

## Short Communication

# Investigating the Time Lag Effect between Economic Recession and Suicide Rates in Agriculture, Fisheries, and Forestry Workers in Korea

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Previous studies on the vast increase in suicide mortality in Southeast Asia have indicated that suicide rates increase in parallel with a rise in unemployment or during periods of economic recession. This paper examines the effects of economic recession on suicidal rates amongst agriculture, fisheries, and forestry workers in Korea. Monthly time-series gross domestic product (GDP) data were linked with suicidal rates gathered from the cause of death records between 1993–2008. Data were analyzed using generalized additive models to analyze trends, while a polynomial lag model was used to assess the unconstrained time lag effects of changes in GDP on suicidal rate. We found that there were significant inverse correlations between changes in GDP and suicide for a time lag of one to four months after the occurrence of economic event. Furthermore, it was evident that the overall relative risks of suicide were high enough to bring about social concern.

**Key Words:** Suicide, Economic recession, Time series analysis

Previous studies on the vast increase in suicide mortality in Southeast Asia in the late 1990s have concluded that the rise corresponded with the Asian economic crisis in 1997–1998 [1]. Suicide has since become a more common cause of death in Asia when compared to previous times, and a number of studies have examined the relationship between socioeconomic status and suicide. Some such studies have indicated that suicide rates increase in parallel with a rise in unemployment [2] or during periods of economic recession [3].

A useful marker to represent macroeconomic recession is

declining gross domestic product (GDP). However, there are complex causal pathways from macroeconomic recession to suicide events, such as unemployment status, alcohol consumption [4], and economic-induced mental illness [5]. Therefore, we hypothesize that a time lag is necessary when analyzing how macroeconomic variables affect changes in the rate of suicide mortality.

According to our previous study [6], the most vulnerable occupation during periods of economic recession is the agriculture, forestry, and fisheries (AFF) sector, whose employees exhibited significantly higher standard suicide mortality rate (341) as compared with other occupations in Korea [6]. This finding is consistent with the available report from the United States [7]. Furthermore, the easy assessments to pesticides have been the important cause of high suicide risk in AFF workers [8]. However, the time lag effect between economic recession and suicide rate has not been frequently studied in AFF workers.

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Hence, the time lag between economic recession and suicide in AFF workers warrants further investigation as an indicator for the prevention of suicide. Therefore, this study aims to examine the time lag effect of GDP on suicidal rates in AFF workers in Korea.

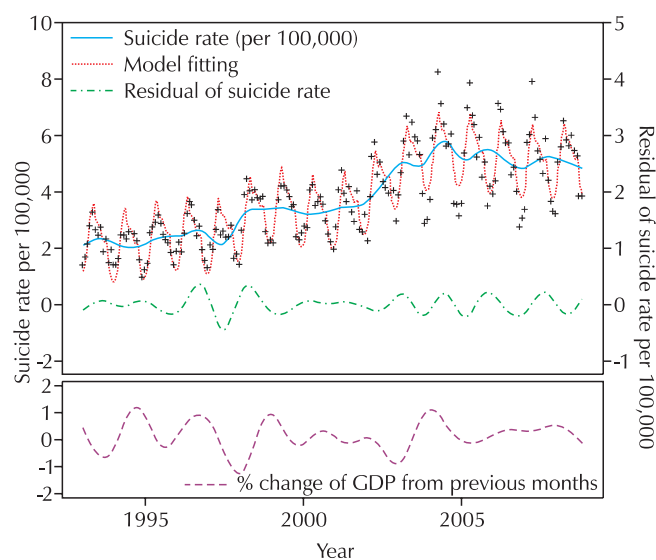
The information on the cause of death from the period from 1993-2008 was obtained from the records available in Korea National Statistical Office (KNSO). The cause of death certificates provided by the KNSO was classified based on the 10th revision of the International Classification of Disease (ICD-10) for the period from 1993-2008. In this study, intentional self-harm (X60-X84) and sequelae of intentional self-harm (Y870) from the ICD-10 were defined as suicide. Monthly unemployment ratios for 1993-2008 were also obtained from the KNSO.

The AFF occupations were identified using the Korean Standard Classification of Occupations, which comprises nine major occupational groups that have been used in cause of death records in Korea.

We also gathered industry-specific GDP data from the KNSO. However, we were unable to gain an exact monthly GDP level for AFF workers, because the KNSO only offers quarterly GDP data. Therefore, we used a generalized additive model (GAM) to calculate a monthly AFF GDP level using the smoothing method. The percentage changes in AFF GDP from previous months were subsequently calculated.

Suicide data were analyzed using time-series analysis. Analyses were carried out using the statistical program R version 2.12.2 with the packages “mgcv” and “ares” for the time-series analysis using the GAM [9]. The analysis consisted of several procedures. Initially, we tried to control the long-term and seasonal trends through the splines, the smoothing function of the GAM. Next, the final model was selected through several rounds of model fitting. We then used graphical assessments and formal statistical approaches for the model estimation and diagnostics. For graphical assessments, we plotted the model fit, partial autocorrelation function, residual deviance, and periodograms. For formal statistical approaches, the Akaike Information Criterion (AIC), a measure of a model's goodness of fit, was used. In general, lower AIC values indicate a better model fit.

In the first model (AIC = 6130.42), the suicide rates in each month of the study period were fitted to the long-term trends using the smoothing function with 11 degrees of freedom. In the second model (AIC = 2350.75), seasonal trends were incorporated for each month, again using 11 degrees of freedom. In the final model (AIC = 2327.66), unemployment rates were further incorporated based on two-month moving average values.



