Regression Coefficients (Beta)						
Standard Parameterization						
Parameter	**Parameter Estimate**	**Standard Error**	**Test Statistic (t)**	**Prob > |t|**		
Intercept 1	2.509030	0.105482	23.786350	0.000000		
Slope 1	0.024138	0.010887	2.217217	0.045049		
General Parameterization						
Parameter	**Parameter Estimate**	**Standard Error**	**Test Statistic (t)**	**Prob > |t|**		
Intercept 1	2.509030	0.105482	23.786350	0.000000		
Slope 1	0.024138	0.010887	2.217217	0.045049		

Table 8. Joinpoint Regression Model Selection and Test for Joinpoints in Farmer Suicide Rates, 2003 – 2017.

Model Selection Method: Permutation Test							
Test for Number of Joinpoints							
Test #	**Null Hypothesis**	**Alternate Hypothesis**	**Numerator Degrees of Freedom**	**Denominator Degrees of Freedom**	**Number Permutations**	**p-value**	**Significance Level**
#1	0 Joinpoint(s)^	3 Joinpoint(s)	6	7	4500	0.229	0.016
#2	0 Joinpoint(s)^	2 Joinpoint(s)	4	9	4500	0.117	0.016
#3	0 Joinpoint(s)^	1 Joinpoint(s)	2	11	4500	0.298	0.016

Abbreviations and Symbols: ^=selected model. ~=Significance level for individual test (alpha=0.05).

Table 9. Joinpoint Regression Annual Percent Changed and Average Annual Percent Changed for Farmer Suicide Rates, 2003 – 2017.

Annual Percent Change							
Segment	**Lower Endpoint**	**Upper Endpoint**	**APC**	**Lower CI**	**Upper CI**	**Test Statistic (t)**	**Prob > (t)**
1	2003	2017	2.44*	0.1	4.9	2.2	0.0
Averaged Annual Percent Change							
Range	**Lower Endpoint**	**Upper Endpoint**	**AAPC**	**Lower CI**	**Upper CI**	**Test Statistic (t)**	**p-value**
Full Range	2003	2014	2.44*	0.1	4.9	2.2	0.0

Abbreviations APC: Annual Percent Change AAPC: Averaged Annual Percent Change
Symbols: ^selected model. ~If the AAPC is within one segment, the t-distribution is used. Otherwise, the normal (z) distribution is used. *Indicates that the APC and AAPC is significantly different from zero alpha=0.05.

Table 10. Estimated Joints with Regression Annual Percent Change from 2005 – 2017.

Estimated Joinpoints							
Joinpoint	**Estimate**	**Lower CI**	**Upper CI**				
1	2005	2005	2015				
Averaged Annual Percent Change							
Segment	**Lower Endpoint**	**Upper Endpoint**	**APC**	**Lower CI**	**Upper CI**	**Test Statistic (t)**	**Prob > (t)**
1	2003	2005	-20.5	-64.8	79.5	-0.6	0.5
2	2005	2017	3.5*	0.6	6.4	2.7	0.0

Abbreviations APC: Annual Percent Change
Symbols: ^selected model. ~If the AAPC is within one segment, the t-distribution is used. Otherwise, the normal (z) distribution is used. *Indicates that the APC is significantly different from zero alpha=0.05.

Table 11. Characterization of Kentucky Male Farmer Suicide Decedents – National Violent Death Reporting System, Kentucky, 2004 – 2017.	
Variable	**Males** (*N=109)*
Age (±SD)	59.66 (18.81)
Age Group, N (%)	
18-44	24 (22.02)
45-64	37 (33.94)
>64	48 (44.04)
Education Level, N (%)	
No Degree/Diploma	42 (38.53)
High School Diploma or GED	51 (46.79)
Some college/Associates Degree	11(10.09)
Bachelor's degree and above	5 (4.59)
Marital Status, N (%)	
Married/Civil Union/Domestic Partnership	39 (35.78)
Single/Never Married	26 (23.85)
Widowed	17 (15.60)
Divorced/Separated	27 (24.77)
Abbreviation: NR: not reported due to small cell size. Missing values not included in the table. SD: Standard Deviation	

Table 12. Four Major Commodity Production Types for Kentucky – Quinquennial Census of Agriculture – 2007, 2012, and 2017.					
Commodity Type	**2007**	**% Change**	**2012**	**% Change**	**2017**
Dairy, Average Head (±SD)	747.28 (1,346.85)	-21.81	584.32 (1,174.76)	-21.13	460.83 (1,085.31)
Dairy, N (%)					
Low – Medium (0 – 1,000)	95 (79.17)		99 (82.50)		103 (85.83)
High (>1, 000)	25 (20.83)		21 (17.50)		17 (14.17)
Hogs, Average Head (±SD)	2,314.78 (7,141.60)	-47.78	1,208.79 (4,638.98)	1.40	1,225.68 (4,458.87)
Hog, N (%)					
Low – Medium (0 – 1,000)	97 (80.83)		104 (86.67)		111 (92.50)
High (>1, 000)	23 (19.17)		16 (13.33)		9 (7.50)
Soy, Average Acres (±SD)	9,031.05 (15,861.33)	35.42	12,229.82 (18,468.61)	28.48	15,712.39 (22,117.81)
Soy Acre, N (%)					
Low (0 – 10,000)	90 (75.00)		83 (69.17)		71 (59.17)
Medium (>10,000 – 30,000)	15 (12.50)		21 (17.50)		26 (21.67)
High (>30,000)	15 (12.50)		16 (13.33)		23 (19.17)
Corn, Average Acres (±SD)	11,659.92 (20,233.83)	15.37	13,452.32 (20,922.32)	-18.38	10,979.39 (17,474.88)
Corn Acre, N (%)					
Low (0 – 10,000)	88 (73.33)		78 (65.00)		82 (68.33)
Medium (>10,000 – 30,000)	17 (14.17)		24 (20.00)		26 (21.67)
High (>30,000)	15 (12.50)		18 (15.00)		12 (10.00)
Poultry, Average Chickens (±SD)	435,779.18 (1286957.58)	-1.32	430,017.67 (1,340,906.06)	4.63	449,932.48 (1,233,718.73)
Poultry, N (%)					
Low (0 – 10,000)	90 (75.00)		87 (72.50)		82 (68.33)
Medium (>10,000 – 900,000)	17 (10.83)		17 (14.17)		21 (17.50)
High (>900,000)	17 (14.17)		16 (13.33)		17 (14.17)

Table 13. Total Counties with Male Farmer Suicide Rate and Risk Ratio by Commodity Production Type for Kentucky, 2004 – 2017.							
Commodity Type	**# Counties**	**# Suicides**	**# Farmers**	**Suicide Rate/100,000**	**RR**	**95% CI, RR**	**p-value**
# Dairy Cows							
Low-Medium (0 – 1,000)	48	79	168,106	47	reference	---	
High (>1, 000)	15	30	86,538	35	0.74	0.48 – 1.12	0.15
# Hogs							
Low-Medium (0 – 1,000)	49	85	187,688	45	reference	---	
High (>1, 000)	14	24	66,956	36	0.79	0.50 – 1.25	0.31
# Corn Acres Harvested							
Low (0 – 10,000)	39	68	149,400	46	reference	---	
Medium (>10,000 – 30,000)	13	21	69,587	30	0.66	0.41 – 1.08	0.09
High (>30,000)	11	20	35,657	56	1.23	0.75 – 2.03	0.41
# Soy Acres Harvested							
Low (0 – 10,000)	40	69	149,714	46	reference	---	
Medium (>10,000 – 40,000)	12	20	77,881	26	0.56	0.34 – 0.92	0.02
High (>40,000)	11	20	27,049	74	1.60	0.98 – 2.64	0.07
# Poultry							
Low (0 – 10,000)	38	65	148,013	44	reference	---	
Medium (>10,000 – 900,000)	12	23	62,929	37	0.83	0.52 – 1.34	0.46
High (>900,000)	13	21	43,702	48	1.09	0.67 – 1.79	0.71
Rates are per 100,000 persons. Abbreviation: RR=Relative Risk.							

Figure 1. Flowchart depicting selection of farmer suicide cases from the NVDRS, 2003-2017.

