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Seasonal Variation of Suicide Rates within Alaska: Associations of Age and Sex

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SEASONAL VARIATION OF SUICIDE RATES WITHIN ALASKA: ASSOCIATIONS OF AGE AND SEX

A Thesis Presented

By

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ABSTRACT

SEASONAL VARIATION OF SUICIDE RATES WITHIN ALASKA: ASSOCIATIONS BY AGE AND SEX

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Background: Among Alaska Natives in rural Alaska, suicide rates are almost 16 times higher than the national average. Although some studies of populations in northern latitudes have shown seasonal variation among suicide rates, with differences in patterns by age and sex, reasons for this variation and contributing factors are unclear. Physiological mechanisms have been proposed, however, it is yet unclear what mechanism effects this population specifically. We modeled our hypotheses based on the assumption that vitamin D deficiency plays a role in seasonal variation of suicide. We assessed the relationship between age and sex with seasonal variation of suicidal behavior in a rural region of Alaska. **Methods:** We utilized data from 804 individuals who exhibited lethal and nonlethal ("attempts") suicidal behavior (1990 through 2009). Information on age, sex, and potential contributing factors were recorded via a case report. We used multivariable logistic regression to identify the association between age, sex, and seasonality of suicide. **Results:** There were a total of 88 suicides, and 715 nonfatal attempts. Among women, we observed a significant 41% increase in risk during season two compared to season one for the adjusted model (OR=1.41, CI=1.06, 1.90); women had a significant 48% increase in risk during season two in the fully adjusted model using data collected between 2002-2009 (OR=1.48, CI=1.04, 2.11). After adjusting for potential confounders, we did not observe any significant findings of seasonality with respects to age. The observed seasonal variation of suicide did not support vitamin D deficiency as an underlying cause, as increased incidence of suicide continued into the summer months when vitamin D deficiency would be less prevalent. **Conclusion:** We observed evidence of seasonal variation of suicidal acts by sex. Future studies of physiologic mechanisms influencing seasonality of suicide will be important for informing public health interventions to target those at highest risk throughout the year.

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CHAPTER I

INTRODUCTION

Suicide occurs within many societies throughout the world. Despite extensive research, there is no complete understanding of the risk factors that make one individual more susceptible compared to another. Globally, suicide rates vary dramatically across different populations, especially when demographic characteristics are taken into consideration such as age, sex and race. In 2006, suicide was the 11th leading cause of death in the United States, responsible for 33,289 deaths of individuals 10 years old and older.[1] Suicide rates of 20.67 and 4.62 per 100,000 males and females, respectively, were observed in 2006.[1]

Within the United States, American Indians and Alaskan Native males have consistently been recognized to have the highest suicide rates, with an age-adjusted rate of 26.2 suicides per 100,000.[1] Among American Indians and Alaskan Natives, overall suicide rates are highest among Alaskan Natives with rates of 38.5 per 100,000 (including male and female). [1] However, it is important to note that rates among indigenous populations vary dramatically within Alaska depending on which part of Alaska is considered. For example, among the Alaskan Natives in the Aleutian Islands, suicide rates are below the national average,[2] while rates within the area above the Arctic Circle are dramatically higher at almost 91 per 100,000.[3] Again this rate is highest in Alaskan Native males between the ages of 15-24; this group has a suicide rate of 142.9 per 100,000, which is a disproportionately high when compared to white U.S. males of the same age group (17.4 per 100,000).[4] This study focuses on a region within Alaska that has a population around 8,000, and a 10-year average suicide rate among youth (aged 15-19) of 185 per 100,000, twice the rate for all ages within Northwest Alaska and almost 16 times higher than national rates.[5]

Although suicide occurs within populations globally, certain sub-populations experience a higher burden of disease than others. Current known risk factors for suicide include family history of suicide, previous suicide attempt, local epidemics of suicide, isolation, loss, cultural and religious beliefs, feelings of hopelessness, and barriers to accessing mental health treatment.[1, 6] Previous studies of suicide decedents have shown that, among males and females, 18% reported an alcohol problem, 31.5% reported an intimate partner problem, 43.6% reported a current depressed mood, 19.5% had a history of suicidal attempt, and 29% disclosed intent to commit suicide to someone.[1]

Within the United States overall, suicide rates are above the annual average during the spring months, and below average during the winter months.[7] Seasonal variations have been observed in high latitude regions with extended sun duration during the summer, and little or no sunlight during winter months. One study conducted in Greenland found a significant peak in suicide behavior in June, and found that north of the Arctic Circle, 48% of suicides took place when there was constant light.[8] Also, when taking into consideration astronomical twilight, the period between dawn and sunrise, and sunset and dusk, it was found that 82% of suicides occurred during the constant light period experienced north of the Arctic Circle.[8]

Understanding the underlying biological mechanisms that may influence seasonal variation of suicide is essential for determining those factors that may put one population at an increased risk compared to another. Unfortunately, risk factors related to seasonal variation of suicide rates have not been well studied. Previous studies have found some factors that may influence seasonal variation at various levels. These factors include age, sex, urban versus rural living, and socioeconomic factors, as well as latitude. [9, 10, 11] Previous studies have also found females to exhibit a bimodal distribution of peak suicide rates, with peaks in the Spring and late Summer, while males have a unimodal distribution of suicide rates, with a peak often found in the spring. [12, 13, 14] Determining if a population exhibits seasonal variation of suicide, whether with a unimodal or bimodal distribution, is important not only for informing public health initiatives, but also for understanding what underlying biological mechanism might contribute to variation in suicide incidence. To date, no known epidemiologic studies have been conducted within the study region that have examined the association between age, sex and seasonal variation of suicide.

For this study, we analyzed the relationship between age and sex and seasonal variation of suicide using data gathered from Suicide Reporting Forms (SRFs) between 1990-2009 and maintained by the Tribal Health Organization, an organization that provides health and social services to the region.

Chapter II

BIOLOGICAL MECHANISM OF AGE, SEX, AND SEASONALITY OF SUICIDE

Current research suggests that there may be a relationship between seasonal variation in suicide and vitamin D. [15] Specifically, vitamin D deficiency, or hypovitaminosis D, may contribute to an increased risk of suicide during the spring months in Alaska when plasma concentrations of vitamin D are expected to be lowest. In order to understand the possible physiological relationship between seasonal variation of suicide and risk factors such as age and gender, it is important to understand factors contributing to vitamin D status, namely: body mass, dietary intake and food sources, race, latitude, time of year, age, and sex. [16]

Vitamin D may play a role in mood and mental health, as well as with physiologic health, and has been documented to reach its lowest levels during late winter/early spring within the Northern Hemisphere, but has been found to vary geographically due to the influence of latitude on the level of UVB radiation. [17, 18, 19, 20] Technically, Vitamin D is not a vitamin, but is a prohormone, which can be produced in the skin photochemically, or obtained through food sources. [19] Vitamin D occurs naturally in two forms: Vitamin D_3 and Vitamin D_2. Vitamin D_3 is produced endogenously in the skin from 7-dehydrocholesterol after exposure to ultraviolet B (UVB) radiation, and is transported to the liver via vitamin D binding proteins. From there is it converted by D-25-hydroxylase (25-OHase) to 25-hydroxyvitamin D [25(OH)D]. 25(OH)D is converted to the biologically active 1,25-dihydroxyvitamin D [1,25(OH)$_2$D] in the kidneys, as well as in other tissues throughout the body such as the brain, by 25-

hydroxyvitamin D-1-α-hydroxylase (1-OHase).[21, 22] 1,25$(OH)_2$D increases the expression of 25-hydroxyvitamin D-242-hydroxylase, which breaks down 1,25$(OH)_2$D and 25(OH)D into fat-soluble, biologically inactive calcitroic acid; this process is regulated in part by parathyroid hormone (PTH).[15, 17] Vitamin D_2 on the other hand, which also requires metabolism into 1,25$(OH)_2$D, is obtained through intake of irradiated plant materials, fortified foods, or pharmacologic doses; vitamin D_3 can also be obtained naturally from foods such as fatty fish, fish liver oil, or egg yolk.[15, 23]

It is currently agreed that vitamin D status is best measured by testing the concentration of serum 25(OH)D, or calcidiol, which is the principle circulating metabolite of Vitamin D.[24] This has been found to be sufficient in indicating the net contributions of both cutaneous synthesis along with food and supplemental intakes.[23] Three levels of vitamin D sufficiency/inadequacy are used to determine an individual's vitamin D status: sufficient (50-125 nmol/L), insufficient (21-29 nmol/L), and deficient (<20 nmol/L).[18]

As previously mentioned, environmental factors such as latitude, ozone, cloud cover, and solar zenith angle have an impact in the amount of vitamin D that can be photochemically produced through the skin, and therefore contribute to the seasonal variation in vitamin D status. Therefore, although vitamin D deficiency is common, the prevalence of vitamin D deficiency varies between populations. For example, one study conducted in Boston (42°N) found rates to be upwards of 24% among adolescents during winter months, while yet another study found more than

36% of young adults between 18-29 to be deficient at the end of winter. [25, 26] Another study conducted in Switzerland (46-47°N) found that 15% of boys, and 17% of girls had serum 25(OH)D levels less than 50 nmol/L during the winter months. [27] A study conducted in Spain (43°N) found an even higher prevalence of vitamin D deficiency/insufficiency, where 80% of the study population had vitamin D levels that were considered insufficient during the winter months, and 31% that were considered vitamin D deficient. [28] Together, these studies serve to demonstrate the point that latitude, time of exposure, and season all influence the amount of circulating serum 25(OH)D. [25, 26, 28] These and other studies will be reviewed in greater detail in Chapter 3.

Within the Arctic Circle, even when the sun is present, the angle of the earth is such that very little UVB radiation reaches the surface; because UVB radiation is the main source of vitamin D, this drastically limits the amount of vitamin D individuals can obtain photochemically. [29] The period of time during which an individual is unable to obtain adequate solar UVB required to synthesize vitamin D may be referred to as the "vitamin D winter", and the duration of this 'winter' is again influenced by latitude; in our population of study, which is above 50 degrees North, the "vitamin D winter" starts in October and lasts until early April. [30]

As previously mentioned, seasonality of suicide has been found to be influenced by latitude. Different latitudes exhibit variations in seasonal characteristics such as temperature, length of day, and duration of season. Our region of study resides above the Arctic Circle in Alaska, a latitude in which there is substantial difference between seasons, where one season is almost devoid of daylight, and the other almost devoid of darkness. [16] Although research has found the half-life of vitamin D to vary, it is generally agreed that vitamin D has a half-life between 1-2 months once it's produced/ingested. [31] Therefore, if the vitamin D winter started roughly in October, without any meritable sources of vitamin D (e.g., pharmacological supplementation), we would expect blood levels to decrease through the fall, reaching levels of deficiency as early as the beginning of December, or as late as mid-March depending on the half-life (i.e. 1 or 2 months) and the amount of circulating vitamin D previous to the vitamin D 'winter'. This means that at the population level, we would expect 25(OH)D levels to be lowest between December and May.