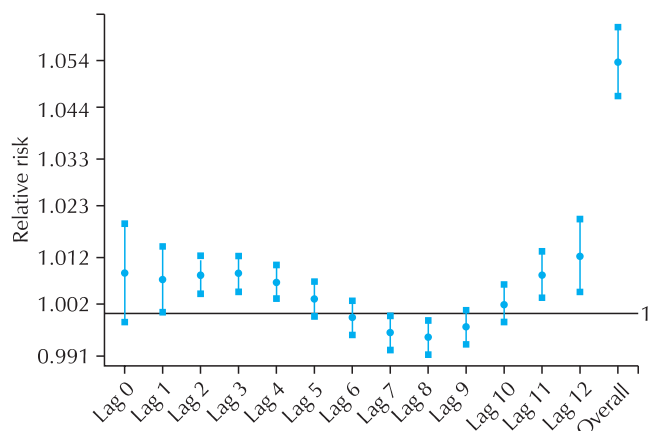
**Fig. 1.** Suicide rate and percentage change in gross domestic product (GDP) from previous months.

Next, relative risks (RR) were calculated to correspond to a 10% decrement in AFF GDP from previous months. To investigate the unconstrained time lag effect [10] between GDP and suicide rates, polynomial distributed lag models were generated using the R package “ares” [9]. The adopted level of statistical significance was  $\alpha = 5\%$  in all analyses.

The long-term and seasonal suicide trends and percentage changes in AFF GDP from previous months are shown in Fig. 1 for the period under study. The figure shows that suicide level peaked during April to July in terms of the seasonal trend and during the period 2004-2005 in terms of the long-term trend. After controlling for the long-term and seasonal trends, the residuals of the suicide rate were also calculated (Fig. 1).

We used polynomial distributed lag models to calculate the lag effect of GDP changes on suicidal rate in AFF workers (Fig. 2). Significant inverse correlations between a 10% decrement in GDP and suicide rate in lags 1-4 (lag 1: RR = 1.07, 95% confidence interval [CI] = 1.00-1.15; lag 2: RR = 1.09, 95%CI = 1.04-1.13; lag 3: RR = 1.09, 95%CI = 1.05-1.13; lag 4: RR = 1.07, 95%CI = 1.03-1.11) were observed. The harvesting effect was observed in lags 7 and 8 (lag 7: RR = 0.96, 95%CI = 0.93-1.00; lag 8: RR = 0.95, 95%CI = 0.92-0.99). The overall RR was 1.69 and 95%CI was 1.57 to 1.81, respectively.

This simple but intriguing investigation highlighted the time lag effect of GDP change on the suicidal rate amongst AFF workers in Korea. The decline in GDP, as a marker of macroeconomic recession, affected suicide events in AFF workers with a time lag of between one and four months. Furthermore, the overall RR of suicide was shown to be high



**Fig. 2.** Polynomial distributed lag models. The Relative risks of suicide were calculated as percentage decrement in gross domestic product from previous months.

enough to bring about social concern.

To the best of our knowledge, this is the first investigation on the time lag effect of economic recession on suicide in AFF workers. Macroeconomic recession is often accompanied by decreasing incomes for individuals, which may lead to a reduction in life opportunities and an growing financial burden, thereby increasing the likelihood of other stressful life events [11]. Further, because the AFF working group consists of small-scale industries or individual proprietors, the financial burden could be sharply increased during periods of economic recession. AFF worker output is often perishable, and economic recession can lead to long waits until new or alternative products generate economic benefits. In particular, it can take several months for workers to gain economic benefits from new agricultural products. These economic characteristics of AFF workers support the findings of this study, which states that economic stress increases the risk of suicide in AFF workers for between one and four months. In term of interventions for preventing the suicide amongst AFF workers, this finding suggests that social support should be initiated with consideration of suicide fluctuation linked in economic recession [12].

Tapia Granados and Diez Roux [13,14] indicated the long term trend of death rate caused by traffic injuries and chronic disease such as cardiovascular disease, cancer, liver cirrhosis and respiratory infections increased with economic expansion. Ruhm [15] suggested that lifestyles and health behavioral changes in temporary economic recession might play an important role for the occurrence of such a phenomenon. In contrary to chronic diseases, suicide rates fall in economic expansion and parallel with unemployment ratio [13,14]. Previously, well designed systemic analysis had been undertaken in Korea; Khang et al. [16] highlighted some different trends of death

rate in Korea when compared to other countries. With respect to suicide, they suggested the social supporting system, which plays a major role as the buffer system for suicide fluctuation, as the foremost cause for the presence of main difference when compared to other countries.

The present study has several limitations. We could not fully explain the reason for time lag effect between macroeconomic recession and suicide. Suicide is affected by several risk factors [17]. These include bio-psychosocial risk factors such as mental disorders, alcohol and other substance abuse, physical illness, and family history; environmental risk factors such as social loss, easy access to lethal means, and economic recession; and socio-cultural risk factors such as a lack of social support and a sense of isolation, certain cultural and religious beliefs, and exposure to and influence by others who have died by suicide. Moreover, we did not adjust for these co-risk factors in this model. Because of selected time lags in time series analysis have apparent arbitrariness, there might be lack of ability to replicate finding from the same data [18]. Hence, to avoid the arbitrariness, we permitted the time lag period from 0 to 12 months in model fitting. However, the period of time lag effect could be changed by different model fitting.

Although this investigation has several limitations, if we focus on the fluctuation between macroeconomic recession and suicide, the results of this study might contribute to gain understanding and preventing on suicide amongst AFF workers.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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