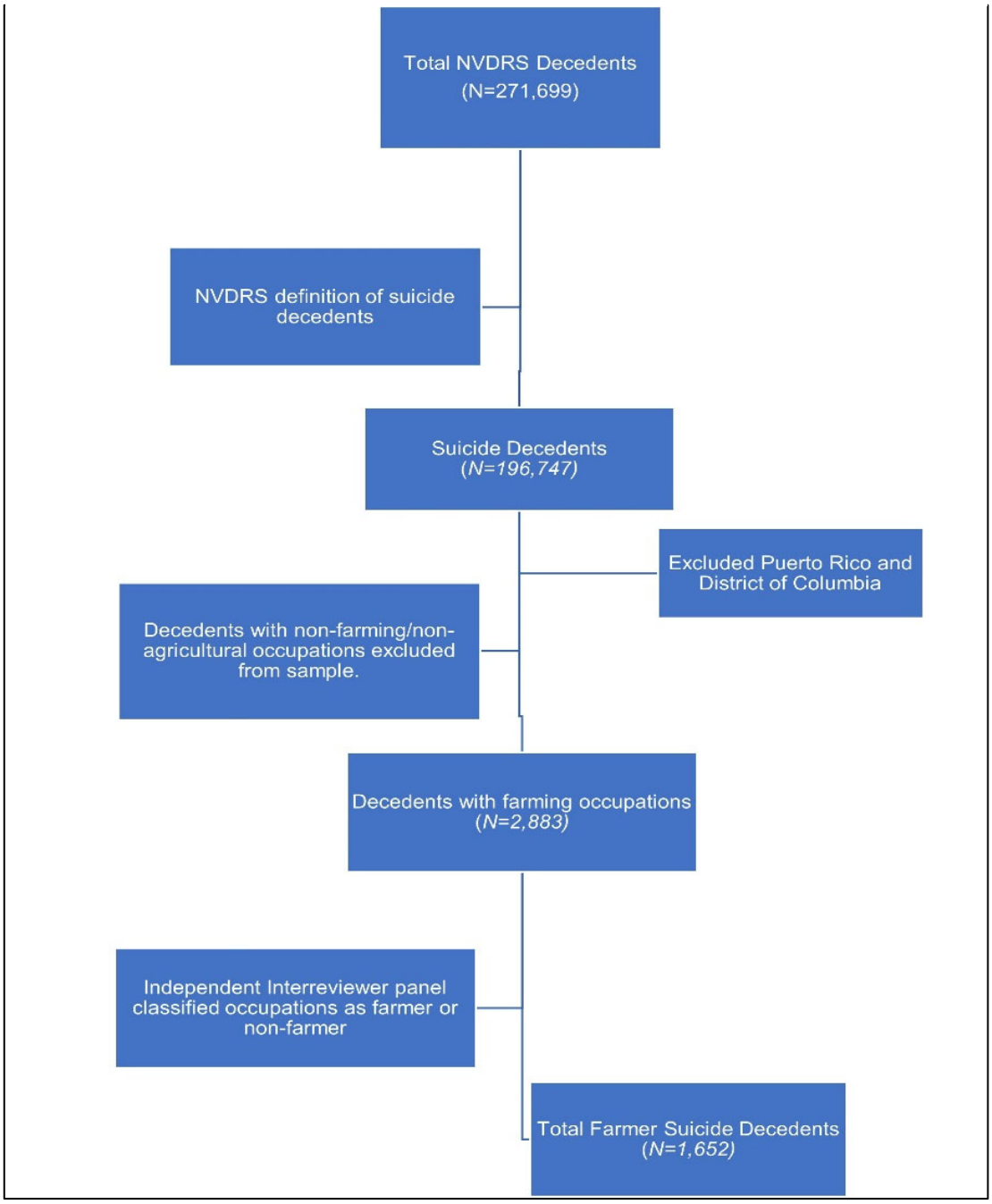


Figure 2. Aggregated male farmer suicide rates by age-group, 2003 – 2017.

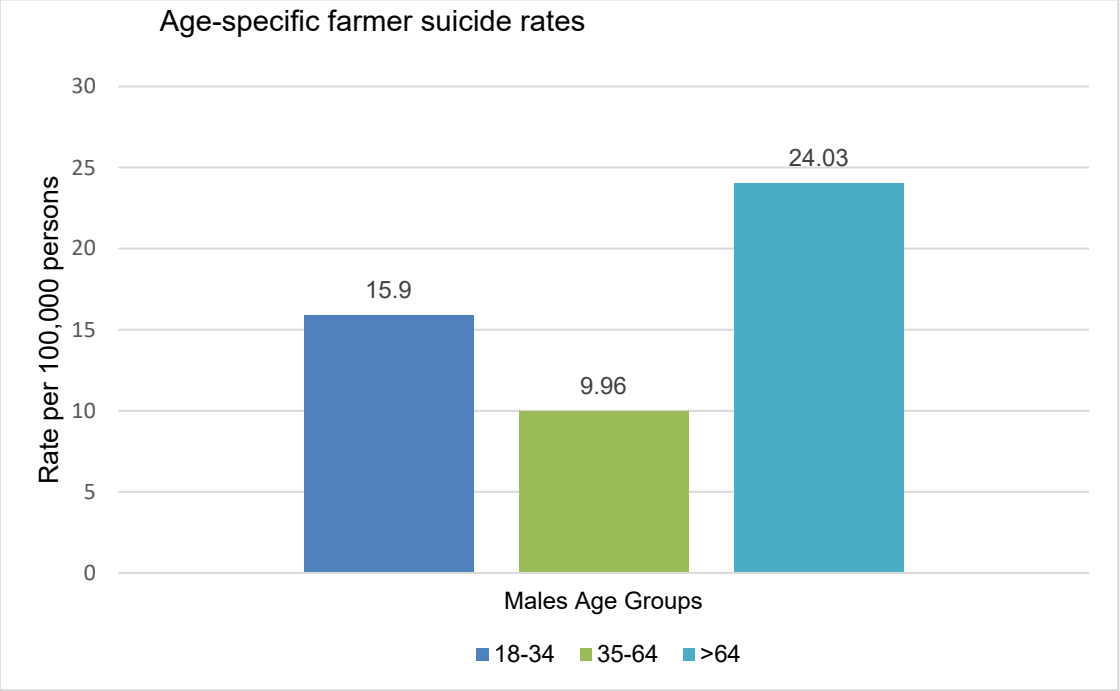
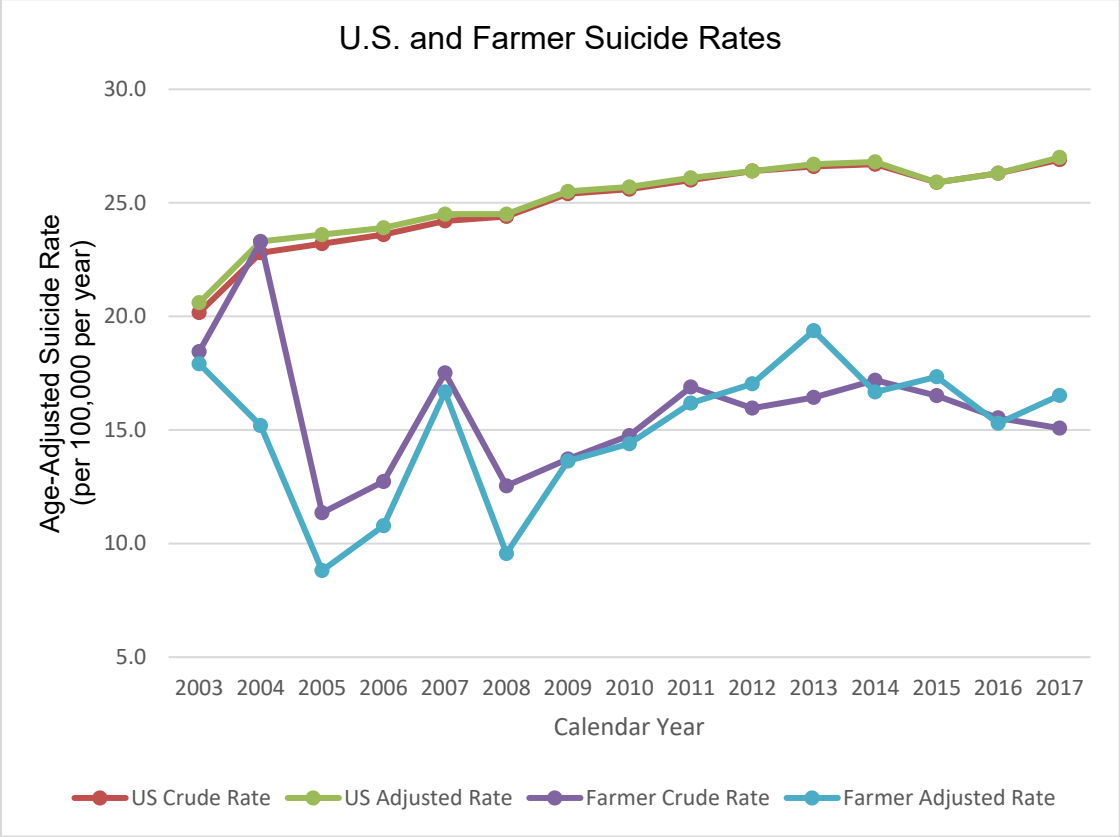
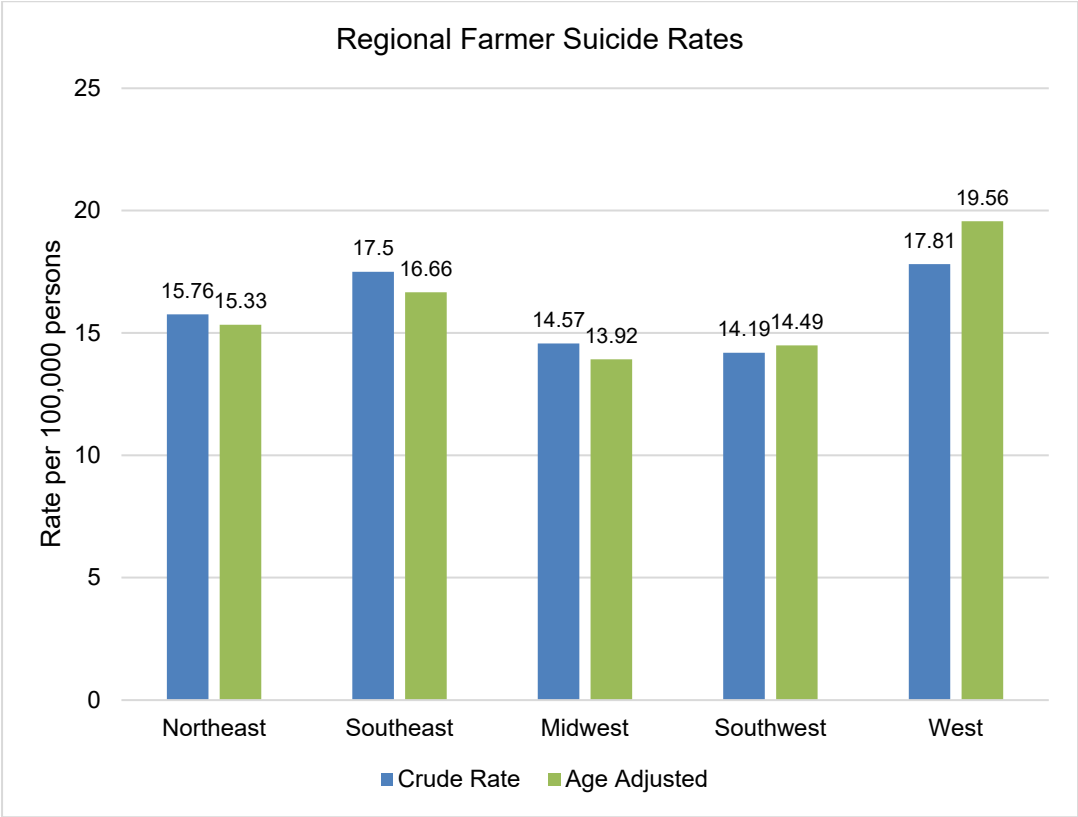