While the lack of an adequate UVB radiation during the winter months may help explain why we might find the lowest vitamin D levels during the spring, as suggested by research conducted by Lagunova *et al*., it does not help to explain the historical pattern of suicide within our population of study, or lack thereof. For example, pre-1960s suicide was not a recognized concern within our population of study. However, post-1960s suicide incidence increased dramatically and became an issue of increasing concern. The "vitamin D winter" contributes to the seasonality of vitamin D levels within the body, which in turn might contribute to the recognized seasonality of suicide among populations. However, the latitude of the Arctic Circle, within which our population of interest resides, has not changed. Therefore, we would not expect the "vitamin D winter" to have an influence on the sudden increase in incidence of suicide seen amongst our population of study.

However, this point of contention may be addressed when considering the second source of vitamin D, dietary intake.

Unfortunately, over the past 50 years or so, among many indigenous communities there has been a transition in diet and lifestyle that has led to a move away from traditional food sources. [29] Historically, aboriginal Arctic populations consumed a diet largely consisting of caribou, marine mammals, and fish, but have transitioned into one consisting largely of non-nutrient-dense, imported, foods. [29] This movement away from traditional food sources is important due to the higher content of vitamin D found in traditional food sources; fatty fish, marine animals, and their organs are rich in vitamin D. [29] One study conducted by Kuhnlein *et al.,* found traditional food sources to have significantly higher nutritional density, especially with respect to vitamin D, when compared to non-traditional food sources. When serum 25(OH)D levels were tested on days that an individual consumed traditional foods, vitamin D levels were found to be significantly higher compared to serum 25(OH)D levels measured on days during which no traditional food sources were consumed. [33] While lack of adequate vitamin D intake through traditional food consumption appears to be increasing in general, it appears that there is also a generational divide of frequency of traditional food consumption. For example, one study found that younger age groups consumed less traditional foods compared to older age groups. [34] Another study found similar results with older adults (>40 years) consuming significantly more than younger adults, and adults above the age of 60 consuming the most out of any age group. [33]From these results, we might expect to find younger age groups to be at a higher risk for seasonal suicide during the spring months when vitamin D levels are at their lowest (March-May), compared to older age groups. Specifically, current literature suggests that older individuals have a higher intake of nutritionally dense (i.e. vitamin D) traditional foods, therefore lending to the conclusion that the higher traditional food intake among older individuals may help them to maintain consistent vitamin D levels throughout the year, while younger individuals may be more susceptible due to less traditional food consumption.

Another potential contributing factor to the seasonality of suicide via the proposed vitamin D deficiency mechanism could be obesity. Prevalence of obesity has steadily increased over the past decades throughout the entire United States, however, there has been a even more marked change among Alaskan Natives. Although the ability of the skin to produce vitamin D via sunlight exposure is not affected by body mass, it has been found that the increase in serum 25(OH)D levels after exposure to UVB are reduced by 52% in obese individuals when compared to those of normal weight. [20] Due to the fat-soluble nature of vitamin D, it is presumed that reduction of serum vitamin D occurs because it is stored in fat, inducing hyperparathyroidism, which in turn affects vitamin D metabolism. [19] One study conducted by Ernst *et al.* found that serum 25-OH(D)$_3$ levels were inversely associated with body mass index, suggesting that obese individuals are at a higher risk for vitamin D deficiency during the months when vitamin D can not be adequately synthesized by UVB exposure. Unfortunately, clinical measures, such as weight, were not collected in our study, and so we therefore cannot assess the association weight has on seasonality of suicide with respect to vitamin D deficiency.

However, because research suggests that it may play a role in seasonality of vitamin D deficiency, it is important to note the potential role weight could play in predicting those at greater risk of suicide based on our proposed biological mechanism.

While seasonal variation of suicide has been found among populations throughout the world, there has also been some research suggesting that seasonal patterns of suicide vary with respect to age and sex; therefore, it is important to consider seasonal variation of vitamin D deficiency within age and sex to determine seasonal patters of suicide within sub-groups. For example, one study looking at the influence of age on vitamin D status found adolescents to have a lower serum 1,25(OH)$_2$D level compared to adults, while another study suggested that adolescents (13-19 years old) had a greater prevalence of vitamin D deficiency compared to pre-teens (8-12 years old). [35, 32] If vitamin D deficiency does indeed play a role in seasonal variation of suicide, this research suggests that we may see more seasonal variation of suicide among adolescents. Some research also suggests that sex may influence vitamin D status; one study found higher serum vitamin D levels in females compared to men, which might suggests that females may be less likely to be vitamin D deficient. [35] However, contrary to research finding higher levels of vitamin D among females, in arctic populations that may be similar to our own, rates of obesity have been found to be higher among Native Alaskan women compared to men. One study conducted by *Hopping et al.* found that indigenous females in the Northwest territory, which may be similar to our study population, had a higher prevalence of obesity. This might therefore suggest that higher rates of suicide might be expected among obese females due to their decreased vitamin D levels resulting from a decrease in ability to fully benefit from UVB exposure during the summer months, as previously mentioned with respects to the impact obesity has on vitamin D metabolism.[33, 35, 19] Another potential influence on vitamin D levels between sex is physical activity; increased physical activity may correspond to higher vitamin D levels due to sun exposure . One study conducted among Alaskan natives compared physical activity to sex, and found that a higher percent of men partook in both low and high physical activity levels.[36] Sedentary lifestyle may also be a potential indicator for the amount of physical activity one engages in, and therefore the amount of sun exposure.

When taking into account the lack of sufficient UVB radiation throughout the year, especially during the winter months, along with the transition away from the nutritionally dense food sources of years past, some of the increase in suicide rates that have been seen among the Alaskan Natives over the past five decades might be explained by vitamin D deficiency, especially with respect to seasonal variation of suicide rates. However, seasonal variation of suicide, even suicide in general, is a little understood, complex human condition that is multi-faceted, and unlikely to be explained by one physiological mechanism. However, the hypothesis that vitamin D deficiency may contribute to seasonal variation in suicide provides a framework for our analysis.

In summation, seasonal variation of suicide has been observed among many populations throughout history, and we believe that vitamin D deficiency may contribute to the seasonality observed within the study population. Specifically, if vitamin D deficiency were indeed a driving factor behind seasonality, we would expect to see certain sub-populations (e.g. adolescents and females) within our population of interest to have a higher incidence of suicidal acts beginning in the winter into the spring months compared to the summer and fall months. Peak suicide incidence is expected during the spring months due to the half-life of vitamin D in the body and the resulting lag between inadequate sun exposure (starting in October) and vitamin D deficiency, and also because previous research has found serum 25(OH)D concentration to be at the lowest levels during the Spring.[32] We also expect women to be at a higher risk than men due to the increased prevalence of obesity found among arctic women compared to men in populations that may be similar to our own, along with their likely lower levels of outdoor physical activity and resulting lower levels of sun exposure.[19] Potential influencing factors that may contribute to seasonal variation of suicide include the amount of traditional food consumption, and obesity. Therefore, we expect there to be more evidence of seasonal variation in suicidal events among adolescents due to their decreased levels of traditional food consumption compared to adults, and among females who were found to have higher prevalence of obesity and lower physical activity levels, suggesting in turn lower levels of serum 25(OH)D when compared to men.[32]

CHAPTER III

EPIDEMIOLOGY OF AGE, SEX AND SEASONAL VARIATION OF SUICIDE

Although studies have been conducted that assess the influence of season on suicide with relation to age and sex as potential predictors of seasonal variation, to our knowledge, there have been no studies that have looked at age and sex with relation to seasonal variation of suicide within the rural Alaskan study region. Previous research has found seasonality to be influenced latitude, and socio-political turmoil, factors which have also been linked to variation in vitamin D, both through consumption (i.e., transitions from traditional, nutritionally dense food sources to non-traditional, commercial food with less nutritional value) and exposure to sunlight.[9, 29] It is therefore important to review epidemiological studies with similar geographical features, and social history. Our region may be especially influenced by seasonal variation of suicide not only due to its extreme latitude (67°N), but also to its recent history of colonization, which effected access to nutritionally dense foods, and the traditional nomadic lifestyle – all of which could play a key role in vitamin D deficiency.

On a whole, previous research on seasonal variation of suicide has found peak months of incidence in the Northern Hemisphere to be during the warmer spring/summer months, while lows have historically been seen during the fall/winter; the reciprocal of this phenomena is found in the Southern Hemisphere. There has also been evidence for a more obvious seasonal pattern to be found in more extreme latitudes, while those populations around the equator tend not to exhibit an obvious seasonal pattern. One cross-national study analyzed the seasonal variation of suicide among various countries globally using mortality data collected for around 10 or more years, reporting ratios of the spring peak to winter trough to determine if there was indeed a difference. Those countries that had some of the highest ratios of spring/summer to fall/winter months were Finland (latitude=62.4°N; R_{males}=1.32, $R_{females}$=1.33), Greece (latitude=38.3°N; R=1.68), Hungary (latitude=47.3°N; R=1.41), Yugoslavia (latitude=44.0°N; R_{males}=1.36, $R_{females}$=1.42), Iceland (latitude=64.8°N; R=1.71), Portugal (latitude=38.7°N; R_{males}=1.70, $R_{females}$=1.57), and Spain (latitude=40.7°N, R_{males}=1.38, $R_{females}$=1.46. [37] Another study conducted in Slovenia (latitude=45.8°N) over using data collected over an 8-year period found seasonal peaks in May and June (Oravecz). [38] Supporting a June peak was another study conducted by Bjorksten *et al.* in Greenland (latitude=67.1°N). A final example of seasonal variation in suicide is of a study conducted in Brazil (latitude=23-34°S), which found seasonal peaks during November, corresponding to springtime for the Southern hemisphere. [39] Together, these studies serve not only to demonstrate consistent findings of seasonal variation of suicide across latitudes, but to also depict the variation in seasonal suicide patterns across latitudes, and demonstrate the importance of regional data collection for informed interventions.

