THE EXTENT OF MISCLASSIFICATION OF ACCIDENTS AND DEATHS OF UNDETERMINED INTENTION ON THE SUICIDE RATE, SWEDEN 1950-2010

JULIANNE OHLANDER

It is widely accepted in mortality research that there exists some misclassification of causes of death. Misclassification is a longstanding concern in suicide mortality research in particular. The annual suicide rate remains one of the most widely used population level suicide metrics. Durkheim (1897/1951) suggested that suicide rates contained some degree of error but assumed that this error was relatively stable from year to year and was nonetheless reliable enough to permit statistical analyses (Douglas, 1967).

Today, deaths that are missing some definitive evidence, such as a suicide note, are of concern. The manner of death, in such situations, is considered the most significant clue for suicidal intent. More violent methods are easier to interpret, for example in the case of specific types of gunshot wounds or hanging. Such methods are considered unequivocal; in these cases the method is presumed to be a definitive indicator of suicide unless there is strong evidence to the contrary (e.g. evidence of accidental death due to erotic asphyxiation). Some types of externally-caused deaths, such as traffic accidents, are rarely investigated as potential suicides. Drowning and poisoning deaths are similarly difficult to interpret as suicides in the absence of a suicide note. They are considered equivocal and are often referred to as "soft" or "nonviolent" methods.

Prior to 1969, externally-caused deaths (ones not due to natural causes) were assigned to one of three categories: accidental, suicide or homicide. The ambiguous nature of determining suicidal intent understandably resulted in misallocation of suicides to other external causes of death and a consistent underreporting of suicide. Moreover, the true suicide rate by method of injury was biased because, lacking evidence of intent, poisonings and drowning were categorized as accidents, suggesting not only random error but also substantial systematic error.

In 1969 a new category for injury deaths was introduced in the 8th revision of the Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death. The new category, "deaths of undetermined intention" (ICD-9 E980-989), has been continued in subsequent revisions. The undetermined intent manner-of-death classification was intended for use "when the information pointing to one manner of death is no more compelling than one or more other competing manners of death in thorough consideration of all available information" (National Association of Medical Examiners). Since 1969 all cases of death for which it is impossible to establish a cause and intent are to be registered as undetermined. The new category likely eased the job of medical

examiners by providing them a "catchall" for difficult to determine deaths, but it had unpredicted impacts on manner of death rates.

Manner of death should be decided through a strict criterion, in which intent must be "beyond a reasonable doubt" (Lindqvist and Gustafsson 2002), but that is not always true with respect to national statistics. In Sweden and elsewhere in Europe it is common practice to include all deaths of undetermined intent in suicide statistics. They are referred to as "uncertain" suicides (Hultén and Wasserman, 1992); the undetermined category probably also includes some accidental deaths and possibly a very small number of homicides, which suggests that the suicide statistics may be inflated in countries that add undetermined deaths to their suicide rates. This may bias mortality studies.

Suicide mortality researchers have lumped together certain and uncertain suicides, often without explanation for the practice or a citation for justification of its use. A study by Hörte (1981) is occasionally cited as justification for the practice; his analysis of autopsy reports and hospital journals revealed that 70 percent of undetermined intent deaths in Sweden were probably true suicides. Sometimes, the agency collecting suicide mortality statistics is cited as considering the true suicide rate to be the sum of reported suicides and undetermined intent deaths (Beskow, et al 1985). Some authors have noted the overestimation of the true suicide incidence but cite international practice as justification (Ovenstone, 1973; Kreitman 1991). Oftentimes, for comparison, analyses are computed separately for reported suicide and the combined rates (Ferrada-Noli 1997; Hulten and Wasserman 1992)).

There is no gold standard by which one can estimate the probable true suicide rate and the matter became more complicated by the introduction of the undetermined intent category in 1969. The practice of including all deaths of undetermined intent in suicide statistics needs reevaluation.

RESEARCH QUESTIONS

External cause-of-death data from 1950-2010 are examined to determine the impact of misclassification of deaths on suicide rates in Sweden. Of particular interest is the impact of the practice of including all deaths of undetermined intent in the suicide rate. Sweden leads in the use of the classification of undetermined intent deaths; a comparative study of the proportion of injury deaths that are of undetermined intent found Sweden to have the highest use of this code compared to Australia and the US (Lu et al 2007).

The research seeks to answer the following questions:

(1) Were suicides misclassified as accidental deaths before 1969 and to what extent?
(2) What is the impact of the introduction of the 1969 undetermined intent category on both suicides and accidental deaths? From which external cause-of-death categories are the undetermined deaths from 1969 and onward being drawn?
(3) How much of the decline in the suicide rate after 1969 is attributable to misclassification?

HYPOTHESES

Two main sets of hypotheses are examined.

H1: Suicide, prior to 1969, was underestimated due to misclassification as accidental deaths.

H2: After 1969, a proportion of the undetermined intent death category included accidents, not only suicides.

H3: Deaths by equivocal methods, such as poisoning or drowning, are more likely to be misclassified.

DATA AND METHODS

Official mortality data from 1950 to 2010 were obtained from Statistics Sweden and the National Board of Health and Welfare on the total number of *external causes of death* (injury deaths), *accidents* or *unintentional injury* (V01-X59, E950-E959 in ICD-9), *suicides* (X60-X84 in ICD-8), *homicides* (X85-Y09 in ICD-8), and *undetermined intent deaths* (Y10-Y34 in ICD-8; E980-E989 in ICD-9). Method of death (by firearms, hanging, poisoning, etc.) was also collected for suicides, accidents, and undetermined intent. Not all methods of injury were continuously available in annual published reports but the most common methods, and the methods most pertinent for the analyses (poisoning, drowning, firearms, and hanging/strangulation) were available.

Mid-year population estimates were also gathered to compute mortality rates per 100,000 inhabitants. Please note that the rates in the present analysis have not yet been standardized to a midpoint age distribution but this will be done in final analyses presented at PAA. Instead, for the purposes of the present analysis, the percent of the population aged 65 and older is included as a control variable. Changes in the patterns of external causes of death are examined before and after the 1969 change to evaluate the extent of misclassification and the potential effect on the suicide rate trends.