Figure 3. Crude and age-adjusted US male suicide rates in comparison to male farmer suicide rates by year, 2003 – 2017.



US male crude and age-adjusted rates were obtained from CDC's WISQARS™ — Web-based Injury Statistics Query and Reporting System: WISQARS Data Visualization (cdc.gov)

Figure 4. US regional male crude and age-adjusted farmer suicide rates aggregated from 2003 – 2017.



States excluded from regional include Alaska, Arizona, Connecticut, Delaware, Hawaii, Illinois, Indiana, Maine, Nevada, New Hampshire, New Jersey, Pennsylvania, Rhode Island, Vermont, Washington, and West Virginia.

Figure 5. Selected Joinpoint regression model graph of observed rates and rate trend line with positive annual percent change, 2003 – 2017.

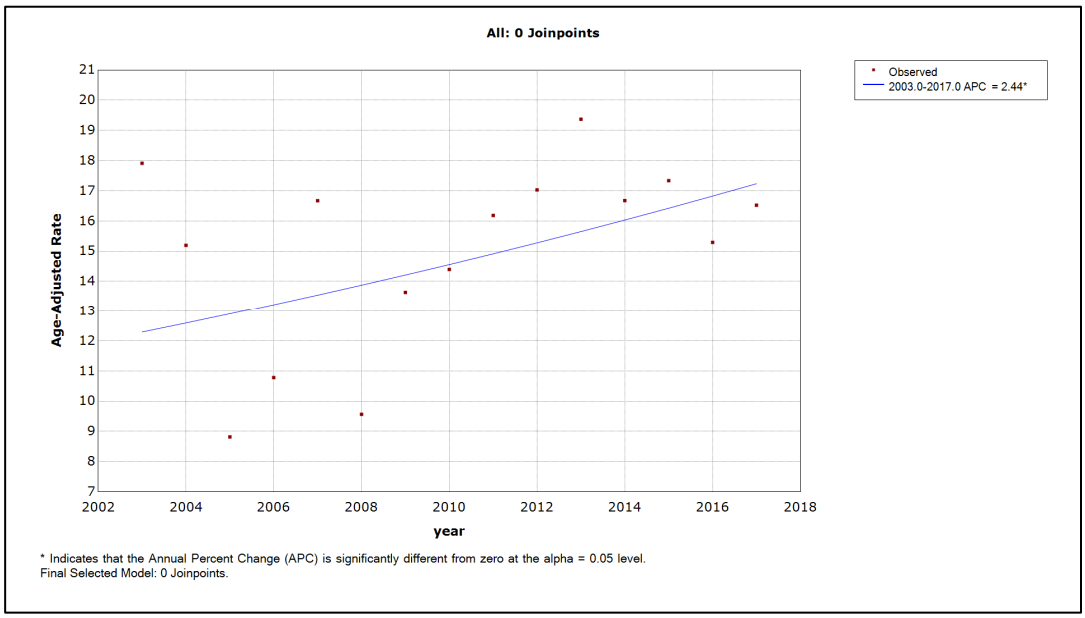
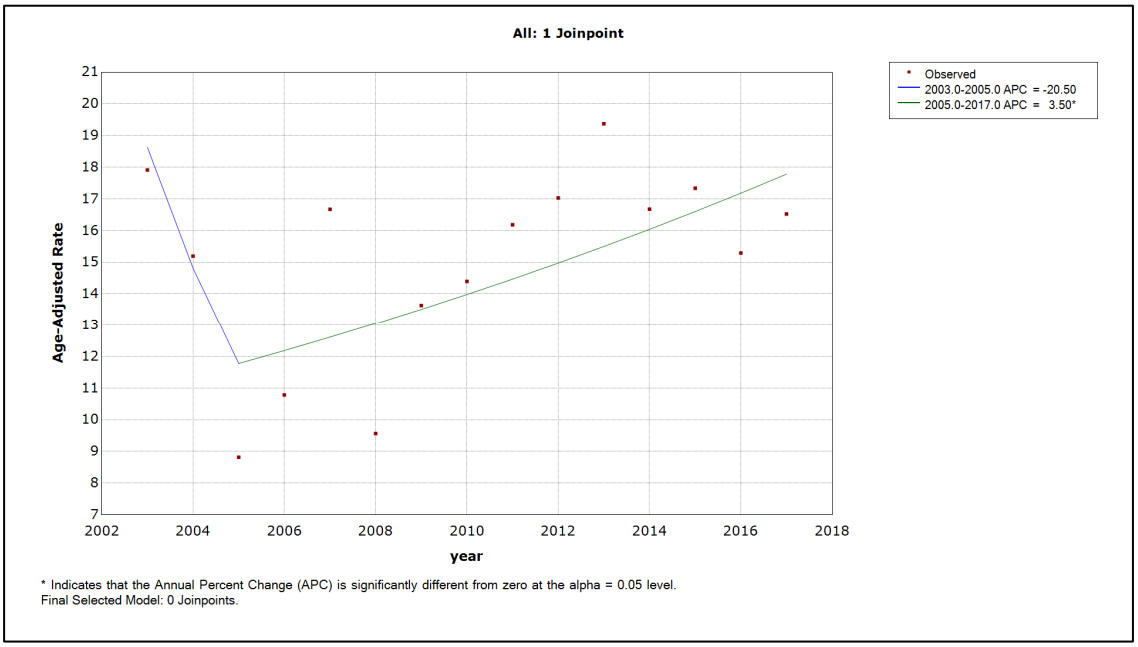


Figure 6. Joinpoint graph of observed rates and positive trend line with annual percent from 2005 – 2017.