Many studies have considered seasonal variation of suicide and have looked specifically at the influence of age and sex on suicide distribution. [8,12, 14] Unfortunately, studies that were conducted in extreme latitudes, or after social upheaval caused by colonization, and that also examined the relationship between age, sex and seasonal variation of suicide are limited. We will examine, in detail, two studies that share similar characteristics with our study population: one conducted by *Kalendiene* et al., another by *Hakko* et al. Although seasonal distribution of suicide rates may vary due to the difference in geographic location and social influences, it is important to consider additional studies that examine our exposures and outcome of interest, even if they are not conducted on a population of extreme latitude because, although populations closer to the equator may be more likely to have attenuated incidence curves if seasonality of suicide is indeed influenced by vitamin D deficiency, they are still helpful in establishing a better understanding of the expected seasonal pattern as it relates to vitamin D deficiency.

Kalediene et al. conducted a cross-sectional study to evaluate the seasonal variation of suicides in Lithuania (latitude=55°N) between the years of 1993-2002, a period of time during which there was political and social upheaval. The authors used archived data abstracted from death certificates from the computerized database of the Lithuanian Department of Statistics.[40] Data was collected on 8,324 persons between 1993-1997, and 7,823 persons between 1998-2002; suicides were recorded for two separate time periods in order to determine if there was a change in frequency over time. Three-month moving averages were used to determine rates of suicide per month, and ratio statistics determined the monthly effect. Chi-square tests were used to assess differences in pattern by sex. The authors found that there was an obvious seasonal pattern for both men and women during both periods of investigation, with an increase during the summer months, especially for those violent methods of suicide ($P=0.165$). A statistically significant association ($p<0.05$) was found among men between the ages of 20-64, with a peak between April-August. Although this study had a relatively large sample size, there is the potential for bias due to the fact that some suicides may have been missed due to ambiguous causes that were ruled as an accident. During the month of April, Lithuania has a solar zenith angle (used to calculate incoming solar UV radiation) of roughly 46°, suggesting that vitamin D should be easily obtained. However, based on previous research findings that serum 25(OH)D concentration is at its lowest in April, this peak in suicide coincides with our proposed physiological mechanism for the one month of the observed seasonal peak, but is unable to explain the continued high incidence of suicide during the summer months when vitamin D status can be easily obtained through UVB exposure.

A second cross-sectional analysis of a population-based cohort study was conducted by *Hakko*, et al. and examined the association between age, sex, suicide method, and seasonal variation in suicide occurrence. This study used information on 21,279 persons residing in Finland (latitude=62°N) who committed suicide between 1980 and 1995, obtained through the Official Statistics of Finland, Statistics Centre. Researchers found that men were significantly younger than women at age of suicide ($P<0.001$), a greater proportion of men were under 40, and that there was a significant seasonal variation within suicides ($P<0.001$). Analysis of seasonal peaks between men and women, revealed a significant peak in suicide from April to July for men, and a bimodal distribution for women with peaks in both May and October. When comparing age groups, significant excess in suicide incidence was found in persons over 65 years old compared to those between 40-64 (difference=1.2%, 95% CI=0.02-2.35%), as well as compared to those under 40 (difference=1.8%, 95% CI=0.81-2.76%). Again, with respects to vitamin D and the seasonal variation found in vitamin D deficiency, the seasonal peaks found by *Hakko et al.* in suicide initially correspond for both men and women. However, the peak in October for women is not explained by our proposed mechanism since theoretically, at that point in time, there should be enough UVB exposure that vitamin D concentrations would not be at their lowest (summer commences in Finland around late-May, which marks increased sun exposure due to periods of 24 hours of light), therefore, the pattern seen by *Hakko* et al., is not consistent with vitamin D deficiency as an underlying cause.

The results of the study conducted by *Hakko*, et al. are consistent with previous literature, in that some evidence was found for seasonal variation of suicide with respects to age, however, it did not support our hypothesis with respects to timing of increased suicide incidence and our proposed underlying biological mechanism. The lack of a significant finding for seasonality of suicide by age, among those younger than 40, could be due to the lack of a more refined analysis that examines the association among smaller age groups, such as pre-teens, adolescents, adults, and seniors. Again, taken together, individuals younger than 40 may not have a significant association with seasonal variation of suicide, but analysis of smaller age groups might reveal that school-age individuals are more likely to have a spring peak in suicide rates compared to older individuals younger than 40.

Another study that considered seasonal variation in suicide with respects to age and sex, but is slightly dissimilar to our study in terms of extreme latitude, socio-demographic and political characteristics, was conducted by Preti *et al.* This was a cross-sectional study that evaluated if age and sex influenced the seasonal distribution of suicide in Italy among male and female suicide victims between 1984-1995.[12] The authors used archived data on suicide collected by the police and military police through death certificates and questioning of 'key informants and relevant witnesses'.[12] Data was collected on 31,771 male suicide victims and 11,984 female suicide victims between the ages of 14-65. Seasonal variation was measured using monthly mean values of climate (mean maximum/minimum temperature, mean degree of humidity, rainfall, daylight) using data collected from the Meteorological Department of the Italian Air Force using a mean average for the entire country (17 meteorological stations). The authors found that men between the ages of 25-64 were more likely to commit suicide in spring than women (Mean=135, SD=20 vs. Mean=52, SD=13). Using ANOVA, researchers found that individuals 65 years and older exhibited a more marked seasonal variability than youths aged 14-24 (P= 0.0001; P=0.97). Study results reported a clear seasonal distribution of suicide for both male and female only amongst the individuals 65 years or older with a peak in the summer month of July (mean number of suicides: male: 88; Female: 37), and reported a seasonal trend with recurrent circannual rhythm for violent suicide method among men and women, but not non-violent methods.[19] These results provide evidence for, and support our hypothesis that we expect to see a variation of seasonal suicide distribution with relation to both age and sex. Due to the similar latitude of the contiguous U.S., summer starts in June until late-August; we would therefore expect to see seasonal peaks in suicide based on vitamin D status during the late months of spring, which is supported among adult men although not within the elderly. Due to the large sample size of this study, researchers had strong power to detect differences between age, sex and seasonal variation in suicide.

Additional studies that have looked at seasonal variation in suicide with respects to age and sex have often found evidence of seasonal variation by age and sex, but have not always found the same distribution, especially with respects to peaks and troughs. One study conducted among rural Chinese youth, found that males were more likely to commit suicide in the spring compared to females (OR=1.6, p=0.04). [14]

Another study looking at seasonal variation of suicide among individuals with depressive disorders found a bimodal distribution for females, with two significant peaks in May and November (p<0.001), while males were found to have a nonsignificant peak in December. [41] Although the study conducted by Bjorksten *et al.* did not consider age and sex as risk factors for seasonal variation in suicide it was conducted in Greenland (67°N), which is of similar extreme latitude to our population, and found a significant peak suicide in June, and found that north of the Arctic Circle, 48% of suicides took place when there was constant light.[8] When taking into consideration astronomical twilight, the period between dawn and sunrise, and sunset and dusk, it was found that 82% of suicides occurred during the constant light period experienced north of the Arctic Circle.[8] An ecological study conducted in Japan (36°N), found there to be a seasonal peak in suicide rates during the month of April, with a trough in December. [42]

To our knowledge, no epidemiological studies to date have examined seasonal variation of suicide, with relation to age and sex, within a remote Alaskan population. Research has been relatively consistent in finding seasonality of suicide with respect to age and sex. [12, 13, 40] The diverse results regarding the zeniths and nadirs of suicide rates throughout the year among different populations supports the idea that latitude plays an important role in determining seasonal suicidal patterns due to the varying lengths and characteristics of seasons (i.e. spring, summer, fall, and winter). [12, 14, 42] Therefore, it appears that culture and geographical location may indeed play a role in seasonality of suicide, which is why regional data needs to be gathered and risk factors examined for our population within rural Alaska, in order to determine the most influential risk factors on seasonal variation of suicide and if our proposed biological mechanism supports and explains some of the observed seasonal variation.

CHAPTER IV

METHODS

Hypothesis and Specific Aims

Using surveillance data, we evaluated the relationship between age, sex and seasonal variation of suicide. The following aims were addressed:

Study Aim 1:

A. To determine if there is an association between age and seasonal variation in suicide using data gathered from suicide reporting forms from 1990 to 2009 within a rural region of Alaska.

B. To determine if there is an association between sex and seasonal variation of suicide using data gathered from suicide reporting forms from 1990-2009 within a rural region of Alaska.

Hypothesis 1a: There will be a seasonal difference in suicidal behavior between males and females; females will be more likely to have suicidal behavior in the months between April-September (Spring/Summer) as compared to those months from October-March (Fall/Winter).

Hypothesis 1b: Age exhibits seasonality of suicide; younger individuals will be more likely to commit suicidal behavior in season two, compared to those older individuals within our population of study.

Study Aim 2:

A. To perform a stratified analysis by time period, 2002-2009 versus 1990-2009, in order to determine if there is an association between age and seasonal variation in suicide.

B. To perform a stratified analysis by time period, 2002-2009 versus 1990-2009, in order to determine if there is an association between sex and seasonal variation in suicide.

Hypothesis 2a: There will be a more prominent seasonal difference in suicidal behavior between males and females using SRFs collected between 2002-2009; females will be more likely to have suicidal behavior in the months between April-September (Spring/Summer) as compared to those months from October-March (Fall/Winter).

Hypothesis 2b: Age will exhibit a greater seasonality of suicide among those SRFs collected between 2002-2009; younger individuals will be more likely to commit suicidal behavior in season two, compared to those older individuals within our population of study.

Study Design and Population

Using surveillance data, we studied the association between age, sex, and seasonal variation of suicide, in a rural region of Alaska. This region has a population of about 9,000, of which about 81% are Alaskan Natives. [44] A Suicide Reporting Form (SRF) was used to record the age and sex of individuals engaging in suicidal behavior. The SRF is a clinician-administered 19-question form, which is maintained by the Tribal Health Organization (THO), an organization that provides health and social services to the Northwest region. Every form was completed by a mental health clinician employed by the THO. The SRF was administered in-person or with a phone interview by the clinician within a week of the event, depending on the availability of the suicide attempter or proxy. In the case of a fatal suicide event, data were collected from the decedent's family, friends, or involved professionals (such as a teacher, or co-worker). For those who attempted suicide, the SRF was administered to the suicidal individual if possible, if not, a proxy was used.

If a suicide death occurred, clinicians were notified as per hospital protocol within 24 hours, and would administer the SRF within a week of notification. In the event of a nonfatal suicidal attempt, clinicians were notified through both formal and informal channels. For example, if a suicidal attempt required medical attention, the attending staff would notify THO's Counseling Services, which would notify the clinicians who administer the SRF. Clinicians would be informally notified if the individual was suicidal at school, which would result in the principle or school counselor notifying Counseling Services.