DEPENDENT VARIABLE

The dependent variable is the number of suicides per 100,000 midyear population.

INDEPENDENT VARIABLES

Two sets of independent variables aimed at evaluating the impact of misclassification of deaths on the suicide rate are described. The first set is comprised of mortality rates. The rate of accidental mortality per 100,000 is used to assess the relationship between the suicide rate and the accidental mortality rate net of other factors. The rate of undetermined intent mortality per 100,000 assumes that increases in the undetermined intent category result from increased misclassification of both suicides and accidents.

The second set of independent variables involves the calculation of mortality ratios. Of focus are the equivocal methods of death, which are most easily transferred among categories in the presence or absence of evidence regarding the intention of the individual. The ratios are aimed at measuring the extent of shifting between categories. Both poisoning and drowning are considered equivocal methods; that is, they can be difficult to determine intent and are more likely to be misclassified (Sorenson et al 1996; Salib and Agnew 2005). Poisoning and drowning are consistently reported over the period of analysis and are combined to represent "equivocal" or "soft" or "nonviolent" methods of death. The ratios are calculated for the following:

- Suicides by equivocal methods (per 100,000 population) / Accidental deaths by equivocal methods (per 100,000 population);
- Suicide by equivocal methods (per 100,000 population) / Undetermined intent by equivocal methods (per 100,000 population);
- Accident by equivocal methods (per 100,000 population) / undetermined intent by equivocal methods (per 100,000 population).

CONTROL VARIABLES

A number of control variables are considered. To consider the effect of time trends, particularly the rise in suicide observed in the 1950s and 1960s and the subsequent decline in suicide after 1970, a variable indicating year is included. External causes of death as a percentage of all deaths is computed to serve as another time trend control.

To control for the aging population in Sweden, the percentage of the population aged 65 and older is used. Elderly deaths are often less thoroughly investigated compared to deaths in younger ages because older persons are

more likely to die from natural causes (Sorenson et al 1997). The elderly have lower rates of autopsy, and lower rates of autopsy have been argued to increase the likelihood of misclassification of deaths. A greater proportion of elderly in the population may affect the probability that an undetermined intent verdict is chosen over suicide or accident.

Another important factor to consider is the use of antidepressant medication. Although the decline in the suicide rate began at least 20 years prior to the boom in antidepressant sales, a major part of the accelerated reduction in suicide rates during the 1990s has been attributed to increased usage of antidepressant medication, although the drugs may increase thoughts of suicide in young people (Ohlander, 2010). Data on sales of antidepressants were obtained from published annual reports from Apoteket AB, the government owned retail monopoly for prescription medication, which collects comprehensive data on drug sales. Antidepressant medication usage is measured in sold quantity of antidepressants in defined daily dose (DDD), assumed to be the average daily dose of the drug when it is used by adults for its main indication. The DDD is set by the World Health Organization and is an internationally accepted standard measurement.

Alcohol consumption is included in studies of suicide because of its association with impulsive and self-destructive behavior. Registered sales of alcohol in Sweden were obtained from the Swedish National Institute of Public Health and are expressed in liters of 100 pure alcohol per capita 15 years or over. Alcohol consumption patterns have changed in Sweden. Swedes used to drink hard liquor but now consume more beer and wine. To reflect changes in alcohol consumption, rather than absolute consumption levels, the sales of spirits in liters of pure alcohol per inhabitant aged 15 and older is included.

Additional controls (to be explained in greater detail in next draft) include the ratio of males to females among injury deaths, the ratio of marriages to divorces as a Durkheimian social integration factor reflecting the breakup of formal unions, and the number of physicians per 10,000 inhabitants as a measure of the growth of the Swedish health care system and its presumed ability to respond to injury deaths sooner.

ANALYTIC PLAN

The data are analyzed through four main methods:

(1) Observed changes in proportions of suicides, accidents, homicides, and deaths of undetermined intent over the time period 1950-2010 (Figures 1 and 2)

(2)An examination of shifts in ratios between rates of suicide, accident, and undetermined intent mortality, with specific focus on equivocal methods (poisoning and drowning).
(3) Correlation coefficients to assess the strength of the relationships
(4) Regression analysis to sort through the effects of the hypothesized variables on the suicide rate trend

Misclassification is generally analyzed through an examination of shifts in mortality ratios between suicide and undetermined intent deaths. Bivariate correlations are also heavily utilized. Some studies have used regression analysis. This study examines in detail shifts in mortality ratios between suicide, undetermined intent, and accidental deaths by method (equivocal methods of poisoning and drowning) over the period 1950-2010. Bivariate correlation coefficients are used to assess the strength of the relationship between annual rates of suicide, accidents, and undetermined deaths. Regression analysis of suicide mortality rates utilizes variables to measure misclassification after the 1969 ICD change and a host of control variables that are predicted to impact the changes in the suicide rate.

This study explicitly controls for aspects not previously considered or underconsidered such as period effects, shifts between categories by method of injury, changing age distribution, the use of antidepressant medication, alcohol consumption, public health variables, social changes, and changing sex distributions in the risk of injury death.

RESULTS

Figure 1 presents the suicide rate trend per 100,000 midyear population in Sweden over the period 1950-2010. The suicide rate, if all deaths of undetermined intent were included, is also presented. Clearly the suicide rate would be overestimated if all such deaths were included. The long-term declining trend, however, remains the same.

