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RESEARCH ARTICLE

Association Between Community Social Capital and Suicide Mortality in Rural Areas of Japan: An Evaluation of Temporal Changes

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Abstract:

Background:

Although previous studies have reported that suicide mortality was associated with social capital, the relation between social capital and suicide mortality has remained controversial. Thus, we evaluated the relation between social capital and suicide mortality in rural areas of Japan, and examined the association between temporal changes in social capital and suicide mortality over the last ten years.

Methods:

We examined the Standardized Mortality Ratio (SMR) for suicide for 26 municipalities of Miyazaki Prefecture and used the data to calculate the average suicide SMRs for two five-year periods: an earlier period, 2004–2008; and a later period, 2012–2016. Social capital (social cohesion and social participation of older people) was measured using information from questionnaire surveys. A multiple linear regression analysis of suicide SMR was conducted for each social capital variable, adjusting for potential confounding factors (population density, the proportion of older people, annual divorce rate, unemployment rate, and proportion of workers engaged in primary industries).

Results:

We demonstrated that male suicide SMR for the earlier period was significantly and positively associated with social cohesion after the adjustment of confounding factors. Temporal changes in male suicide SMRs were significantly and negatively associated with temporal changes in the social participation of older people in the adjusted model. No association was found for female suicide SMRs in either period.

Conclusion:

The present findings suggest that the social participation of older people might reduce suicide among males.

Keywords: Suicide, Social capital, Social cohesion, Social participation, Older people, Community.

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1. INTRODUCTION

Suicide is a considerable problem in Japan, and as reported by the World Health Organization, Japan has the highest suicide mortality rates of any country [1]. Furthermore, Japan's suicide mortality rates increased suddenly following the economic crisis at the end of the 20th Century. The number of suicide victims in Japan was over 30,000 in 1998, and the number remained over 30,000 until 2011. Recently, suicide mortality rates in Japan have been declining, however, the number of suicide victims in 2016 was still approximately 20,000 [2]. Suicide mortality rates vary widely among the 47 prefectures in Japan, and Miyazaki Prefecture has the highest rates in Kyushu area. In Miyazaki Prefecture, the suicide rates declined by 33% between 2007, which saw the largest number of suicide, and 2014.

There are many risk factors for suicide, and recently, social capital has been linked to suicide. Subsequently, many studies have examined the association between social capital and mental health [3 - 10], and mortality and suicide rates [10, 11]. This link has been investigated in Europe [12 - 15], North America [16, 17], and Asia (including Japan) [18 - 21]. However, few studies have investigated the link between social capital and suicide in the Asian region. Yamaoka used data from a cross-sectional interview survey conducted in East Asia (in Japan, South Korea, Singapore, five areas of Mainland

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China, and Taiwan) during 2002–2004 and reported that elements of social capital were positively associated with self-reported somatic symptoms and overall well-being [9]. Okamoto *et al.* investigated the association between social capital and suicide rates in 20 administrative municipalities of Tokyo and found that good social trust, which is an element of social capital, is related to low suicide rates [18]. Additionally, previous studies reported that suicidal ideation was associated with social capital [19 - 21]. Yamamura found that both individual- and community-level social trust reduced the probability of considering suicide [19].

On the other hand, Stafford found associations between social capital of the neighborhood and common mental disorders among people living in deprived circumstances. Moreover, elements of bridging social capital, such as contact among local friends, were associated with lower levels of reported of common mental disorders, but elements of bonding social capital, such as attachment to the neighborhood, were associated with higher levels of reported of common mental disorders [4]. Thus, higher bonding social capital is related to higher reporting of common mental disorders. Kushner *et al.* re-analyzed Emil Durkheim's original data on social cohesion and suicide and concluded that suicide rates are often higher among communities with high levels of social cohesion [22]. Therefore, while some studies have demonstrated that good social capital induced good mental health and prevented suicide [3, 6 - 21], other studies have reported the opposite that good social capital is related to poor mental health and high suicide risk [4, 5, 22, 23]. Hence, the relation between social capital and suicide is controversial.