This study used data collected by SRFs between 1990-2009. All individuals living in the Northwest region of Alaska who committed or attempted suicide that was reported to authorities were eligible to be included in this analysis. The only exclusion for this study was incomplete SRFs, where the age, sex, and date of attempted or completed suicide were not filled out. Fatal events that were considered by the clinician to be ambiguous, and therefore had the potential to not be a suicidal act were also excluded from our study. Lack of information on age/sex would result in the inability to determine exposure status, while lack of date of attempted/completed suicide would result in the inability to determine outcome status.

Exposure Assessment

The exposures of interest are age and sex, which were reported in the SRF; the exposure of sex was dichotomized, female or male, while age was categorized into groups ≤ 29 or >29 (Table 1).

Validity of Exposure Assessment

We believe the proxy reporting method used for many of our cases to have adequate validity. Previous research has examined the validity of proxy-based data for reporting demographic, medical and lifestyle factors. [43] Researchers reported a Kappa of 1.00 for between subject- and proxy-based reports for age. Although no studies were found that reported Kappa statistics for the reliability of proxy-based reports on sex, it can be assumed to be as good as proxy-based reports on age.

Outcome Assessment

Information on suicidal behavior and timing was also assessed using the SRF. On the SRF, along with sex and age, date of suicide or suicidal attempt was also recorded. Using the date of suicide/suicidal attempt, we dichotomized the variable into season one (1) and season two (2). Season 1 includes the months October, November, December, January, February, and March; season 2 includes April, May, June, July, August, and September. Season of suicide was dichotomized after looking at the overall distribution of frequency per month. We dichotomized season in order to facilitate multivariable analysis that would allow us to assess whether the likelihood of seasonal differences in frequency of suicide events varied by age, sex, or other measured covariates.

In 2000, a concerted, directed, suicide prevention program was initiated, during which there was a push to capture data more comprehensively about suicide attempts. Due to this modification in recording procedures, we evaluated seasonal trends by time period, 1990-2001 and 2002-2009.

Validity of Outcome Assessment

We used trained masters-level clinicians in order to obtain the date of the suicidal event and date of suicidal event was recorded on SRF within one week of event. Therefore, there is little likelihood of error.

Covariate Assessment

Along with collecting exposure and outcome information, the SRF also included questions on factors potentially involved in suicidal behavior and factors that could vary by season. [17] These factors included: family history of suicide, previous suicide attempts, method, substance abuse history, fatal vs. nonfatal suicide behavior, substance abuse type, possible warning signs, such as increased substance abuse and psychological symptoms of depression, contributing factors that may have helped to cause the suicide (romantic/relationship conflicts, bullying etc.), and history of mental illness/contact with mental health service provider.

<u>Data Analysis:</u>

Specific Aims

Specific Aim 1a: To evaluate the association between age and seasonal variation of suicide in a population of predominantly Alaskan Natives living within a rural region of Alaska.

Specific Aim 1b: To evaluate the association between sex and seasonal variation of suicide in a population of predominantly Alaskan Natives living within a rural region of Alaska

Univariate Analysis

The number of subjects, along with the characteristics of the study population prior to exclusion is presented in Table 1. The frequency of suicides per month for the entire population is presented in Table 3. The percent distribution of age (Table 2), and seasonality of suicidal behavior are also presented (Table 5)

The percent distribution of sex (Table 1), and seasonality of suicidal behavior will also be presented (Table 4).

For those variables lacking comprehensive data collection, excluding age, sex, and date of suicidal event, assumptions were made in order to deal with missing data so as to have a more complete dataset for statistical analysis and model building. Since our population is predominantly Alaskan Native, for SRFs missing data on race, we assumed the individual to be Alaskan Native (n=30). Since there was likely variability in collection techniques between clinicians in how they recorded information, we made the assumption that employment status, if not recorded as "Not in the Labor Force" was left intentionally blank for those individuals under 25 years of age, and assumed that they should be recorded within this category (n=27); all other SRFs in which this field was left blank, and where the individual was 25 or more years of age, employment status was re-coded as "Unknown" (n=29). Missing values for marital status were also reassigned to a new "Unknown" category (n=29). Among SRFs for which the education field was left blank, and the age was recorded as less than or equal to 19, the individual was considered to have an education status of "Less than High School" (n=15), while those older than 19 and who were missing an education history were re-coded into a new "Unknown" category (n=89). Missing values regarding previous history of a suicide attempt were also assigned to a new "Unknown" category (n=100).

For questions regarding family history (e.g., of suicide, substance abuse, "other" abuse, and "other"), missing values were assumed to be left blank due no family history, or because they were unknown, and so were re-coded as "None/Not Specified" (n=138); for this variable, an individual could be recorded within more than one category of family history. This same approach was taken for potential warning signs (i.e., planned suicide, increased substance abuse, told someone beforehand, depression, or having no warning sign; not mutually exclusive; n=385), substance abuse history (n=8), and substance abuse type (n=36) where all missing values were assigned to a "None/Not Specified" category.

Bivariate Analysis

The distribution of frequency of suicide/suicidal ideation per month by sex between 1990 and 2009 was graphed using frequency counts; chi-square tests were used to determine whether the incidence of events varied significantly by month (Figure 4).

Covariates were cross-tabulated with the exposures of interest, age (Table 5), along with the outcome of interest (Table 6); this was done in order to determine if likelihood of potential confounding. Using a chi-square test and corresponding p-values, we determined whether the observed distribution fits the expected distribution. When cell counts were small (<5), a Fisher's exact test was used.

Again, covariates were cross-tabulated with the exposure of interest, sex (Table 4), along with the outcome of interest (Table 6); this was done in order to determine the likelihood of potential confounding. We used a chi-square test and corresponding p-values to determine whether the observed distribution of suicide per month fits the expected distribution. In some comparisons, when cell counts were small, Fisher's Exact Test was used.

Unadjusted relative risks and 95% confidence intervals were calculated in order to measure the crude association between age (≤29 vs. >29) and risk of suicidal behavior in season 1 vs. season 2 (Table 7), along with a multivariable association between age and risk of suicide in season 2 (Table 8).

Unadjusted relative risks and 95% confidence intervals were also calculated to measure the crude association between sex and risk of suicidal behavior in season 1 vs. season 2 (Table 7), along with a multivariable association between sex and risk of suicide in season 2 (Table 8).

Multivariable Analysis

We modeled the relationship between age and risk of suicide in season two using multivariable logistic regression models using data reported between 1990-2009 (Table 8).

The relationship between sex and risk of suicide in season two was also modeled using multivariable logistic regression models (Table 8).

Confounders were evaluated by running all models with and without the suspected confounder. Covariates were considered a confounder if there was a 10% or greater change in the estimate for age or sex when the covariate was included in the model. Odds ratios were reported with 95% confidence intervals.

Power Analysis

There are 802 available SRFs that have been completed by suicide attempters and proxies. The approximate ratio between males and females is about 0.98:1. The estimated disease prevalence (suicidal behavior in season one) in unexposed (males) was calculated at 40%. With 802 subjects, we have 80% power to detect an odds ratio of at least 1.48. Power is greater to detect higher odds ratios.

Specific Aims: Sub-Analysis

Specific Aim 2a: To conduct a sub-analysis by year of event (1990-2009 vs. 2002-2009) to evaluate the association of age and seasonal variation of suicide in a population of predominantly Alaskan Natives within a rural region of Alaska.

Specific Aim 2b: To conduct a sub-analysis by year (1990-2009 vs. 2002-2009) to evaluate the association of sex and seasonal variation of suicide in a population of predominantly Alaskan Natives within a rural region of Alaska.

Multivariable Analysis

Among data collected between 2002 through 2009, we modeled the relationship between age and risk of suicide in season two using multivariable logistic regression models (Table 9). The relationship between sex and risk of suicide in season two was also modeled using multivariable logistic regression models (Table 9).

Confounders were evaluated by running all models with and without the suspected confounder. Covariates were considered a confounder if there was a 10% or greater change in the estimate for age or sex when included in the model. Odds ratios were reported with 95% confidence intervals.

CHAPTER V

RESULTS

The study population consists of 804 primarily Alaskan Native individuals. Within this population, 48.9% (n=393) are females, and 51.1% (n=411) are males (Table 1). Within our study population, of recorded events among women, 2.6% were fatal, while 97.3% were not. Among men, 19% of events were fatal compared to 81% that were not. The average age of the study population was 24.9 years (SD=10.2); 75.2% (n=595) of the population was less than or equal to 29 years of age (Table 2).

Chi-square tests were performed on the time specific data of the years 1990-2001 and 2002-2009, which revealed a statistically significant difference in the distribution of suicide frequencies per month ($p=0.05$) (Figure 1).

We first graphed the frequency of suicide per month and stratified by our main covariate in order to determine how to group the months into a dichotomous variable (season one versus season two). We also wanted to assess whether the observed suicide distribution per month was actually different than the expected, expected being all suicides divided by the total number of months, ensuring an even distribution for each month representing what one would expected if there was no seasonal variation in suicide frequency. Chi-square tests indicated a statistically significant difference in expected versus observed suicide frequency ($p<0.001$) (Table 3, Figure 2). Figure 3 shows the number of suicide events increased in March, and were even higher in May, after which there is a general trend downwards until

September, which marks the beginning of sharper downward trend. From this information we decided to categorize outcomes into two six-month periods; season one includes those winter months from October-February, and season two includes those months at which the general trend upward begins, March, through to September, which is the point at which the accelerated downwards trend begins (Figure 3).

Characteristics of the study population by sex and age are described in Table 4 and Table 5 respectively. Chi-square tests suggested marital status to be significantly different between men compared to women, as well as employment status, method of suicide, location of act, psychological symptoms as a possible warning sign, romantic conflicts as well as mental health issues ($P<0.05$)(Table 4).

When looking at the distribution of covariates by age category (≤29 or >29) results suggest that several factors varied by age group. Race, marital status, employment status, education level, location of act, substance abuse history, and substance abuse type were significantly different between age groups. Other factors did not vary by age, including sex, method of suicide, previous suicide attempts, and psychological symptoms of depression (Table5).

Season of suicidal act are described in Table 6. Analysis comparing the distribution of factors between season one and season two suggested that having a family history of suicide ($P=0.05$), family history of substance abuse ($p<0.01$), and location of act ($P=0.02$), vary significantly between events occurring in season 1 (fall/winter) and season 2 (spring/summer) (Table 6).