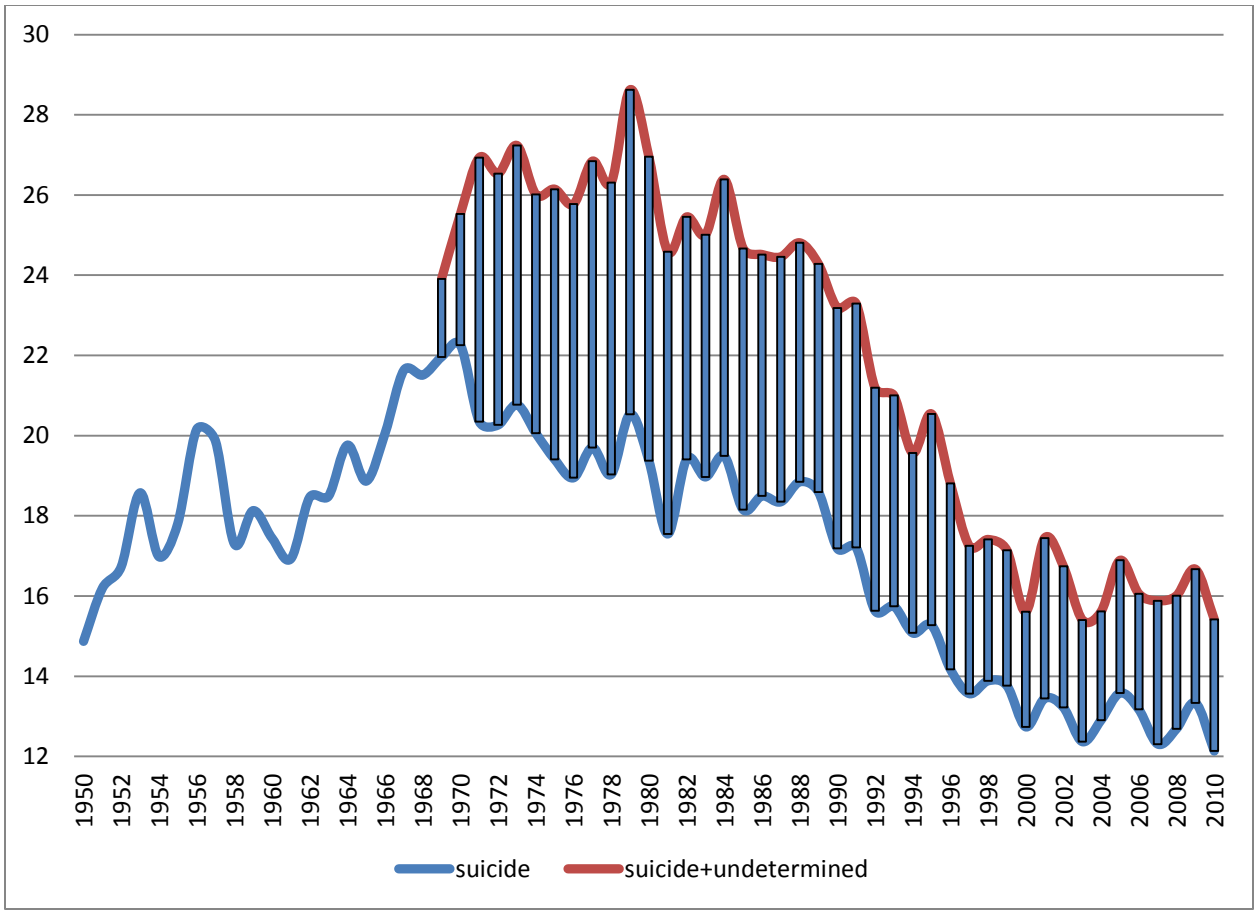

Figure 1
Suicide Rate with and without Undetermined Intent Deaths, 1950-2010

Figure 2 displays the external causes of death broken down into suicide, accident, homicide, and undetermined intent as a percentage of the total external causes of death. Undetermined intent, when introduced in 1969, appears to have drawn deaths from both suicides and accidents. The percent of suicides declines, and the percent of accidents declines. If the undetermined intent category was drawing misclassified suicides solely, then we would expect the percentage of accidents to remain relatively stable while the percentage of suicides declined. Although, later in the time series, the percentage of accidents rebounds but not to its previous high level whereas suicide continues to comprise a lower percentage of injury deaths.