CHAPTER 5

IMPLICATIONS FOR PUBLIC HEALTH

Conclusion

The highest number of farmer suicide decedents occurred among older male farmers whereas female farmer suicides represented a small proportion of the overall study population with the greatest number of female farmer suicides occurring decedents between 45 and 65. The age and sex-specific distributions are consistent with prior studies that reported on age and sex-specific farmer suicides. Studies out of Australia . farmer and agricultural suicide studies that utilize state and national data. which is consistent with prior researh.[2-4, 30, 36, 89] Only two of the 111 farmer suicides which occurred in Kentucky between 2993 and 2917 were female. Overall, crude and age-adjusted male farmer suicide rates in this study showed substantial rate differences compared to rates for US males and male farmers.[2-4, 34] Age-specific rates were highest among the older farmers, while middle-aged farmers showed the lowest suicide risk. Current farmer suicide research is inconsistent for age-specific rate differences. However, elevated rates among younger farmers are concerning given the rise in young farmers, and that suicide is the 2nd leading cause of death for persons between 10 and 34.[1, 19, 65, 109]

The body of farmer suicide research shows that farmer suicide rates exceed US males and other manual labor occupations.[2, 3, 34] In a recent study of occupational suicides among farmers and farmworkers, Ringgenberg (2018) reported rates for farmers and agricultural workers were 3.5x higher than of all other occupations.[34] By contrast, a study utilizing the NVDRS reported lower suicide rates among farming, fishing, and forestry workers; whereas, rates for a sub-section of farm, ranch, and other agricultural managers exceeded rates of other occupations.[4] Lower rates among male farmers in this study are attributable to several factors, including case classification, the denominator population, and occupation reporting.

Our classification process to initially obtain decedents with an agricultural occupation paralleled the total number of agricultural suicide decedents reported in prior studies for similar sampling periods.[3, 4, 30, 36, 118] The current study; however, disaggregated the various farm occupations and excluded farmers workers resulting in

an overall lower number of farmer suicide decedents. Moreover, the classification methodology separated farmers from the respective SOC groups, thus reducing rate bias through excluded fishing and forestry workers in rate calculations. From there, we employed the Census of Agriculture as our denominator population.[4, 34, 89] The use of the Census of Agriculture resulted in a farming population aligned with numerator definition and encompassed the background suicide risk associated with farming. The methodology employed for the current sought to reduce classification and study bias, precipitating the inconsistencies with previously reported US farmer suicide rates.[2, 3, 34] The findings; however, are not altogether inconsistent with all farmer suicide studies where Pickett (1999) found lower farm operator suicide rates compared to that of the general Canadian population.[94]

When concluding rate differences between farmers and US male suicide rates, the magnitude of risk and suicide rates between farmers and the US males are unparalleled because of differing levels of multifactorial suicide risk in the US male population. The multifactorial risk factors prevalent in US male suicide rates include the presence of high suicide risk professions, increased levels of unemployment and disadvantageous socioeconomic circumstances, chronic disease, and mental illness.[6, 12, 119, 120] Further, the number of farmers working off-farm jobs continues to increase, which may lead to a misclassification of occupation reported by family members at the time of death, further complicated by the lack of investigatory resources for suicides.[19, 109] In other words, suicide rates for farmers who farm may be included in other occupations or the general population because of occupation misreporting.

How families perceive and report occupation is a long-standing element of occupation misrepresentation, especially for on-farm females who consistently engage in farm operations and day-to-day decisions but may not consider themselves operators.[65, 121] When conducting this study, there were numerous decedents without a farming or agricultural designation whose occupation was listed as “housewife” or “homemaker.” The perceived roles of females resulting from traditional norms and gender bias may indicate the high number of non-farm occupation designations and the low number of female farmer decedents in this study. Consequently, the low number of female farmer suicide decedents prevented estimation of age-adjusted rates for female farmers.

Overall rate trends showed an upward trend for male farmers also observed in the US male population. Trend analysis showed a statistically significant APC in farmer suicide rates, which indicates that farmer suicide mortality continues to increase in the

U.S., paralleling US male suicide rates.[5, 13, 34, 58, 122] The annual rates for farmers; however, show rate variations across years with notable rate variations in state and regional rates, likely impacted by differing years states reported to the NVDRS. Prior studies of Midwestern farming states show excess farmer suicide rates for the Midwest region; however, not all Midwestern states report to the NVDRS.[96, 97] By contrast, population-level studies show decreases in Southeastern and Southwestern states with substantial (>30%) increases in Western and Midwestern states.[58] The differences in state-based reporting potentially affect overall suicide rates by year, especially when reporting inconsistencies in states like Kentucky, cannot be ruled out.

Several studies indicate a myriad of farm-specific stressors impact SDV behaviors in farmers, while studies of pesticide application demonstrate increases in risk factors like depression know to impact SDV behaviors. Studies of Australian farmer suicide notes that a variety of stressors impact the psychological well-being of farmers, which include financial difficulties, public policy, decision farm business operation, uncontrollable market shifts, and unpredictable forces like drought and flooding that impact livestock health and the ability to harvest crops.[26] US studies provide scant information about predictors and factors that fully differentiate rate shifts and state-to-state variations; however, environmental, physical, socioeconomic, and commodity-specific risk factors like pesticide used cannot be ruled out. The marked fluctuations in annual farmer suicide rates coupled with state and regional variations and a definitive upward trend beginning in 2005 substantiate the further exploration of factors associated with suicide among US farmers.

The age of Kentucky farmers is similar to that of the farmer decedents in our national study (59.7 versus 61.3 years), while 44% of the decedents were over 64 years. As with prior research, most of our Kentucky farmer decedents were white (99%), married (36%), and held at least a high school diploma or GED (47%).[2, 30, 118] Exploring four types of commodity production indicated that dairy production in Kentucky experienced over a 21% decrease in the average number of dairy cattle between 2007 and 2017 (Table 12). However, the number of counties ranked as having a “low-medium” number of dairy cattle increased between each census. Farmer suicide rates in counties with the highest number of dairy cattle were not statistically different from the rates of farmer suicide among low producing dairy counties, although Kentucky experienced a 61% decrease in the total number of dairy farms between the 2007 and 2017 Census of Agriculture (Table 13).[19, 109, 111] The average number of acres harvested

in Kentucky decreased by 18% from 2012 to 2017, and farmers in the medium category for corn acres harvested indicated negligible suicide risk to those farmers harvesting over 30,000 acres. By contrast, farmers in medium yield soy production groups showed lower reduced suicide mortality than farmers harvesting over 30,000 acres.

Farmers consistently report stress associated with farming and rural living and express concern over the scant resources to cope with the stressors and constant demands of farming.[21, 24, 103, 123, 124] Moreover, the rural nature of farming does not facilitate coping strategies because of social isolation, health resource scarcity, and proximity to behavioral health services.[7, 12] The variations in farmer suicide mortality by commodity production group is concerning given the hazards and stressors associated with farming, and these findings demonstrate plausibility for an association between commodity production and farmer suicide mortality. However, the differences in rate ratios are not elucidated and are likely biased by factors that include contextual factors associated with suicide, farm income and expense, exposure to environmental hazards, and high rural-urban gradients. Future studies should focus on determining characteristics associated with farmer suicide, including analyzing contextual and agricultural production factors. Examples of contextual and agricultural characteristics might include decedent sociodemographic, off-farm labor, farm size, commodity production variables (income, expense, and debt), median county income, county population, and insurance status.

Future Research and Interventions

The current study extends a vital area of research and draws attention to several public health sectors. Although this study found that farmer suicide rates were lower than that of US males, this study showed a similar rise in male farmer suicide rates that parallel the general population. Further, prior research consistently demonstrates that suicide rates among agricultural occupations have risen over time.[2, 34] Accordingly, a recent study utilizing the NVDRS demonstrated higher rates for farmers, ranchers, and other agricultural managers and agricultural workers compared to other manual occupations.[4] Findings from this study and prior studies demonstrate the need for future research to differentiate suicide rates by agricultural productions and independently assess rates for farmers and agricultural workers and laborers. By contrast, a higher number of male and female farmers are reporting increases in off-farm labor, and female farmers have a long-standing history of tri-vocational roles as home-maker, farmers, and off-farm

providers. Because of shifts in vocational demographics of farmers, state and federal policies need to adjust and provided increased resources to ensure occupational roles are adequately assessed during suicide investigations. The only tracking system for violent deaths by occupation is the Census of Fatal Occupational Injuries, which tracks violent deaths at the workplace. However, the majority of farmers report living and working on their farms. Federal and state operator organizations, such as the NIOSH, should explore improving tracking and reporting of occupation concerning suicide and SDV behaviors, given that research shows that occupational exposures are associated with elevated suicide risk.

The average age of male farmers in this study was about 61, and results showed the most significant risk for suicide occurred among farmers over 64, followed by younger farmers under 35 years. Research consistently shows that older male farming populations and older male populations generally have the highest suicide rates.[1] Kennedy (2021) et al. documented that persons over 65 who engaged in farming occupations showed over two-fold odds for suicide compared to non-farming occupations.[118] While research is inconsistent for high rates among younger farmers, the elevated rates among farmers 18 – 34 warrants attention because suicide is the 2nd leading cause of death for that age group. These findings indicate that interventionists need to consider targeting the oldest and youngest farmers and use various pathways, including extension agents, commodity associations, and state departments of agriculture. The USDA has reported that the number of younger farmers is on the rise; therefore, interventionists must consider directing prevention efforts toward younger agrarian populations and emerging farmers involved in 4H and FFA.[19] Examples of successful farmer suicide interventions include hotlines developed for farmers as well as media campaigns and online mental health resources for farmers with rural isolation.[125, 126]

This study found that suicide rates varied by year as well as by state and US region. Several studies elucidate the relationship between contextual factors associated with suicide in farming populations; however, research is limited regarding commodity production factors associated with farmer suicide.[2, 5, 24, 26, 30, 118, 123, 124] In addition to focusing interventions toward the oldest and youngest farmers, future research needs to evaluate underlying risk factors associated with temporal trends and state and regional rate differences. Epidemiologic studies focused on better understanding farmer suicide

in the US might consider evaluating factors associated with suicide, including general risk factors and agricultural risks such as commodity production type, farm expenses, farm sales, and farm size.