We observed marked seasonal variation of suicide frequency from 2002-2009, with a marked peak in May. In contrast, between 1990-2001 there was no true discernible peak with little variation (Figure 1). When the data were graphed and chi-square tests were performed to look at distribution of events by month in women compared with men for all events occurring between 1990-2009, visual inspection suggested a non-significant, slightly bimodal distribution for women, and a more unimodal distribution for men (p=0.69)(Figure 4).

Chi-square tests were also used to determine if the timing of suicide events varied differently by age, grouped as less than or equal to 29 and greater than 29 years. We did not find the seasonal distribution to vary by dichotomized age groups when using all data from 1990-2009 (p=0.69) (Figure 6).

A univariate analysis using logistic regression was used to determine the association between season of suicidal act with age and sex (Table 7). In the univariate analysis, no statistically significant associations were found, however, there it did suggest that females had a 31% increase of risk compared to males (OR=1.31, 95% CI=0.99, 1.74, p=0.06). In unadjusted analysis, older age (>29) or younger age (≤29) did not vary in risk of suicide in season two.

An adjusted, multivariate analysis, including age, family history of ‘other’ abuse, and location of suicidal act, results suggested an association between sex and season of suicide, where females were 41% more likely to commit suicide in season two compared to males (OR=1.41, 95% CI=1.06, 1.90) (Table 8).

In the unadjusted analysis, timing of suicide did not appear to vary significantly for the dichotomous age variable. Results from multivariable analysis were similar (Table 8). In unadjusted analysis, those younger than 15 had a statistically significant 130% increase in risk of committing a suicidal act during spring/summer months versus fall/winter months compared to those between the ages of 15-19 (OR=2.30, 95% CI=1.08, 4.90, p=0.03). After adjusting for sex, there remained a statistically significant 122% increase in risk during spring/summer months compared to fall/winter months among those younger than 15 compared to those between the ages of 15-19 (OR=2.22, 95% CI=1.04, 4.75, p<0.05). After adjusting for sex as well as having family history of 'other' abuse, family history of substance abuse, and location of act, the risk for those less than 15 was slightly attenuated (OR=2.00, 95% CI=0.92, 4.36, p=0.08)(Table 8).

Limiting our analysis to events occurring between 2002 and 2009 resulted in a graph that had a curve with a more obvious peak in May, that declined steadily thereafter into November (Figure 1). Among sex, we again found less variability, with a roughly unimodal distribution for women with a zenith in July, while the peak month for men was April (Figure 6) (P=0.12). In our analyses limited to events occurring between 2002-2009, we again found that suicide distribution per month varied by age, with a slightly more distinguished peak in July for those older than 29 (Figure 7) (p=0.82).

Unadjusted and adjusted analyses were performed using data collected between the years 2002-2009 to determine the association of sex and seasonal variation in suicide. Fully adjusted analysis revealed a statistically significant increase in risk among females. Unadjusted analysis suggested a 51% increase in risk among females for events in season two compared to season one (OR=1.51, 95% CI=1.07, 2.13, p=0.02) (Table 9). Multivariate analysis (adjusting for age, and having a family history of substance abuse) found that the likelihood of females to commit a suicidal act during the spring/summer months decreased slightly from 51% to 48% (OR=1.48, 95% CI=1.04, 2.11, p=0.03).

Again, unadjusted and adjusted logistic regressions were performed using data collected between 2002-2009 for both the categorical and dichotomized variables of age. The unadjusted logistic regressions of the dichotomized age variable found no significant findings, with odds ratios close to 1.0; this was the case for age-adjusted, and fully adjusted analysis as well (Table 9). For the age variable, separated into six categories, the unadjusted analysis of association among data collected between 2002 through 2009 found no statistically significant finding (Table 9). The multivariate adjusted sub-analysis also resulted in no statistically significant associations (Table 9).

CHAPTER VI

DISCUSSION

In this study on seasonal variation in suicide, which considers a predominantly Alaskan Native population from a region above the Arctic Circle within Alaska, we found that this population exhibited seasonal variation of suicide, and that sex was a predictor for those individuals at highest risk during the spring-summer months, compared to fall-winter months. The analysis on age, which was performed using only data collected between 2002 through 2009, only suggested associations, as all findings were non-significant. Results from the sub-analysis of the association between sex and seasonal variation in suicide suggest that women exhibit a 48% increase in risk for suicide compared to men in season two ($p<0.05$).

Some limitations within our study could be non-differential misclassification of the outcome, confounding, and residual confounding. Since our study design is akin to a cross-sectional study, outcome and exposure were measured at the same point in time. In 2000, an effort was made to collect data on suicidal ideations more comprehensively, because before this date, comprehensive collection efforts were mainly focused on those individuals who committed suicide. This is most like non-differential misclassification of our outcome since, although we're not classifying events and non-events, there is an underassessment of the numbers of outcomes; although this could affect the study power, it wouldn't introduce a systematic bias. This might have contributed to the lack of seasonality in stratified data looking at data reported between 1990-2001. In order to determine the influence of this on our study, we performed a sensitivity analysis, where we conducted both a full analysis on all collected data, as well as an analysis limited to events occurring between 2002 and 2009. The variations in significance of associations especially with respect to age, suggest that there may be misclassification within the data collected pre-2000, which would attenuate the effects.

After evaluating all exposure measures using only that data which was collected between 2002 through 2009, we considered age/sex, and having family history of substance abuse to be associated with our outcome, and should therefore be treated as potential confounders. We controlled for these confounding factors within the analysis using a multivariable logistic regression. Other factors that we didn't consider because they were not measured, but which could be associated with both age and season of suicide, might be school attendance. School age individuals who attend school, and are forced to attend remedial school during the summer months (season 2) due to poor academic performance, could cause an overestimation of the association between age and season if 'summer school' attendance is associated with increased suicide risk. Since we only collected information on education level, and not current attendance, this was unmeasured. If truly a confounder, this would explain the fact that we saw high odds among school age children for season 2, compared to the referent group; our non-significant p-values are likely due to small numbers within this age category. Despite our best efforts to effectively categorize and capture all potential confounders and important covariates, there is the potential for residual confounding due to poor measurement of covariates. Residual confounding could explain the lack of seasonality with association to age, and would therefore result in an underestimate of effect.

There could also be bias within our study related to the method we used to deal with missing data. When dealing with our missing data, we often made assumptions that a lack of information for a question meant that the clinician did not fill in the question because the response was 'none' for the individual for whom the SRF was being filled out. This introduces bias, through non-differential misclassification with respect to season, since we do not know for sure what the true intentions of the clinician were, and therefore do not know for sure if our assumptions were correct. Therefore, we could have potentially underestimated the effect of many of the variables. What could also be potentially problematic is that for some variables, there were patterns of missingness that appeared to be not missing at random, and were in fact related to the more comprehensive data collection post-2000. This would have had an effect on our analysis using all data (1990-2009), and could have potentially underestimated our results due to incomplete data collection, which would increase the potential for confounding. For those variables that we chose to create a new "unknown" category for missing data, and which appeared to be missing at random, our results would be attenuated towards the null, which might help explain the lack of association due to inadequate data collection and the lack of adequate control of potential confounders. However, we found little evidence of confounding within our analysis using data collected from 2002 through 2009; it is therefore unlikely that residual confounding is having a strong effect on the data collected between 1990 through 2001.

This study focuses on a very specific population that is a culture vastly different from most of the rest of the United States. Not only is this population predominantly Alaskan Natives, but lives at a higher latitude than the rest of the contiguous United States, and because it lies above the arctic circle, experiences periods of constant daylight (Polar Day), as well as almost constant darkness (Polar Night). We would expect that Native Alaskans risk for suicide would vary differentially when compared to non-Natives due to socioeconomic and cultural influences.[1, 5] If there was another population at similar extreme latitudes, and that also had a large indigenous population, also experiencing a period of acculturation, then the study might be able to be generalized to this population.

In our analysis, we found that women exhibited a statistically significant 48% increase in risk of suicide compared to men during spring/summer months, after adjustment, with a roughly bimodal distribution with peaks in July and September. The bimodal distribution found among women is consistent with prior literature; however, the peak months within our bimodal distribution is not as consistent with prior literature. [8, 13, 14] The inconsistency in peak months is likely due to the difference in previous studies with regards to latitude and seasonal variation of factors such as temperature, and daylight hours. Higher latitudes such as that seen above the Arctic Circle experience periods of time when there is constant sunlight during the summer months, or constant darkness during the winter months (Polar Night). On the other hand, the equator always experiences 12 hours of sunlight no matter what season of the year. If vitamin D deficiency indeed plays a role in the seasonal variation of incidence in suicide, then this variation of sufficient UVB radiation, which is needed to produce vitamin D, would impact what months would experience peaks in suicide incidence. For example, at the equator, very little seasonal variation of suicide is seen, if any at all, which again corresponds to the lack of seasonal variation in daylight duration. [37]

Our population was predominantly Alaskan Natives who lived North of the Arctic Circle (66°33'44"N), in an area which experiences periods of prolonged light during the summer months, and prolonged periods of darkness during the winter months. This is a population that has undergone excessive social and cultural upheaval through the colonization, and settlement of the region, forcing nomadic people into sedentary villages. [45] Understanding the physiologic mechanism driving seasonal variation of suicide is a complicated task due to competing theories of mechanisms. The results from this study did match somewhat to what we expected to theoretically observe based on our proposed physiological mechanism, vitamin D deficiency, in that an increase in suicide incidence would be found during the spring. However, if vitamin D deficiency increased the likelihood of suicide, we would have expected there to be a peak in suicide incidence during the spring, but then a decrease beginning in summer when vitamin D deficiency is less likely due to the increase in UVB rays reaching the earth.

Previous research has found a higher prevalence of obesity among women; as previously mentioned, obesity has been found to influence the ability of an individual to metabolize vitamin D. When hypothesizing what the seasonal patterns of suicide would look like in our population, and who would be at higher risk for seasonal variation of suicide, we assumed that our population exhibits similar obesity prevalence to that of researched populations, and therefore expected to see females at greater risk than males. Therefore, our results are consistent with was we expected to see in that we found females had a greater risk of suicidal events compared to males. We also expected to see younger age groups (e.g., adolescents) at greater risk for seasonal variation of suicidal events compared to adults based on previous findings that older age groups are more likely to consume traditional food sources, which have been found to be much more nutritionally dense than imported food (especially with respect to vitamin D_3). Our results suggested consistency to what we hypothesized since we found adolescents to have an especially great increase in potential risk compared to older age groups, albeit these results were not statistically significant.