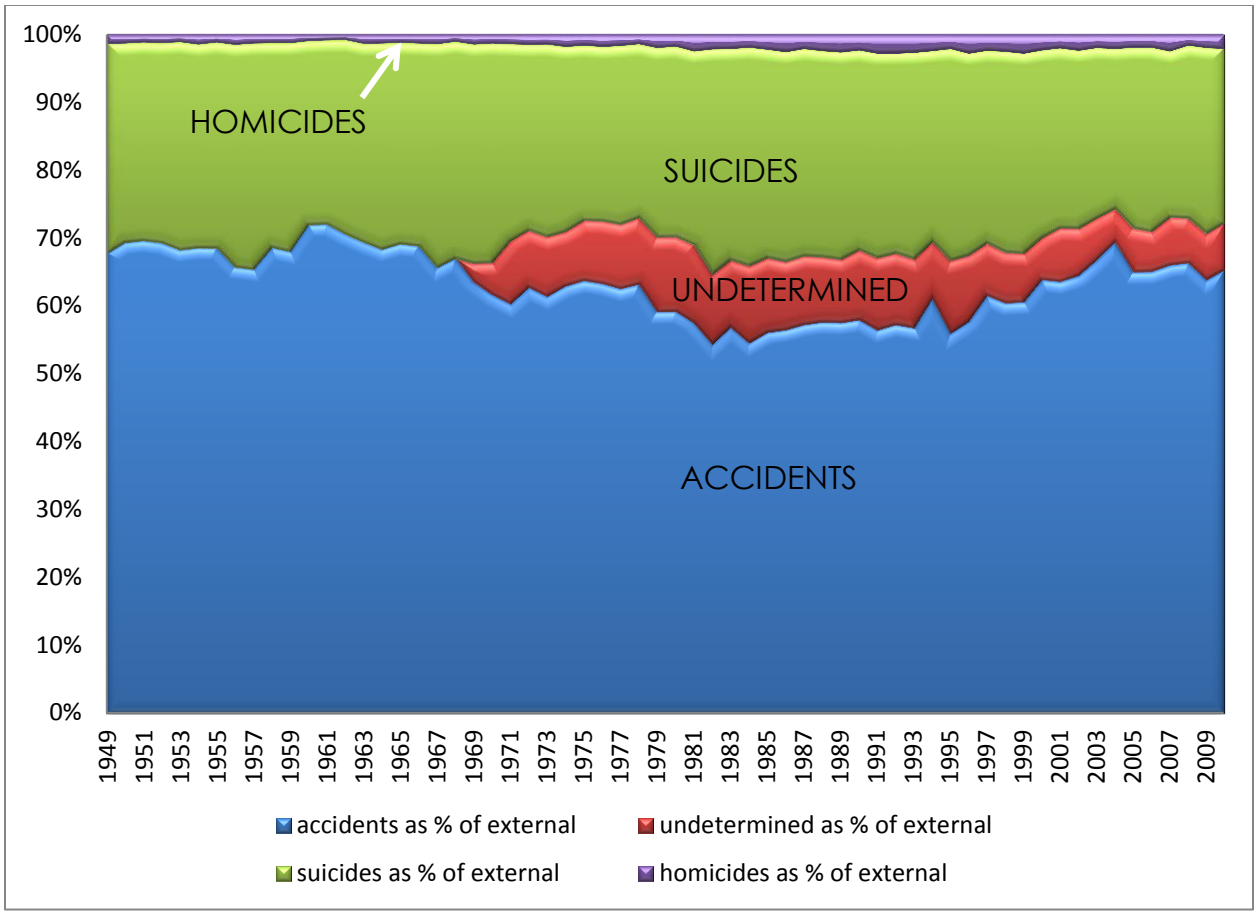

Figure 2.
Suicides, Accidents, Homicides, and Undetermined Intent Deaths as Percent of All External Causes of Death, 1949-2010

The most common method of analyzing misclassification is the observance of trends in ratios between two causes of death assumed to be related. A changing ratio is generally accepted as an indication of underestimation of one of the causes of death under comparison. In Figure 3, ratios were computed between rates of suicides and undetermined intent, accidents and undetermined intent, and accidents and suicides. Higher numbers (higher ratios) indicate greater number of suicides or accidents relative to undetermined intent deaths or a greater number of accidents compared to suicides. The initial high ratio of suicide to undetermined intent deaths indicates the adjustment period when the undetermined intent category was just beginning to be used; at this early point, very few deaths were initially placed as undetermined intent. By 1971, however, the declining ratio means that the use of the undetermined category was quickly becoming utilized.

Higher numbers (higher ratios) indicate more suicides or accidents relative to undetermined deaths. Initial high ratio of suicide to undetermined indicates the

adjustment period when undetermined intent just starting to get used (very few undetermined deaths compared to suicides and accidents) (Figure 3). But then around 1971, we see the use of undetermined intent deaths adjusting as the use of the undetermined deaths jumped (so the ratio declined). The ratio between suicides and accidents appears fairly stable over the period, however, it has narrowed. This narrowing of the ratio between suicides and accidents suggests that suicides may be misclassified into the accidental injury category, but more so after the early 1990s. Right about this same time is when the sale of antidepressant medication skyrocketed. Since then we have learned that antidepressants may cause suicidal thoughts and behavior in younger individuals. It could be that these are the individuals who are being misclassified as accidents (future research). The stable ratio between suicides and accidents throughout the 1970s and 1980s suggests little misclassification between the two categories during this period.

Are accidents being misclassified into undetermined intent? The ratio between the accidental death rate and the undetermined rate did decline between 1971 and the mid-1980s, suggesting some shifting of accidental deaths into the undetermined intent category (Figure 3). However, the ratio reversed its course by the late 1990s. This may indicate that the popularity of the undetermined intent category, at least when the deaths should probably have been coded as true accidents, has waned.

Are suicides being misclassified as undetermined intent deaths? To more closely examine the trend over the period, Figure 4 presents a more focused view on the relationship. Initially, yes, it appears that suicides were being misclassified as undetermined intent, as evidence by a decline in the ratio between the suicide rate and the undetermined intent rate during the 1970s. The undetermined intent category was initially popular in the 1970s for placing deaths that earlier would be have coded as suicide or accident. The popularity of this practice appears to have waned earlier for suicides than for accidents. This is illustrated by the increasing ratio between the suicide rate and the undetermined rate throughout the 1980s, 1990s, and 2000s (Figure 4).