Lastly, results from this study showed a large proportion of female farmer suicide decedents were middled-aged and under and married. But because of the small number of cells for female farmers, we were unable to calculate age-adjusted suicide rates. Research consistently reports elevated suicide risk for females in farm occupations and shows mixed findings for risk by age group. Similarly, minority farmers were underrepresented in this study and are disproportionately represented in farming ownership and operations, whereas they have higher rates of suicide compared to their white counterparts.[19] This study shows that researchers need to focus efforts toward accurately determining risk for suicide among female and minority farmers while seeking to improve occupational reporting of female decedents.

Strengths and Limitations

There were several strengths with this current study. First, this study used a national violent death database to determine farmer suicide mortality. While prior studies have reported farmer suicide mortality, those studies have focused on state-based violent death reporting systems or utilized death certificate data with limited reporting periods. Secondly, prior studies defined farmers by their SOC groups or aggregated operators and producers with farmer laborers or equipment operators to determine rates. While those methodologies provide insights into suicide mortality among agricultural populations, by definition, they do not provide a farmer-specific suicide rate. Thirdly, we used a farmer-specific denominator population from the Census of Agriculture to improve the representation of background risk among the population giving rise to farmer decedents to estimate rates. Fourthly, this study utilized 15 years of data resulting in our ability to assess, which demonstrated a statistically significant farmer suicide rate that trended upward with US male suicide rates. Lastly, this study preliminarily showed that commodity production differed over time by county and demonstrated a potential relationship between type and level of commodity production and farmer suicide.

There are multiple limitations with the current study. For example, the working definition of a farmer in the numerator and denominator data is a limitation because we cannot establish the number of hours spent farming, decedent reliance on farm income,

or relationships to exposures. Inevitably, the number of farmers working off-farm jobs continues to increase, which can confound the rates because of background occupational exposures. By contrast, farmers who work off-farm and rely on farm income may be underrepresented in NVDRS data because their occupation is not reported as farmers. For example, in this study, there were several decedents included in the study with two vocations listed. Further, the current study employed multiple search terms to identify decedents, and from there, employed inter-raters to select the final number of farmer suicide decedents. However, the potential for misclassification exists because of the high degree of specificity used to exclude occupations through the snowballing sampling technique.

Secondly, we selected operators from 2002, 2007, and 2012 quinquennial Census of Agriculture while producers were selected from the 2017 census for our denominator population. Farmers reported in the Census of Agriculture as an operator or producer "if $1,000 or more of agricultural products were produced and sold, or would normally have been sold, during the census year."[110] When using this definition, it increased the potential for overestimating the denominator population because persons who meet the criteria as an operator or producer do not inherently incur the same exposures or fiscal demands resulting from farming. Additionally, 2002, 2007, and 2012 censuses reported demographics on up to three operators, while the 2017 census reported demographics on up to four operators. To account for these differences in reporting and lack of intercensal estimates from the NASS, we forecasted the total number of farmers within each state through interpolation; therefore, our denominator was an estimate of the total number of farmers between quinquennial census years.

Thirdly, the ecological nature of this study inhibits the ability to draw inferences about individual farmers from this group of farmer suicide decedents and their reported rates. Fourthly, the low number of female farmer suicide decedents resulted in our inability to calculate age-adjusted female farmer suicide rates throughout the study period, and female farmers were likely underestimated. Evidence suggests that female farmers participate in daily farm operations related to fiscal and marketing decisions while commodity production work is perceived as a helping role. Female perceptions of their farm roles result from traditional gender norms and biases.[19, 65]

Because of the small number of minority decedents, we did not calculate rates for minority farmers. Racial disparities in Agriculture are a substantial concern, and Indigenous People groups demonstrate the highest suicide rates. Consequently, states

known for agricultural production, high rural-urban gradients, and clustering of Indigenous People groups exhibit some of the highest state suicide rates.[5, 55-57, 59, 79] Further, the author acknowledges the disproportionate distribution of agricultural production and farm ownership is controlled by white males that may result from longstanding, systemic racism in the US.

Fourthly, the reporting period for NVDRS states differed throughout the study, and we were unable to report rates for states not meeting our rate calculation standards. The inability to report rates hindered our capability to portray and make state-based rate comparisons visually. Likewise, the low number of decedents for states within the study decreased the overall sample for rates by US regions.

Lastly, our estimation of suicide risk by commodity production types was limited to one state, limiting our overall sample. We limited our assessment of risk to four major commodity groups and collapsed types of commodity production for corn and poultry. In doing so, we were unable to detect differences by types of poultry and corn acres production. Further, we could not obtain county-level intercensal estimates for our four commodity production categories, resulting in taking an averaged commodity production over each census year. The average for commodity production was recategorized to prevent low decedent counts by production type, likely reducing our ability to evaluate risk by commodity type. Although preliminary results indicated that higher commodity production levels are protective for farmer suicide in those counties, the results were not statistically significant. Further, suicide risk is multifactorial, and we did not stratify to account confounding factors, like age groupings, for suicide risk by commodity type. Future studies should consider employing Generalized Linear Regression models to control for confounding and fully assess the risk of suicide by commodity production type.

REFERENCES

1. National Institute of Mental Health. Suicide Statistics. NIMH. Accessed July 1, 2020, 2020. https://www.nimh.nih.gov/health/statistics/suicide.shtml#part_155137
2. Browning SR, Westneat SC, McKnight RH. Suicides among farmers in three southeastern states, 1990-1998. *Journal of Agricultural Safety and Health*. 2008;14(4):461-472. doi:10.13031/2013.25282
3. Stallones L, Doenges T, Dik BJ, Valley MA. Occupation and suicide: Colorado, 2004–2006. *American Journal of Industrial Medicine*. 2013;56(11):1290-1295. doi:10.1002/ajim.22228
4. Peterson C, Stone D, Marsh S, et al. Suicide Rates by Major Occupational Group - 17 States, 2012 and 2015. *MMWR Morbidity and Mortality Weekly Report*. 2018;67(45):1253-1260.
5. Rockett IRH, Regier MD, Kapusta ND, et al. Leading causes of unintentional and intentional injury mortality: United States, 2000-2009. *American journal of public health*. 2012;102(11):e84. doi:10.2105/AJPH.2012.300960
6. Suicide in American: Frequencly Asked Questions. National Institute of Mental Health; 2020.
7. Action Alliance for Suicide Prevention. *2012 National Strategy for Suicide Prevention: Goals and Objectives for Action*. 2012. *A Report fo the US Surgeon General and of the National Action Alliance for Suicide Prevention*.
8. Hempstead KA, Phillips JA. Rising Suicide Among Adults Aged 40–64 Years. *American Journal of Preventive Medicine*. 2015;48(5):491-500. doi:10.1016/j.amepre.2014.11.006
9. Nock MK, Borges G, Bromet EJ, et al. Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *The British journal of psychiatry : the journal of mental science*. 2008;192(2):98. doi:10.1192/bjp.bp.107.040113
10. Denney JT, Rogers RG, Krueger PM, Wadsworth T. Adult Suicide Mortality in the United States: Marital Status, Family Size, Socioeconomic Status, and Differences by Sex. *Social science quarterly*. 2009;90(5):1167-1167. doi:10.1111/j.1540-6237.2009.00652.x
11. Ratcliffe EG, Enns WM, Belik WS-L, Sareen WJ. Chronic Pain Conditions and Suicidal Ideation and Suicide Attempts: An Epidemiologic Perspective. *The Clinical Journal of Pain*. 2008;24(3):204-210. doi:10.1097/AJP.0b013e31815ca2a3
12. Harp K, Borders TF. Suicidal Thoughts, Plans, and Attempts by Non-Metropolitan and Metropolitan Residence. 2019.
13. Rossen LM, Hedegaard H, Khan D, Warner M. County-Level Trends in Suicide Rates in the U.S., 2005–2015. *American Journal of Preventive Medicine*. 2018;55(1):72-79. doi:10.1016/j.amepre.2018.03.020
14. Bureau of Labor Statistics. Standard Occupational Classification System. United States Department of Labor. Accessed 12/9/2020, https://www.bls.gov/soc/2018/major_groups.htm
15. Bureau of Labor Statistics. Farmers, Ranchers, and Other Agricultural Managers. U.S. Department of Labor. Accessed August 21, 2020, 2020. https://www.bls.gov/ooh/management/farmers-ranchers-and-other-agricultural-managers.htm#tab-2
16. Beseler C, Stallones L, Hoppin JA, et al. Depression and pesticide exposures in female spouses of licensed pesticide applicators in the agricultural health study cohort.