Given our hypothesis, if vitamin D were the underlying biological mechanism driving the seasonal patterns of suicide behavior, we would expect to see a decrease in suicide incidence during the summer and fall months, and an increase in suicide during the late-winter/spring months when vitamin D deficiency is most prevalent. When comparing our results to the hypothesized seasonal patterns, we found that the seasonal peaks and troughs did not correspond to the expected seasonal patterns. We saw the greatest incidence of suicidal acts during the summer months, while we expected instead that during the summer months there would be a decrease in incidence due to increased vitamin D levels from prolonged sun exposure.

Unfortunately, seasonality of suicide is complex with various influencing factors that could be in turn affected by multiple mechanisms and their interactions. So, although vitamin D status and its relationship with obesity and traditional food sources helps to somewhat explain why we would expect females within our population of study to have higher rates of suicidal events during the spring/summer months compared to males, and why adolescents were at higher risk during the spring/summer months, additional research needs to be done focused specifically on additional physiological mechanisms before we have a complete and comprehensive understanding of the issue to accurately inform future interventions.

Overall, we found evidence to support both of our main hypotheses; there is seasonal variation of suicide rates within our population of predominantly Alaskan Natives, and also that sex is a significant predictor of seasonal variation in suicide rates. This study suggests that, although sex is not a modifiable risk factor, it is a suitable predictor for determining which groups are at highest risk for suicide during the various seasons. Understanding the implications of sex is necessary for full comprehension of how it impacts suicide risk. Sex or gender has both biological and social implications, and it is important that we further explore what exactly they are. For example, while females had a higher risk for suicide during the spring/summer months compared to fall/winter months, and males exhibited less seasonal variation, males had a higher overall incidence of suicide. Further research is needed to answer questions about what patterns of activities, or biological mechanisms, differ seasonally, and differ between males and females. Similar questions are important for understanding the impact of age on seasonal variation of suicide, since, although we did not find any statistically significant results with respect to age, there was the suggestion that age influenced seasonal variation of suicidal events, and that adolescents were at higher risk during season one compared to older age groups, a group that also composed a large percentage of all suicidal events. The seasonal pattern that we observed also suggests that the driving force behind seasonal variation of suicide may not be easily explained by one physiological mechanism, and may instead be caused by an interplay between multiple mechanisms within the body that vary biologically by sex or age.

CHAPTER VII

SIGNIFICANCE

To date, no study has evaluated the association between age, sex and seasonal variation in suicide, or seasonal variation overall, within this rural population of Alaska. We found that not only does seasonal variation of suicide exist within this population, but also that sex seems to be a significant predictor of seasonal differences in occurrence. Again, although there was more evidence for seasonal fluctuations among females, we found that overall, males had a higher incidence of suicide with more fatal events. Females had a lower incidence of suicide death, with the vast majority of suicidal events being nonfatal (97.3%). Given that suicide rates within this region are high, knowledge of seasonal variation in suicidal behavior associated with age or sex will be helpful in informing targeted interventions among those sub-populations at highest risk. For example, additional support could be given to females and adolescents during the summer months on how to deal with suicidal thoughts. Because males had overall higher incidence of suicidal events, and therefore at higher risk overall, males might benefit most from additional support year round. Results from this study will also be helpful in providing a foundation from which to generate additional hypotheses about the physiological mechanism fueling the increase of suicide incidence seen after the 1960s. Suicide is a major burden on this society, and this study will aid in informing future public health interventions to reduce suicide burden.

CHAPTER VIII

Human Subject Protection

The individuals that collect SRFs are trained Masters-level clinicians who have undergone training on how to ensure the privacy of the participants. SRFs do not have any information on the name of the individual, or any identification number, and are kept within a locked cabinet. Computer files are kept on a secure server that is password protected, and is only accessible by study personnel. The dataset used for analysis within this study was de-identified.

CHAPTER IX

PERMISSION TO ACCESS DATA

I received permission from the principal investigator (PI) of the Alaska Suicide Study to access the data used for this study to assess the relationship between age, sex, and seasonal variation of suicide.

TABLES

Table 1. Characteristics of the Study Population Prior to Exclusions: Alaska Suicide Study (1990-2009)

Characteristics	N (%)
Race	
Alaskan Native	798 (99.3)
Non-Native	6 (0.8)
Sex	
Male	411 (51.1)
Female	393 (48.9)
Marital Status	
Single/Divorced	623 (77.5)
Married/Cohabitating	152 (18.9)
Unknown	29 (3.6)
Employment	
Employed	151 (20.2)
Unemployed	409 (54.7)
Not in Labor Force	188 (25.1)
Unknown	56 (7.0)
Education	
Less than High School	529 (65.8)
High School or Greater	183 (22.8)
Unknown	92 (11.4)
Characteristic	**Mean (SD)**
Age	24.9 (10.2)

Table 2. Distribution of Age: Alaska Suicide Study (1990-2009)

Characteristics	N (%)
Age (years)	
≤ 29	595 (75.2)
>29	196 (24.8)
Age (years)	
<15	40 (5.1)
15-19	256 (32.4)
20-24	189 (23.9)
25-29	110 (13.9)
30-34	64 (8.1)
>35	132 (16.7)

Table 3. Distribution of Suicide per Month Actual vs. Expected*: Alaska Suicide Study (1990-2009)

Month	Actual	Expected
January	61	66.7
February	56	66.7
March	77	66.7
April	77	66.7
May	88	66.7
June	87	66.7
July	81	66.7
August	68	66.7
September	67	66.7
October	52	66.7
November	41	66.7
December	45	66.7

* P <0.001

Table 4. Distribution of Covariates According to Sex: Alaska Suicide Study (1990-2009)

	Male		Female		
	n	%	n	%	p-value
Race					0.96
Alaskan Native	408	99.3	390	99.2	
Non-native	3	0.7	3	0.8	
Marital Status					<0.001
Single/Divorced	346	84.2	277	70.5	
Married/Cohabitating	53	12.9	99	25.2	
Unknown	12	2.9	17	4.3	
Age					0.32
≤15	14	3.5	26	6.7	
15-19	124	30.9	132	33.9	
20-24	100	24.9	89	22.9	
25-29	59	14.7	51	13.1	
30-34	34	8.5	30	7.7	
≥35	71	17.7	61	15.7	
Employment					<0.001
Employed	66	16.1	85	21.6	
Unemployed	219	53.3	190	48.4	
Not in labor force	85	20.7	103	26.2	
Unknown	41	10.0	15	3.8	
Education					0.14
Less than high school	264	64.2	265	67.4	
High school or greater	91	22.1	92	23.4	
Unknown	56	13.6	36	9.2	
Previous Suicide Attempts					0.38
No	169	41.1	159	40.5	
Yes	185	45.0	191	48.6	
Family History*					
Suicide	162	47.9	158	48.2	0.95
Substance Abuse	40	9.7	39	9.9	0.93
Other abuse	15	3.7	19	4.8	0.40
Other	28	6.8	28	7.1	0.86
None	108	32.0	103	31.4	0.88
Method					<0.001
Firearm	66	16.1	4	1.0	
Other	345	83.9	389	99.0	

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 4 - Cont. Distribution of Covariates According to Sex: Alaska Suicide Study (1990-2009)

	Male		Female		
	n	%	n	%	p-value
Location of Act					0.04
Own Home or Vicinity	295	71.8	314	79.9	
Isolated Area	12	2.9	8	2.0	
Public Place	47	11.4	26	6.6	
Other	57	13.9	45	11.5	
Substance Abuse History					0.86
Drugs/None	194	47.2	183	46.6	
Alcohol/Alcohol & Drugs	217	52.8	210	53.4	
Substance Abuse Type					0.32
Alcohol	192	46.7	192	48.9	
Alcohol/other drugs	25	6.1	18	4.6	
Other Drugs	19	4.6	10	2.5	
No	175	42.6	173	44.0	
Possible Warning Signs*					
Had Psychological Symptoms of Depression	43	10.5	69	17.6	0.00
Increased Substance Abuse	36	8.8	36	9.2	0.84
Planned the Suicide	4	1.0	4	1.0	0.95
Told Someone They Were Suicidal	56	13.6	38	9.7	0.08
None	139	33.8	147	37.4	0.30
Contributing Factors*					
Romantic/other relationship conflicts	161	39.2	216	55.0	<0.001
Family of origin relationship conflicts	1	0.2	2	0.5	0.54
Death/suicide of a loved one	83	20.2	96	24.4	0.15
Bullying	3	0.7	7	1.8	0.18
Mental Health Issues	22	5.4	9	2.3	0.02

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 5. Distribution of Covariates According to Age: Alaska Suicide Study (1990-2009)

	≤ 29		>29		
	n	%	n	%	p-value
Race					0.02
Alaskan Native	593	99.7	192	98.0	
Non-native	2	0.3	4	2.0	
Marital Status					<0.001
Single/Divorced	514	86.4	99	50.5	
Married/Cohabitating	72	12.1	78	39.8	
Unknown	9	1.5	19	9.7	
Sex					0.34
Male	297	49.9	105	53.6	
Female	298	50.1	91	46.4	
Employment					<0.001
Employed	87	14.6	62	31.6	
Unemployed	284	47.7	119	60.7	
Not in labor force	184	30.9	1	0.5	
Unknown	40	6.7	14	7.1	
Education					<0.001
Less than high school	434	64.2	85	43.4	
High school or greater	108	22.1	74	37.8	
Unknown	53	13.6	37	18.9	
Previous Suicide Attempts					0.94
No	246	41.6	78	40.2	
Yes	278	47.0	93	47.9	
Unknown	67	11.3	23	11.9	
Family History*					
Suicide	249	49.8	67	42.1	0.09
Substance Abuse	58	9.8	21	10.7	0.70
Other abuse	23	3.9	11	5.6	0.30
Other	39	6.6	16	8.2	0.44
None	154	30.8	55	34.6	0.37
Method					0.06
Firearm	44	7.4	23	11.7	
Other	551	92.6	173	88.3	
Location of Act					0.04
Own Home or Vicinity	438	73.6	162	82.7	
Isolated Area	14	2.4	6	3.1	
Public Place	58	9.8	13	6.6	
Other	85	14.3	15	7.7	

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 5 Cont. Distribution of Covariates According to Age: Alaska Suicide Study (1990-2009)