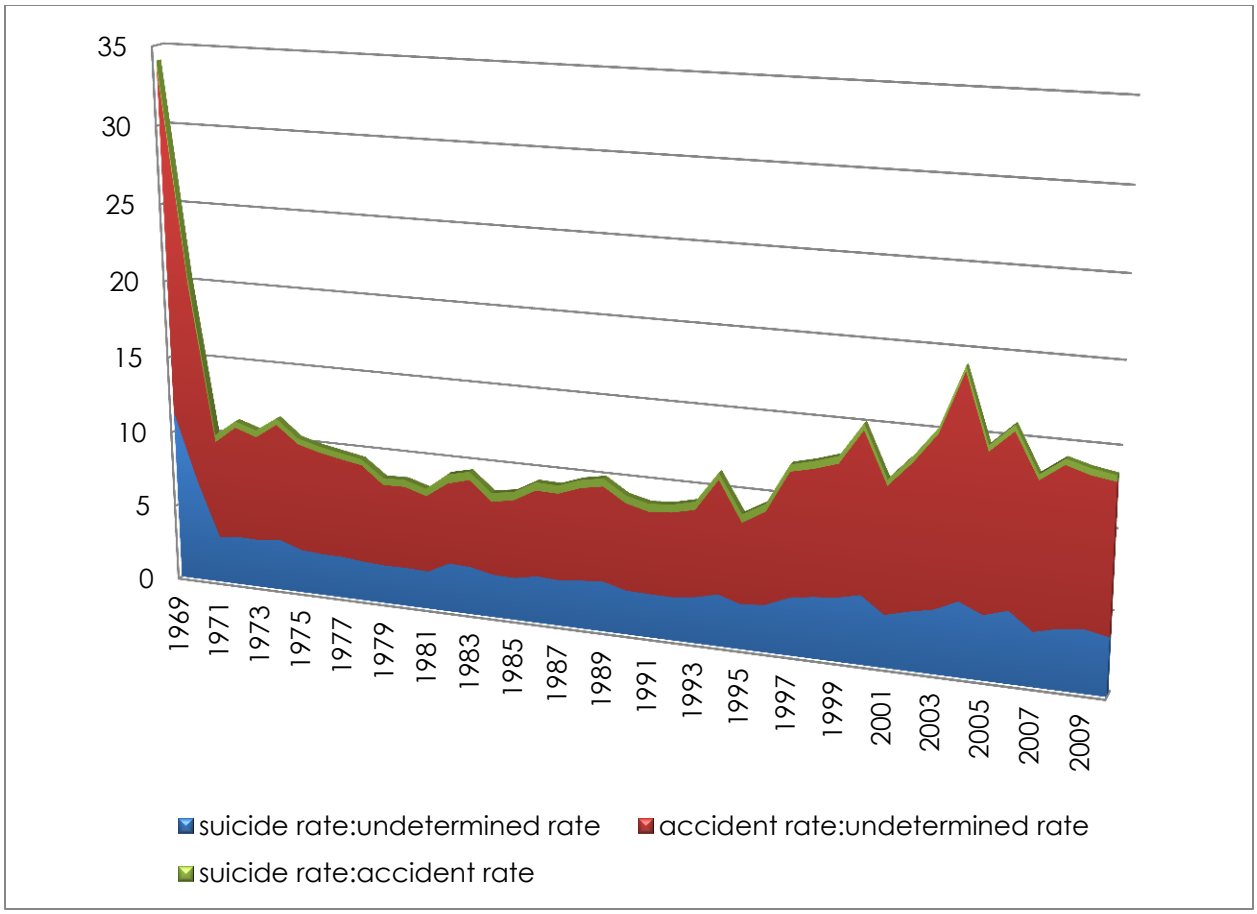

Figure 3.
Ratio of Mortality Rates: Suicides, Accidents, and Undetermined Intent, 1969-2010

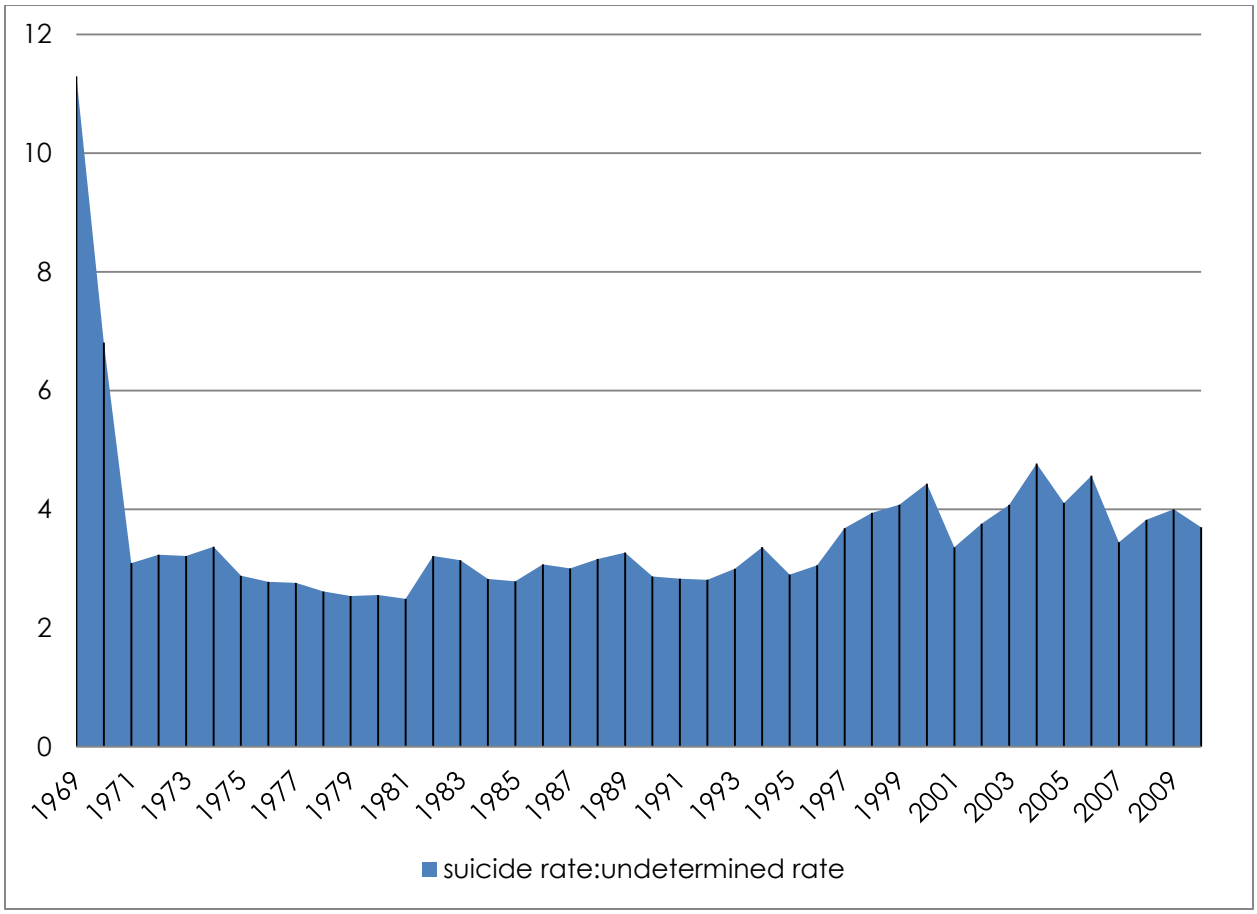

Figure 4
Ratio of Mortality Rates: Suicides to Undetermined Intent, 1969-2010

The analysis so far has provided evidence for misclassification of suicides and accidents as undetermined intent deaths and some evidence of slight misclassification of suicides as accidents later in the time series. The next step is to evaluate whether the relationship between accidents and suicides changed with the 1969 ICD code (Figure 5). If the undetermined category is drawing from one category more than the other (suicide more than accidents, for example), then we would expect to see a stable relationship between suicides and accidents before 1969 but a change in the ratio after 1969. The ratio did decline somewhat in the decade after the 1969 change (Figure 5). The ratio between suicides and accidents was at a lower level in the 1980s than it was in previous decades. This suggests that the undetermined category may be drawing unequally from either accidents or suicides. If undetermined intent is taking equally from suicides and accidents, then we would expect no change in the ratio between suicides and accidents. But the ratio has dropped, at least until the year 2000. We have to assume that the ratio pre-1969 reflects normal fluctuation between the accidental death rate and the suicide rate. After 1969 the ratio between suicides and accidents does drop below 2.0, an indication