Journal of occupational and environmental medicine. 2006;48(10):1005-1013. doi:10.1097/01.jom.0000235938.70212.dd
17. Booth N, Briscoe M, Powell R. Suicide in the farming community: methods used and contact with health services. *Occupational and Environmental Medicine*. 2000;57(9):642. doi:10.1136/oem.57.9.642
18. Scarth RD, Stallones L, Zwerling C, Burmeister LF. The prevalence of depressive symptoms and risk factors among Iowa and Colorado farmers. *American journal of industrial medicine*. 2000;37(4):382-389. doi:10.1002/(SICI)1097-0274(200004)37:4<382::AID-AJIM8>3.0.CO;2-4
19. National Agricultural Statistics Service. *2017 Census of Agriculture*. 2019:820.
20. Milner A, Spittal M, Pirkis J, Lamontagne AD. Suicide by occupation: systematic review and meta-analysis. *British Journal Of Psychiatry*. 2013;203(6):409-416. doi:10.1192/bjp.bp.113.128405
21. Amshoff SK, Reed DB. Health, Work, and Safety of Farmers Ages 50 and Older. *Geriatric Nursing*. 2005;26(5):304-308. doi:10.1016/j.gerinurse.2005.08.008
22. Arcury T, Quandt S. Occupational and environmental health risks in farm labor. *Human Organization*. 1998;57(3):331-334. doi:10.17730/humo.57.3.m77667m3j2136178
23. Frank AL, McKnight R, Kirkhorn SR, Gunderson P. Issues of Agricultural Safety and Health. 2004;25(1):225-245. doi:10.1146/annurev.publhealth.25.101802.123007
24. Fraser CE, Smith KB, Judd F, Humphreys JS, Fragar LJ, Henderson A. Farming and mental health problems and mental illness. *The International journal of social psychiatry*. 2005;51(4):340-349. doi:10.1177/0020764005060844
25. Gregoire A. The mental health of farmers. *Journal of Occupational Medicine*. 2002;52(8):471-476.
26. Judd F, Jackson H, Fraser C, Murray G, Robins G, Komiti A. Understanding suicide in Australian farmers. *Social Psychiatry and Psychiatric Epidemiology*. 2006;41(1):1-10. doi:10.1007/s00127-005-0007-1
27. Bao AM, Ruhé HG, Gao SF, Swaab DF. Chapter 8 - Neurotransmitters and neuropeptides in depression. In: Aminoff MJ, Boller F, Swaab DF, eds. *Handbook of Clinical Neurology*. Elsevier; 2012:107-136.
28. Malmberg A, Simkin S, Hawton K. Suicide in farmers. *British Journal Of Psychiatry*. 1999;175:103-105.
29. van Heeringen K, Mann JJ. The neurobiology of suicide. *The Lancet Psychiatry*. 2014;1(1):63-72. doi:10.1016/S2215-0366(14)70220-2
30. Scheyett A, Bayakly R, Whitaker M. Characteristics and Contextual Stressors in Farmer and Agricultural Worker Suicides in Georgia From 2008–2015. *Journal of Rural Mental Health*. 2019;43(2-3):61-72. doi:10.1037/rmh0000114
31. Alston M. Rural male suicide in Australia. *Social science & medicine*. 2012;74(4):515-522.
32. Singh G, Siahpush M. Increasing rural-urban gradients in US suicide mortality, 1970-1997. *American Journal of Public Health*. 2002;92(7):1161-7.
33. Perceval M, Ross V, Reddy P, De Leo D. Social factors and Australian farmer suicide: a qualitative study. *BMC Public Health*. 2018;18doi:10.1186/s12889-018-6287-7
34. Ringgenberg W, Peek-Asa C, Donham K, Ramirez M. Trends and Characteristics of Occupational Suicide and Homicide in Farmers and Agriculture Workers, 1992–2010. *Journal of Rural Health*. 2018;34(3):246-253. doi:10.1111/jrh.12245
35. Stallones L. Suicide mortality among Kentucky farmers, 1979–1985. *Suicide and Life-Threatening Behavior*. 1990;20(2):156-163.
36. Lavender A, Ramirez-Irizarry V, Bayakly AR, Koplan C, Bryan JM. Violent Deaths Among Georgia Workers: An Examination of Suicides and Homicides by Occupation,

2006-2009. *American journal of preventive medicine*. 2016;51(5):S241-S250. doi:10.1016/j.amepre.2016.07.025
37. Arnautovska U, McPhedran S, Kelly B, Reddy P, De Leo D. Geographic variation in suicide rates in Australian farmers: Why is the problem more frequent in Queensland than in New South Wales? *Death Studies*. 2016;40(6):367-372. doi:10.1080/07481187.2016.1153007
38. Hawton K, Fagg J, Simkin S, Harriss L, Malmberg A, Smith D. The geographical distribution of suicides in farmers in England and Wales. *Social Psychiatry and Psychiatric Epidemiology*. 1999;34(3):122-127. doi:10.1007/s001270050122
39. Health NIoM. The NIH Almanac. NIMH. Accessed 2020, https://www.nih.gov/about-nih/what-we-do/nih-almanac/national-institute-mental-health-nimh
40. Administration SAaMHS. About Us. SAMHSA. 2020. https://www.samhsa.gov/about-us
41. Substance Abuse and Mental Health Services Administration. *Key substance use and mental health indicators in the United States: Results from the 2018 National Survey on Drug Use and Health (HHS Publication No. PEP19-5068, NSDUH Series H-54)*. 2019. https://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHNationalFindingsReport2018/NSDUHNationalFindingsReport2018.pdf
42. Administration SAaMHS. *SAMHSA Strategic Plan – FY2019-FY2023*. 2018:36. https://www.samhsa.gov/sites/default/files/samhsa_strategic_plan_fy19-fy23_final-508.pdf
43. CDC. *Rural Health Policy Brief: Preventing Opioid Overdoses in Rural America*. 2018. Accessed May 12, 2018. https://www.cdc.gov/ruralhealth/drug-overdose/pdf/Policy-Brief_Opioiod-Overdoses-H.pdf
44. Kposowa AJ. Suicide mortality in the United States: Differentials by industrial and occupational groups. *American journal of industrial medicine*. 1999;36(6):645-652. doi:10.1002/(SICI)1097-0274(199912)36:6<645::AID-AJIM7>3.0.CO;2-T
45. Lykouras L, Poulakou-Rebelakou E, Tsiamis C, Ploumpidis D. Suicidal behaviour in the ancient Greek and Roman world. *Asian Journal of Psychiatry*. 2013;6(6):548-551. doi:10.1016/j.ajp.2013.08.001
46. Durkheim E. *Suicide: a study in sociology*. Routledge & K. Paul London; 1952.
47. Fincham B. *Understanding suicide : a sociological autopsy*. Houndmills, Basingstoke, Hampshire ; New York : Palgrave Macmillan; 2011.
48. Crosby AE. *Self-directed violence surveillance uniform definitions and recommended data elements*. Version 1.0. ed. Uniform definitions and recommended data elements. Atlanta, Ga. : Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Violence Prevention; 2011.
49. Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite SR, Selby EA, Joiner TE, Jr. The interpersonal theory of suicide. *Psychol Rev*. Apr 2010;117(2):575-600. doi:10.1037/a0018697
50. Timmermans S. Suicide Determination and the Professional Authority of Medical Examiners. *American sociological review*. 2005;70(2):311-333. doi:10.1177/000312240507000206
51. Cheung G, Merry S, Sundram F. Medical examiner and coroner reports: uses and limitations in the epidemiology and prevention of late-life suicide. *International journal of geriatric psychiatry*. 2015;30(8):781-792. doi:10.1002/gps.4294
52. Rockett I. Reliability and sensitivity of suicide certification in higher-income countries. *Suicide and life-threatening behavior*. 1999;29(2):141. doi:10.1111/j.1943-278X.1999.tb01052.x