	≤ 29		>29		
	n	%	n	%	p-value
Substance Abuse History					<0.001
Drugs/None	288	48.4	134	68.4	
Alcohol/Alcohol & Drugs	307	51.6	62	31.6	
Substance Abuse Type					<0.001
Alcohol	252	42.4	127	64.8	
Alcohol/other drugs	36	6.1	7	3.6	
Other Drugs	29	4.9	0.0	0.0	
No	278	46.7	62	31.6	
Possible Warning Signs*					
Had Psychological Symptoms of Depression	85	14.3	26	13.3	0.72
Increased Substance Abuse	50	8.4	20	10.2	0.44
Planned the Suicide	5	0.8	3	1.5	0.40
Told Someone They Were Suicidal	74	12.4	17	8.7	0.15
None	214	36.0	66	33.7	0.56
Contributing Factors*					
Romantic/other relationship conflicts	285	47.9	89	45.4	0.55
Family of origin relationship conflicts	2	0.3	1	0.5	0.73
Death/suicide of a loved one	134	22.5	41	20.9	0.64
Bullying	8	1.3	2	1.0	0.73
Mental Health Issues	22	3.7	9	4.6	0.58

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 6. Distribution of Covariates According to Season: Alaska Suicide Study (1990-2009)

	Season 1		Season 2		
	n	%	n	%	p-value
Race					0.68
Alaskan Native	333	99.1	465	99.4	
Non-native	3	0.9	3	0.6	
Marital Status					0.72
Single/Divorced	262	78.0	361	77.1	
Married/Cohabitating	64	19.1	88	18.8	
Unknown	10	3.0	19	4.1	
Age					0.23
≤15	10	3.0	30	6.5	
15-19	111	33.5	145	31.5	
20-24	85	25.7	104	22.6	
25-29	41	12.4	69	15.0	
30-34	29	8.8	35	7.6	
≥35	55	16.6	77	16.7	
Sex					0.06
Male	185	55.1	226	48.3	
Female	151	44.9	242	51.7	
Employment					0.70
Employed	59	17.6	92	19.7	
Unemployed	169	50.3	240	51.3	
Not in labor force	85	25.3	103	22.0	
Unknown	23	6.9	33	7.1	
Education					0.30
Less than high school	219	65.2	310	66.2	
High school or greater	72	21.4	111	23.7	
Unknown	45	13.4	47	10.0	
Previous Suicide Attempts					0.62
No	138	41.3	190	41.0	
Yes	153	45.8	223	48.2	
Unknown	43	12.9	50	10.8	
Family History					
Suicide	119	43.3	201	51.3	0.05
Substance Abuse	46	13.7	33	7.1	0.00
Other abuse	18	5.4	16	3.4	0.18
Other	29	8.6	27	5.8	0.12
None	80	29.2	131	33.4	0.25

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 6 Cont. Distribution of Covariates According to Season: Alaska Suicide Study (1990-2009)

	Season 1		Season 2		
	n	%	n	%	p-value
Method					0.49
Firearm	32	9.5	38	8.1	
Other	304	90.5	430	91.9	
Location of Act					0.02
Own Home or Vicinity	270	80.4	339	72.4	
Isolated Area	3	0.9	17	3.6	
Public Place	24	7.1	49	10.5	
Other	39	11.6	63	13.5	
Substance Abuse History					0.73
Drugs/None	160	47.6	217	30.6	
Alcohol/Alcohol & Drugs	176	52.4	251	53.6	
Substance Abuse Type					0.31
Alcohol	163	48.5	221	47.2	
Alcohol/other drugs	13	3.9	30	6.4	
Other Drugs	15	4.5	14	3.0	
No	145	43.2	203	43.4	
Possible Warning Signs					
Had Psychological Symptoms of Depression	44	13.1	68	14.5	0.56
Increased Substance Abuse	28	8.3	44	9.4	0.60
Planned the Suicide	4	1.2	4	0.8	0.64
Told Someone They Were Suicidal	43	12.8	51	10.9	0.41
None	217	63.6	301	64.3	0.94
Contributing Factors					
Romantic/other relationship conflicts	160	47.6	217	46.4	0.73
Family of origin relationship conflicts	0	0.0	3	0.6	0.14
Death/suicide of a loved one	69	20.5	110	23.5	0.32
Bullying	2	0.6	8	1.7	0.16
Mental Health Issues	14	4.2	17	3.6	0.70

* *Indicates that variable is not mutually exclusive (i.e., an individual can be recorded within multiple categories of the variable*

Table 7. Univariate Analysis of the Association of Season with Covariates: Alaska Suicide Study (1990-2009)

		Season One vs. Season Two		
		OR	**95% CI**	**p-value**
Sex				
	Male	*ref*	*ref*	*ref*
	Female	1.31	0.99,1.74	0.06
Age				
	≤29	*ref*	*ref*	*ref*
	>29	0.95	0.68, 1.31	0.74

Table 8. Association of Age and Sex with Seasonal Variation of Suicide: Alaska Suicide Study, 1990-2009

	Unadjusted OR	95% CI	Sex/Age Adjusted	95% CI	Fully Adjusted OR*	95% CI
Age						
≤29	1.00	Referent	1.00	Referent	1.00	Referent
>29	0.95	0.68, 1.31	0.96	0.69, 1.33	1.12	0.76, 1.62
Age						
<15	2.30**	1.08, 4.90	2.22**	1.04, 4.75	2.00	0.92, 4.36
15-19	1.00	Referent	1.00	Referent	1.00	Referent
20-24	0.94	0.64, 1.37	0.95	0.65, 1.39	0.94	0.64, 1.39
25-29	1.29	0.81, 2.04	1.31	0.83, 2.07	1.35	0.85, 2.16
30-34	0.92	0.53, 1.60	0.94	0.54, 1.62	1.02	0.58, 1.80
≥35	1.07	0.70, 1.64	1.09	0.71, 1.67	1.11	0.72, 1.72
Sex						
Male	1.00	Referent	1.00	Referent	1.00	Referent
Female	1.31	0.99, 1.74	1.31	0.98, 1.74	1.41**	1.06, 1.90

* Adjusted for Age/Sex, Family History of 'Other' Abuse, Family History of Substance Abuse, and Location of Suicidal Act

** Indicates a P-value<0.05

Table 9. Association of Age and Sex with Seasonal Variation of Suicide: Alaska Suicide Study, 2002-2009

	Unadjusted OR	95% CI	Sex/Age Adjusted	95% CI	Fully Adjusted OR*	95% CI
Age						
≤29	1.00	Referent	1.00	Referent	1.00	Referent
>29	1.02	0.68, 1.54	1.03	0.68, 1.55	1.05	0.69, 1.59
Age						
<15	2.06	0.83, 5.08	1.92	0.77, 4.77	1.86	0.75, 4.66
15-19	1.00	Referent	1.00	Referent	1.00	Referent
20-24	1.00	0.62, 1.56	1.02	0.64, 1.61	1.01	0.63, 1.60
25-29	1.23	0.70, 2.18	1.24	0.70, 2.20	1.25	0.70, 2.24
30-34	0.95	0.44, 2.05	0.91	0.42, 1.97	0.94	0.43, 2.05
≥35	1.16	0.69, 1.93	1.19	0.71, 2.00	1.21	0.72, 2.04
Sex						
Male	1.00	Referent	1.00	Referent	1.00	Referent
Female	1.51**	1.07, 2.13	1.51**	1.07, 2.15	1.48**	1.04, 2.11

* Adjusted for Age/Sex, and Family History of Substance Abuse

** Indicates a P-value<0.05

FIGURES

Figure 1. Frequency of Suicide Distribution per Month by Year (1990-2009), Alaska Suicide Study (P=0.05)

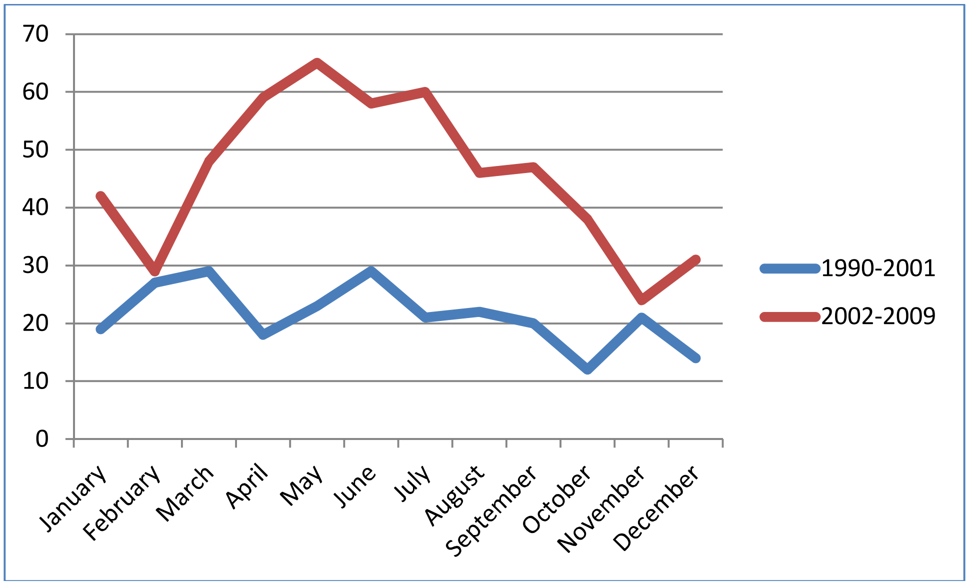


Figure 2. Frequency of Suicide Distribution per Month by Expected vs. Actual (1990-2009), Alaska Suicide Study (P<0.001)