that the accidental death rate has dropped relative to the suicide rate. This ratio increases to its highest level after 2000 (more accidents relative to suicides) but this is certainly a long time after the ICD change. This may indicate that a decade after the introduction of the undetermined intent category, the undetermined category is drawing more from accidents since the accidental death rate has dropped faster than the suicide rate has declined; the ratio between the two dropped.

What is occurring with the actual reported rates of suicide and accidental death during this period of changing ratios? In the first decade after the 1969 change, we see a peak in the accidental death rate (about 1975) while the suicide rate has already begun a gradual decline (from its peak in about 1970). During this same period, there is a higher ratio of accidents to suicides (as illustrated in the first orange triangle in Figure 5). It appears that the undetermined are drawing more from suicides during this initial period after the 1969 change.

During the next decade (the 1980s) there is a decline in the accidental death rate while the suicide rate continues its gradual decline (Figure 5). The ratio between accidents and suicides lowers to below 2.0 (2 accidents per 1 suicide). This suggests that the undetermined category may be taking more deaths from accidents than suicides. Of course, this assumes that these declines are due to the undetermined category rather than some external factor. The decline in suicide could certainly be due to other factors, and this is evaluated in the multiple regression analysis. If undetermined intent was taking more from suicides, we would see a rising ratio between accidents and suicides, and we do not see evidence of such a rise in the 20 year period after the ICD change. The opposite occurs; the ratio declines, suggesting that undetermined intent deaths are drawing more from accidents than from suicides.

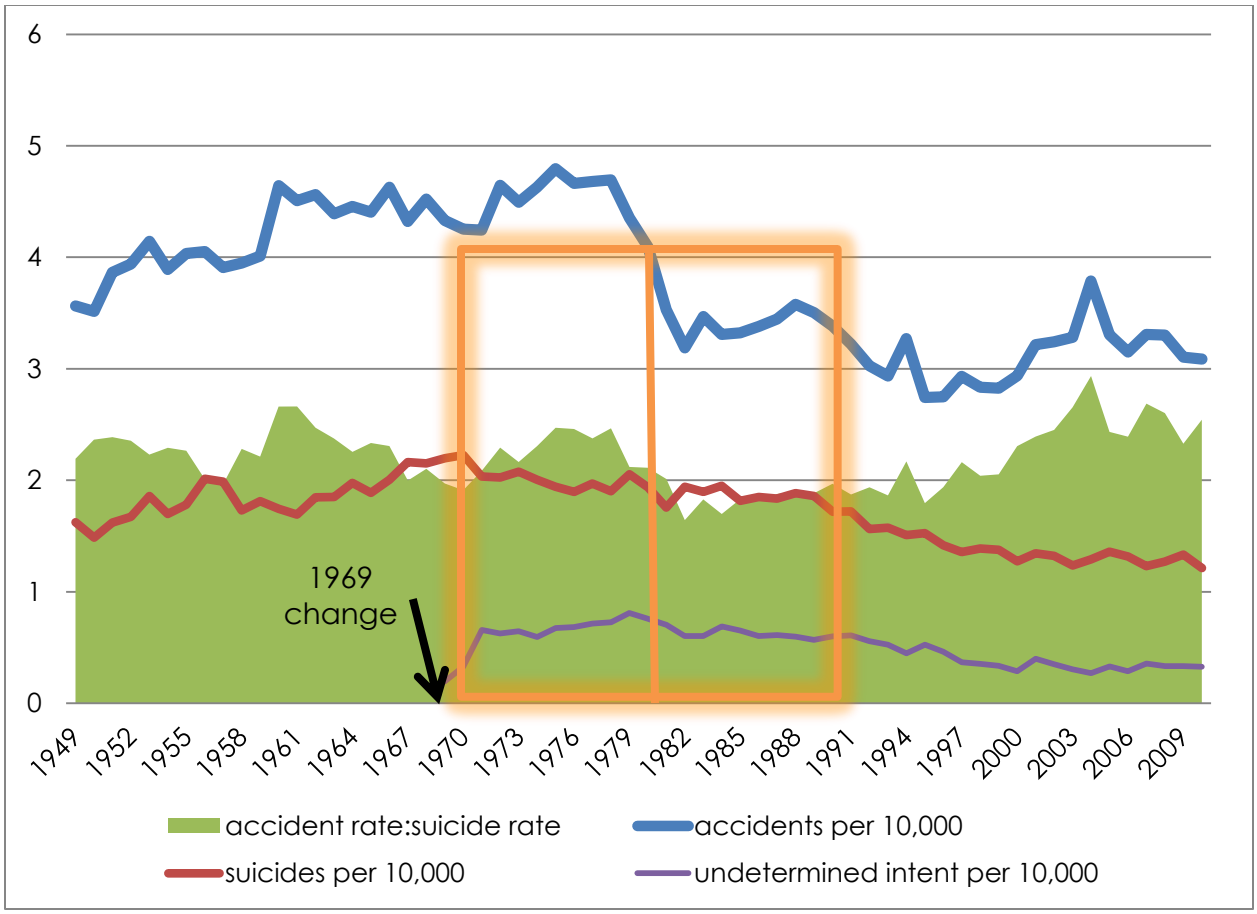

Figure 5
Ratio and Rates of Accidental Death and Suicide (per 10,000)

Previous studies have suggested that method of injury is extremely important. Of particular significance is that certain types of injuries are more difficult to classify one way or the other. The next analysis focuses on sorting out these differences. Figure 6 shows the undetermined intent deaths distributed by method of injury. The majority of undetermined intent deaths are poisoning (ranging from 48 to 77 percent of all undetermined intent deaths, depending on the year). Drowning also comprise a significant portion. These are two categories that are considered nonviolent or soft methods of injury. In the absence of a suicide note or other clear-cut evidence, such deaths could be either suicides or accidental deaths. In the analyses, these methods are labeled "equivocal" methods.