53. National Center for Injury Prevention and Control. Key Injury and Violence Data. National Center for Injury Prevention and Control. Accessed 10/31/19, https://www.cdc.gov/injury/wisqars/overview/key_data.html
54. World Health Organization. *Suicide in the world: global health estimates*. 2019.
55. Centers for Disease Control and Prevention. National Center for Injury Prevention and Control: WISQARS Leading Cause of Death reports, National and Regional, 1999-2005. U.S. Department of Health and Human Services. Accessed December 5, 2017. https://www.cdc.gov/injury/images/lc-charts/leading_causes_of_death_age_group_2015_1050w740h.gif
56. Centers for Disease Control and Prevention. Leading Causes of Nonfatal Injury Reports, 2000 - 2017. US Department of Health and Human Services. Accessed 9/4/19, 2019. https://webappa.cdc.gov/sasweb/ncipc/nfilead.html
57. CDC. Web-based Injury Statistics Query and Reporting System (WISQARS). CDC. 2020. https://www.cdc.gov/injury/wisqars/index.html
58. Stone DM, Simon TR, Fowler KA, et al. Vital Signs: Trends in State Suicide Rates - United States, 1999-2016 and Circumstances Contributing to Suicide - 27 States, 2015. *MMWR Morbidity and Mortality Weekly Report*. 2018;67(22):617. doi:10.15585/mmwr.mm6722a1
59. Centers for Disease C, Prevention. Suicide among adults aged 35-64 years--United States, 1999-2010. *MMWR Morbidity and Mortality Weekly Report*. 2013;62(17):321-325.
60. Phillips JA. Factors Associated With Temporal and Spatial Patterns in Suicide Rates Across U.S. States, 1976–2000. *Demography*. 2013;50(2):591-614. doi:10.1007/s13524-012-0176-y
61. Ivey-Stephenson AZ, Crosby AE, Jack SPD, Haileyesus T, Kresnow-Sedacca M-J. Suicide Trends Among and Within Urbanization Levels by Sex, Race/Ethnicity, Age Group, and Mechanism of Death - United States, 2001-2015. *Morbidity and mortality weekly report Surveillance summaries (Washington, DC : 2002)*. 2017;66(18):1-16. doi:10.15585/mmwr.ss6618a1
62. Florence C, Thomas S, Haegerich T, Feijun L, Chao Z. Estimated Lifetime Medical and Work-Loss Costs of Fatal Injuries — United States, 2013. *MMWR Morbidity and mortality weekly report*. 2015;64(38):1074-1077. doi:10.15585/mmwr.mm6438a4
63. Shepard DS, Gurewich D, Lwin AK, Reed GA, Silverman MM. Suicide and Suicidal Attempts in the United States: Costs and Policy Implications. *Suicide & life-threatening behavior*. 2016;46(3):352-362. doi:10.1111/sltb.12225
64. Cerel J, Jordan JR, Duberstein PR. The Impact of Suicide on the Family. *Crisis: The Journal of Crisis Intervention and Suicide Prevention*. 2008;29(1):38-44. doi:10.1027/0227-5910.29.1.38
65. Brasier KJ, Sachs CE, Kiernan NE, Trauger A, Barbercheck ME. Capturing the Multiple and Shifting Identities of Farm Women in the Northeastern United S tates. *Rural Sociology*. 2014;79(3):283-309. doi:10.1111/ruso.12040
66. Browning SR, Westneat SC, Sanderson WT, Reed DB. Cattle-related injuries and farm management practices on Kentucky beef cattle farms. *Journal of agricultural safety and health*. 2013;19(1):37-49. doi:10.13031/2013.42541
67. Purschwitz MA, Field WE. Scope and magnitude of injuries in the agricultural workplace. *American Journal of Industrial Medicine*. 1990;18(2):179-192. doi:10.1002/ajim.4700180210
68. Nordgren TM, Bailey KL. Pulmonary health effects of agriculture. *Current opinion in pulmonary medicine*. 2016;22(2):144-149. doi:10.1097/mcp.0000000000000247

69. Stallones L, Leff M, Garrett C, Criswell L, Gillan T. Depressive Symptoms Among Colorado Farmers. *Journal of Agricultural Safety and Health*. 1995;1(1):37-43. doi:10.13031/2013.19454
70. Beseler CL, Stallones L, Hoppin JA, et al. Depression and Pesticide Exposures among Private Pesticide Applicators Enrolled in the Agricultural Health Study. *Environmental health perspectives*. 2008;116(12):1713-1719. doi:10.1289/ehp.11091
71. Freire C, Koifman S. Pesticides, depression and suicide: A systematic review of the epidemiological evidence. *International journal of hygiene and environmental health*. 2013;216(4):445-460. doi:10.1016/j.ijheh.2012.12.003
72. Stallones L. Suicide and Potential Occupational Exposure to Pesticides, Colorado 1990–1999. *Journal of Agromedicine*. 2006/12/01 2006;11(3-4):107-112. doi:10.1300/J096v11n03_11
73. Stallones L, Beseler C. Pesticide Poisoning and Depressive Symptoms among Farm Residents. *Annals of epidemiology*. 2002;12(6):389-394. doi:10.1016/S1047-2797(01)00298-8
74. Kearney GD, Rafferty AP, Hendricks LR, Allen DL, Tutor-Marcom R. A cross-sectional study of stressors among farmers in eastern North Carolina. *North Carolina medical journal*. 2014;75(6):384-392.
75. Freeman SA, Schwab CV, Jiang CV. Quantifying stressors among Iowa farmers. *Journal of Agricultural Safety and Health*. 2008;14(4):431-439. doi:10.13031/2013.25280
76. Kennedy AJ, Maple MJ, McKay K, Brumby SA. Suicide and accidental death in Australia's rural farming communities: a review of the literature. *Rural and remote health*. 2014;14(1):2517-2517.
77. Choi B. Job strain, long work hours, and suicidal ideation in US workers: a longitudinal study. *International archives of occupational and environmental health*. 2018;91(7):865-875.
78. Boxer AP, Burnett AC, Swanson AN. Suicide and Occupation: A Review of the Literature. *Journal of Occupational and Environmental Medicine*. 1995;37(4):442-452. doi:10.1097/00043764-199504000-00016
79. Bedeian AG. Suicide and occupation: A review. *Journal of Vocational Behavior*. 1982;21(2):206-223. doi:10.1016/0001-8791(82)90030-6
80. Gallagher RP, Threlfall WJ, Spinelli JJ, Band PR. Occupational mortality patterns among British Columbia farm workers. *Journal of occupational medicine*. 1984;26(12):906-908.
81. Fragar L, Depczynski J, Lower T. Mortality patterns of Australian male farmers and farm managers. *Australian Journal of Rural Health*. 2011;19(4):179-184. doi:10.1111/j.1440-1584.2011.01209.x
82. Lee WJ, Alavanja MCR, Hoppin JA, et al. Mortality among pesticide applicators exposed to chlorpyrifos in the Agricultural Health Study. *Environmental health perspectives : EHP*. 2007;115(4):528-534. doi:10.1289/ehp.9662
83. Pickett W, King WD, Lees REM, Bienefeld M, Morrison HI, Brison RJ. Suicide mortality and pesticide use among Canadian farmers. *American journal of industrial medicine*. 1998;34(4):364-372. doi:10.1002/(SICI)1097-0274(199810)34:4<364::AID-AJIM10>3.0.CO;2-0
84. Blair A, Sandler DP, Tarone R, et al. Mortality among Participants in the Agricultural Health Study. *Annals of epidemiology*. 2005;15(4):279-285. doi:10.1016/j.annepidem.2004.08.008
85. Waggoner JK, Kullman GJ, Henneberger PK, et al. Mortality in the Agricultural Health Study, 1993-2007. *American journal of epidemiology*. 2010;173(1):71-83. doi:10.1093/aje/kwq323

86. Beard JD, Umbach DM, Hoppin JA, et al. Suicide and Pesticide Use among Pesticide Applicators and Their Spouses in the Agricultural Health Study. *Environmental health perspectives*. 2011;119(11):1610-1615. doi:10.1289/ehp.1103413
87. Roberts S, Jaremin B, Lloyd K. High-risk occupations for suicide. *Psychological Medicine*. 2013;43(6):1231-40. doi:10.1017/S0033291712002024
88. Liu T, Waterbor JW. Comparison of suicide rates among industrial groups. *American Journal of Industrial Medicine*. 1994;25(2):197-203. doi:10.1002/ajim.4700250206
89. Stack S. Occupation and suicide. *Social science quarterly*. 2001;82(2):384. doi:info:doi/
90. Pegula S. *An Analysis of Workplace Suicides, 1992-2001*. Vol. 2018. 2004. https://stats.bls.gov/opub/mlr/cwc/an-analysis-of-workplace-suicides-1992-2001.pdf
91. Page AN, Fragar LJ. Suicide in Australian Farming, 1988–1997. *Australian and New Zealand Journal of Psychiatry*. 2002;36(1):81-85. doi:10.1046/j.1440-1614.2002.00975.x
92. Guiney R. Farming suicides during the Victorian drought: 2001–2007. *Australian Journal of Rural Health*. 2012;20(1):11-15. doi:10.1111/j.1440-1584.2011.01244.x
93. Arnautovska U, McPhedran S, De Leo D. A regional approach to understanding farmer suicide rates in Queensland. *Social psychiatry and psychiatric epidemiology*. 2014;49(4):593-599. doi:10.1007/s00127-013-0777-9
94. Pickett W, King WD, Faelker T, Lees RE, Morrison HI, Bienefeld M. Suicides among Canadian farm operators. *Chronic diseases in Canada*. 1999;20(3):105-110.
95. Pickett W, Davidson JR, Brison RJ. Suicides on Ontario Farms. *Canadian journal of public health*. 1993;84(4):226-230.
96. Pylka KT, Gunderson PD. An epidemiologic study of suicide among farmers and its clinical implications. *Marshfield Clinic Bull*. 1992;26:29-57.
97. Gunderson P, Donner D, Nashold R, Salkowicz L, Sperry S, Wittman B. The Epidemiology of Suicide Among Farm Residents or Workers in Five North-Central States, 1980-1988. *American journal of preventive medicine*. 1993;9(3):26-32. doi:10.1016/S0749-3797(18)30675-5