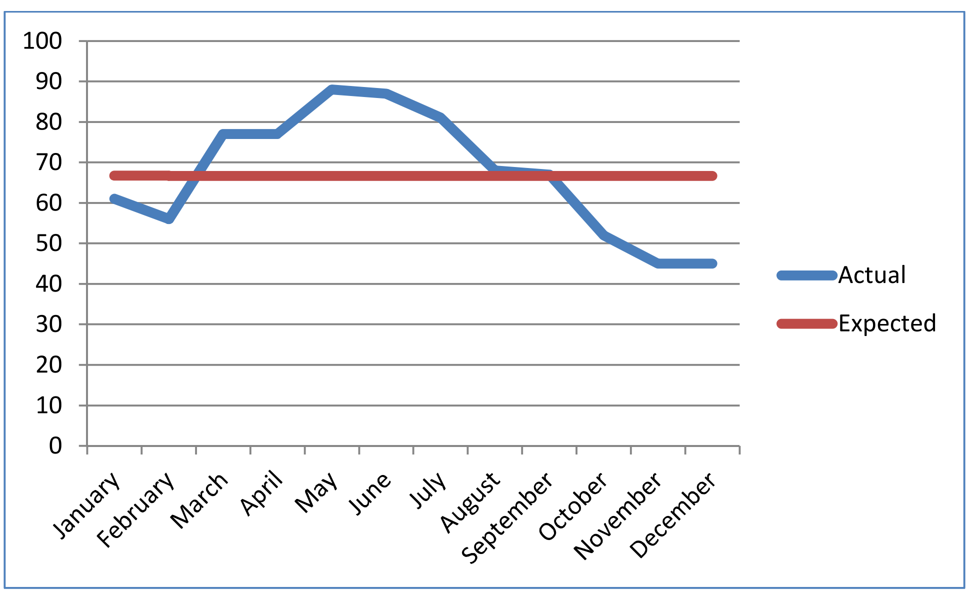


Figure 3. Frequency of Suicide per Month (1990-2009), Alaska Suicide Study

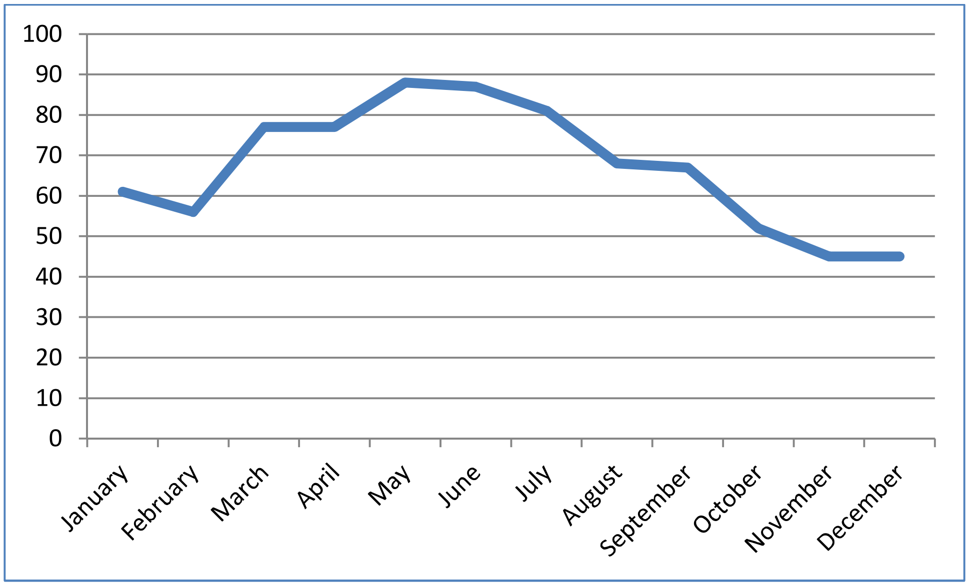


Figure 4. Frequency of Suicide per Month by Sex (1990-2009), Alaska Suicide Study (P=0.69)

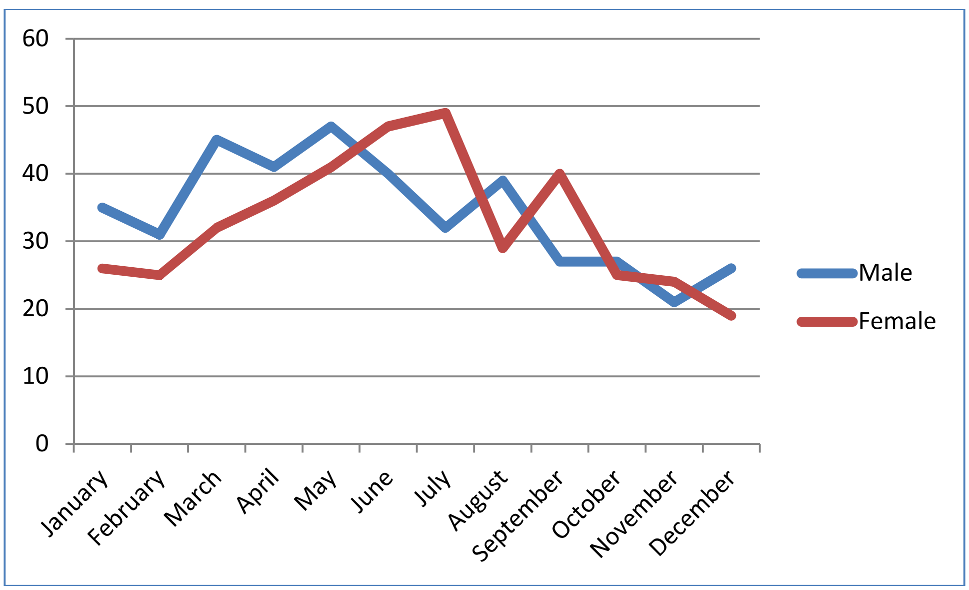


Figure 5. Frequency of Suicide per Month by Age (1990-2009), Alaska Suicide Study (P=0.69)

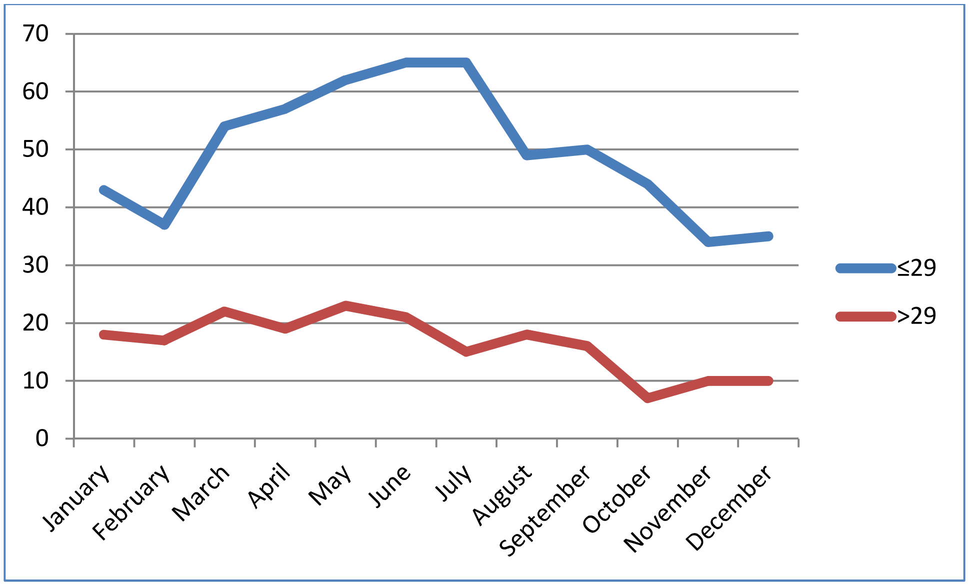


Figure 6. Frequency of Suicide per Month by Sex (2002-2009), Alaska Suicide Study (P=0.12)

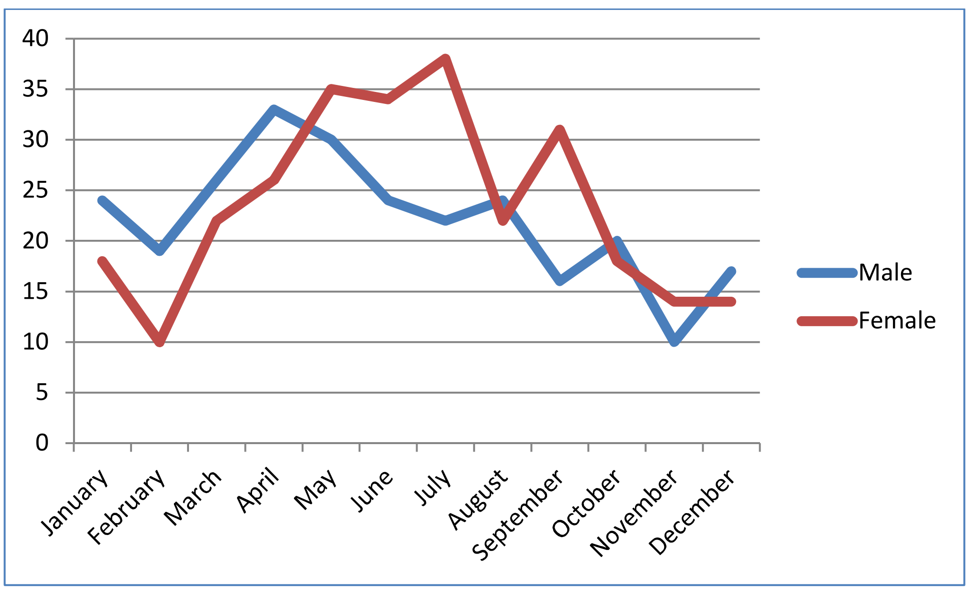
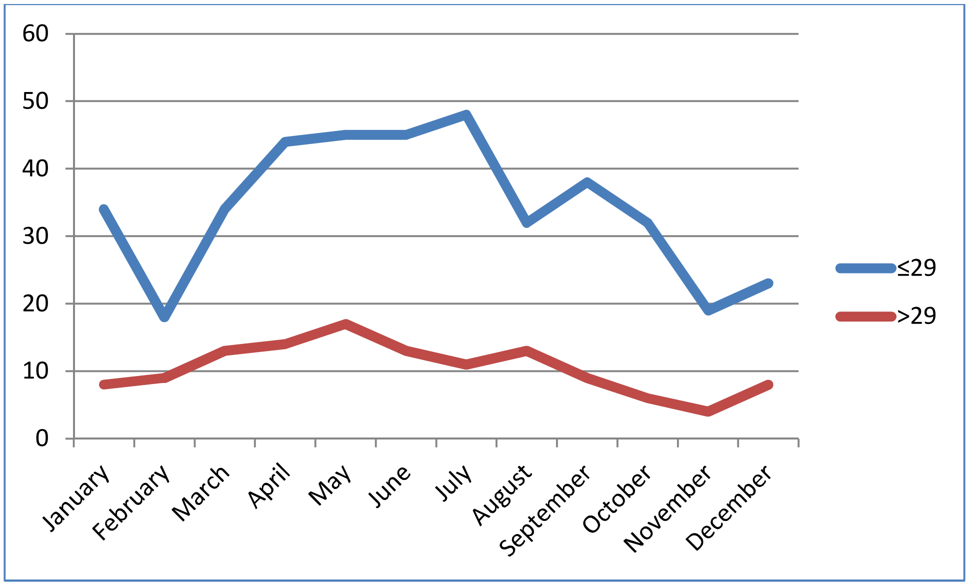


Figure 7. Frequency of Suicide per Month by Age (2002-2009), Alaska Suicide Study (P=0.82)



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