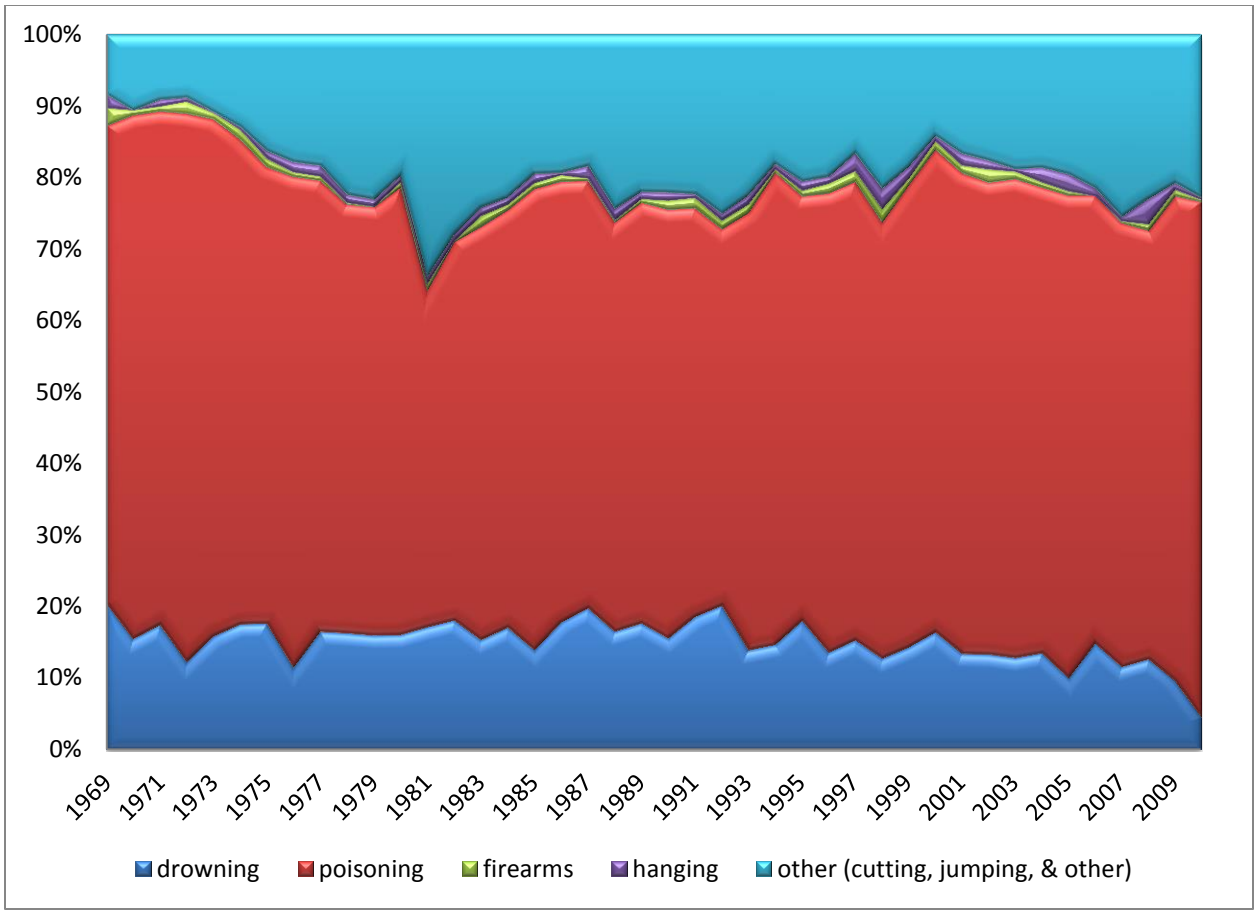

Figure 6
Undetermined Intent Deaths by Method of Injury, 1969-2010

Figure 7 illustrates the long-term decline in suicide in general after 1970. Suicide has declined for both types of methods, equivocal (poisoning and drowning) and unequivocal (firearms and hanging), although the decline is more steep for equivocal methods, particularly after the late 1990s when antidepressants had become quite common. If antidepressants truly worked and caused fewer equivocal suicides. Females are also more likely to be taking antidepressants as well as usually equivocal methods of suicide. This would suggest decreases in equivocal suicides would differentiate from the unequivocal suicide rate which reflects more male behavior. Males are less likely to be taking antidepressants so a separation in these two rates of suicide should not be surprising (future analysis by gender).