info:doi/10.1016/S0749-3797(18)30675-5
98. Stallones L, Cook M. Suicide Rates in Colorado from 1980 to 1989: Metropolitan, Nonmetropolitan, and Farm Comparisons. *The Journal of Rural Health*. 1992;8(2):139-142. doi:10.1111/j.1748-0361.1992.tb00340.x
99. National Association of State Mental Health Program Directors Education Development Center. *Preventing suicide: a toolkit for high schools*. Center for Mental Health Services, Substance Abuse and Mental Health Services Administration; 2012.
100. Office of Continuous Improvement and Support. Suicide Prevention and Awareness. Kentucky Department of Education. https://education.ky.gov/school/sdfs/Pages/Suicide-Prevention-and-Awareness.aspx
101. Stone D. *Preventing suicide : a technical package of policy, programs, and practices*. Atlanta, Georgia : Division of Violence Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention; 2017.
102. Zechmeister I, Kilian R, McDaid D. Is it worth investing in mental health promotion and prevention of mental illness? A systematic review of the evidence from economic evaluations. *BMC Public Health*. 2008;8:20-20. doi:10.1186/1471-2458-8-20
103. Reed DB. The risky business of production agriculture: health and safety for farm workers. *AAOHN journal : official journal of the American Association of Occupational Health Nurses*. 2004;52(9):401-9; quiz 410-1.

104. Osborne A, Blake C, Fullen BM, et al. Prevalence of musculoskeletal disorders among farmers: A systematic review. *American journal of industrial medicine*. 2012;55(2):143-158. doi:10.1002/ajim.21033
105. Simkin S, Hawton K, Fagg J, Malmberg A. Stress in farmers: a survey of farmers in England and Wales. *Occupational and Environmental Medicine*. 1998;55(11):729. doi:10.1136/oem.55.11.729
106. Booth NJ, Lloyd K. Stress in Farmers. *International Journal of Social Psychiatry*. 2000;46(1):67-73. doi:10.1177/002076400004600108
107. Centers for Disease Control and Prevention. *National Violent Death Reporting System (NVDRS) Coding Manual Revised [Online]*. 2018. https://www.cdc.gov/injury/
108. National Agricultural Statistics Service. Quick Stats. United States Department of Agriculture. Accessed 02/02/2019, 2020. https://quickstats.nass.usda.gov/
109. National Agricultural Statistics Service. *2012 Census of Agriculture*. 2014:695.
110. National Agricultural Statistics Service. *2002 Census of Agriculture*. 2004.
111. National Agricultural Statistics Service. *2007 Census of Agriculture*. 2009.
112. U.S. Census Bureau. Population and Housing Estimates. U.S. Census Bureau. 2021. https://www.census.gov/programs-surveys/popest/data/data-sets.html
113. Bando DH, Brunoni AR, Fernandes TG, Benseñor IM, Lotufo PA. Suicide rates and trends in São Paulo, Brazil, according to gender, age and demographic aspects: a joinpoint regression analysis. *Revista brasileira de psiquiatria : publication of the Associação Brasileira de Psiquiatria - ABP, Asociación Psiquiátrica de la América Latina - APAL*. 2012;34(3):286-293. doi:10.1016/j.rbp.2012.02.001
114. Thomas K, Chang S-S, Gunnell D. Suicide epidemics: The impact of newly emerging methods on overall suicide rates - A time trends study. *BMC public health*. 2011;11(1):314-314. doi:10.1186/1471-2458-11-314
115. Vichi M, Masocco M, Pompili M, Lester D, Tatarelli R, Vanacore N. Suicide mortality in Italy from 1980 to 2002. *Psychiatry research*. 2008;175(1):89-97. doi:10.1016/j.psychres.2008.12.008
116. Kim H, Fay M, Feuer E, Midthun D. Permutation testes for joinpoint regression with applications to cancer rates. *Statistics in Medicine*. 2000;(19):335-351.
117. *SAS 9.04.01 TS*. SAS Institute Inc.; 2013.
118. Kennedy A, Cerel J, Kheibari A, Leske S, Watts J. A comparison of farming- and non-farming-related suicides from the United States' National Violent Deaths Reporting System, 2003-2016. *Suicide Life Threat Behav*. Jan 6 2021;doi:10.1111/sltb.12725
119. Agerbo E, Gunnell D, Bonde J, Bo Mortensen P, Nordentoft M. Suicide and occupation: the impact of socio-economic, demographic and psychiatric differences. *Psychological Medicine*. 2007;37(8):1131-40. doi:10.1017/S0033291707000487
120. National Advisory Committee on Rural Health and Human Services. *Understanding the Impact of Suicide in Rural America: Policy Brief and Recommendations*. 2017.
121. Burge PL. Triple Roles of Appalachian Farm Women: Household, Farm and Wage-Earning. *Research in Rural Education*. 1983;2(2):69-72.
122. Hedegaard H, Curtin SCW, Margaret. *Suicide Mortality in the United States, 1999 -019*. 2021. *NCHS Data Brief*. https://www.cdc.gov/nchs/products/databriefs.htm
123. Judd F, Cooper A-M, Fraser C, Davis J. Rural suicide-people or place effects? *Australian and New Zealand Journal of Psychiatry*. 2006;40(3):208-216. doi:10.1080/j.1440-1614.2006.01776.x
124. Reed DB, Claunch DT. Risk for Depressive Symptoms and Suicide Among U.S. Primary Farmers and Family Members: A Systematic Literature Review. *Workplace Health Saf*. May 2020;68(5):236-248. doi:10.1177/2165079919888940

125. Farm Crisis Council of Interchur Ministries of Nebraska. The Nebraska Rural Response HOTLINE. Farm Crisi Council of Interchur Ministries of Nebraska,. Accessed 12/09/2020, https://www.fsa.usda.gov/Internet/FSA_File/farmcrisis11.pdf
126. Deakin University. National Centre for Farmer Health,. National Centre for Farmer Health,. Accessed 12/10/2020, https://farmerhealth.org.au/farmers

VITA

Paul Edward Norrod

EDUCATION

2012 – Master of Arts in Counseling; Asbury Theological Seminary

2012 – Master of Divinity; Asbury Theological Seminary

2000 – Bachelor of Science in Nursing; Tennessee Technological University

1997 – Emergency Medical Technician IV; Roane State Community College

1996 – Emergency Medical Technician; Tennessee Technological University

PROFESSIONAL EXPERIENCE

2021 – Current, Principal Extension Specialist for Rural Health and Stress, UK College of Agriculture

2020 – Current, Community and Public Health Instructor; UK, College of Nursing, Lexington, KY

2017 – 2021, Registered Nurse; Baptist Health, Lexington, KY

2015 – Current, Adjunct Professor of Psychology; Asbury University, Wilmore, KY

2017 – 2019, Epidemiology Graduate/Teaching Assistant; University of Kentucky, Lexington, KY

2016 – 2017, Fatherhood Program Coordinator; Lexington Leadership Foundation, Lexington, KY

2015 – 2016, Program Coordinator; Prevent Child Abuse Kentucky, Lexington, KY

2014 – 2015, Case Manager, Fatherhood Program; Lexington Leadership Foundation, Lexington, KY

2009 – 2014, Registered Nurse; Saint Joseph Primary Care Associates, Wilmore, KY

2002 – 2008, Owner/Operator; Intricate PC Solutions, Lexington, KY

2002 – 2006, Registered Nurse: Cumberland Medical Center, Crossville, TN

2000 – 2002, Registered Nurse; Cookeville Regional Medical Center, Cookeville, TN

1996 – 2001, EMT-IV; Cumberland County EMS, Crossville, TN

HONORS

2021, Outstanding Doctoral Student Award, UK College of Public Health

2020, Department Recognition for Patient Care and Safety, Baptist Health Systems

2018, NIOSH/UK Central Appalachian Education and Resource Center Epidemiology Fellow

2014, Good Catch Patient Safety Award, Catholic Health Initiatives

2006, Volunteer of the Year Service Award, Office of Community Life International, Asbury Theological Seminary.

2000, Theta-Phi Nursing Award for Best Group Research Proposal and Presentation, Tennessee Technological University.

1999, County Commissioner's Emergency Service Recognition, Cumberland County EMS.

PUBLICATIONS

Norrod, P. (2014), Dictionary of the Bible and Western Culture: Flesh and Retribution. Edited by Mary Ann Beavis and Michael J. Gilmour. Sheffield, UK: Sheffield Phoenix, 2012. pages 165, 440.