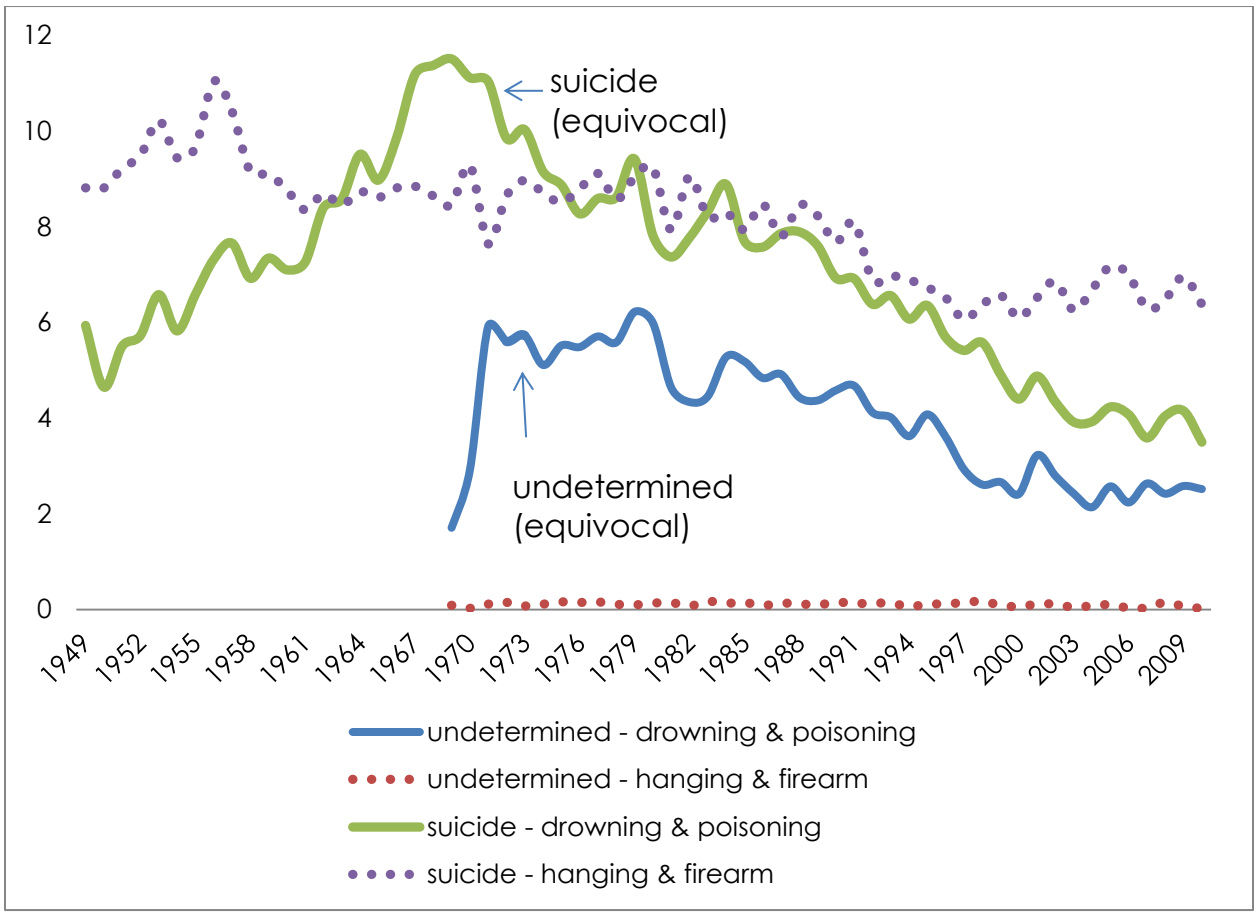

Figure 7
Suicide and Undetermined Intent Mortality Rates by Method: Equivocal (Drowning & Poisoning) vs Unequivocal (Hanging & Firearm)

The following Table 1 displays the bivariate correlations between the suicide rate and the variables of interest. (Due to lack of time, these are not discussed for now)

Table 1
Bivariate Correlations with Suicide Rate (n=42 years)

rate of death per 100,000: suicide	1.000
rate of death per 100,000: accident	.727***
rate of death per 100,000: undetermined intent	.673***
ratio of rates: suicide equivocal / accident equivocal (drowning + poisoning)	.605***
ratio of rates: suicide equivocal / undetermined equivocal (drowning + poisoning)	.344*
ratio of rates: accident equivocal / undetermined equivocal (drowning +poisoning)	-.431**
year	-.961***
external causes as percent of all deaths	.781***
percent of population 65+ (m+f combined)	-.711***
antidepressant use (11C/N06A) M+F in DDD/inhabitant/day	-.902***
sales of alcoholic beverages in liters of pure alcohol per inhabitant 15+ (spirits)	.925***
#marriages : # divorces	.332*
# physicians per 10,000 inhabitants (Dec 31 pop, males & females)	-.852***
ratio of rates: external causes males / external causes females	.726***

The regression model statistics are presented next – an ARIMA model performed in Stata. The results are presented below but will be discussed in more detail in the presentation. The variables that were statistically significant with the suicide rate during the period 1969-2010 (note that analysis restricted to these years due to absence of some data) including the following:

- Accidental mortality rate: negative association with suicide rate
- Ratio of rates: suicide to accident (equivocal methods): positive association

- Ratio of rates: accident to undetermined (equivocal methods): negative association with suicide rate
- External causes of death as a percent of total deaths: positive association with suicide rate
- Sales of alcohol/spirits: positive association with suicide rate
- Physicians per 10,000 population: positive association with suicide rate

ARIMA time series regression, Sample: 1969 to 2010 (42 observations)

Variable	**Coefficient**	**Std Error**	**95% Confidence interval**	
Accidental mortality rate per 100,000	-.329299***	.098534	-.5224221	-.1361759
Undetermined intent rate per 100,000	.0912863	.2485831	-.3959277	.5785003
Ratio of rates: suicide to accident (equivocal)	-.6301001	.7565811	-2.112972	.8527716
Ratio of rates: suicide to undetermined (equivocal)	1.460511**	.5392405	.403619	2.517403
Ratio of rates: accident to undetermined (equivocal)	-2.47097*	1.206883	-4.836417	-.1055231
External as % of all deaths	3.312782***	.7847249	1.77475	4.850815
Population aged 65+ as %	-.6630284†	.3760651	-1.400102	.0740456
Antidepressants	-.0397768†	.0237822	-.086389	.0068355
Alcohol (spirits)	1.578119**	.5612571	.4780758	2.678163
Male to female ratio in external causes of death	1.269916	1.259795	-1.199237	3.739069
Ratio of marriages to divorces	.3452085	4.096415	-.4576741	1.148091
Physicians per 10,000 population	.2935595***	.0785343	.1396351	.4474838

Wald Chi-square(12) = 2069.19
Log likelihood = -18.73882
Prob > Chi-square = 0.0000

***p<.001, **p<.01, *p<.05, †p<.10

**Please note that I did not have time to finish the analysis write-up or discussion. I am happy to email an updated draft in a couple of weeks.