According to Putnam *et al.*, social capital comprises features of social organization (*e.g.*, networks of secondary associations, high levels of interpersonal trust, and norms of mutual aid and reciprocity) that act as resources for individuals and facilitate collective action [24 - 26]. The elements of social capital are separated by structural and cognitive components. The structural component includes externally observable aspects of social organization and is characterized by behavioral manifestations of network connections or civic engagement. The cognitive component reflects subjective attitudes such as trust in others and norms of reciprocity [10]. Therefore, in research about social capital, it is important to evaluate the two components separately.

Since the research of Durkheim, large geographical variations in suicide mortality related to sociodemographic conditions and economic situations have been observed in many countries [27 - 33]. These factors have influenced suicide mortality rates and changed over the years. However, it is unclear whether social capital has a higher impact in areas with higher or lower suicide mortality rates, and during periods with higher or lower suicide mortality rates, as well as whether social capital influences suicide or suicide influences social capital. Moreover, few studies have investigated the link between temporal changes in social capital and suicide mortality. Thus, in this study, we used data from the Miyazaki General Social Survey (MGSS) to investigate the changing tendency of the association between community social capital and suicide mortality rates in the last ten years. We evaluated the association between community social capital and suicide mortality rates separated by an earlier period (2004–2008) and a later period (2012–2016). The earlier (later) period had higher (lower) suicide mortality rates.

2. MATERIALS AND METHODS

2.1. Study Population

Miyazaki Prefecture is located in the Kyushu district of Japan and has 26 municipalities, of which Miyazaki city has the largest, and Nishimera village has the smallest population. Thus, population size varies widely across the 26 municipalities. We used data from the MGSS for 2007 (as the earlier period) and 2014 (as the later period), the Statistics Bureau of the Ministry of Internal Affairs and Communications, and the Ministry of Health Labor and Welfare.

The MGSS is a cross-sectional comprehensive community survey that has been conducted every year since 2004. The method of the survey is described as follows. Participants are selected randomly from residents of each municipality who are older than 20 years using a registered list. Questionnaires are sent to 3,500 subjects by mail every year: 2,050 questionnaires were obtained in 2007 (response rate: 58.6%) and 1,631 in 2014 (response rate: 46.6%) after excluding incomplete questionnaires. The MGSS data was anonymized, did not include personal information, and was published and provided for purposes of a secondary analysis. As the privacy and anonymity of the participants were strictly protected, approval from the institutional review board was not necessary.

2.2. Measurement of Social Capital

Two scales of social capital (social cohesion and social participation of older people) were obtained from the MGSS data. Social cohesion was assessed by the question, "Do you think that your neighborhood area can be connected strongly socially?" The answers are rated on a five-point Likert scale ranging from "can be connected strongly" to "cannot be connected strongly." Social participation of older people was assessed by the question, "Do you think that older people in your neighborhood can participate in social activities (*e.g.*, engagement, hobby, sport, culture, and organization in the community?" The answers are rated on a five-point Likert scale ranging from "can participate actively" to "cannot participate actively." The responses were dichotomized. We used the proportion of respondents who gave a high score for each question to indicate the social capital scale of each municipality, and high scores indicate high social capital.

2.3. Suicide Mortality Rate

We used the Standardized Mortality Ratio (SMR) for each municipality with regard to the differences in gender and age distributions in individual municipality populations. The SMR is an indirect method of adjusting mortality rates, defined as the number of observed deaths in an individual municipality's population divided by the number of expected deaths, compared with gender and the age-matched general population. We obtained suicide mortality rate data from the Ministry of

Health, Labor and Welfare and used the average SMRs for 2004-2008 (earlier period) and 2012-2016 (later period).

2.4. Sociodemographic Factors

Area-based sociodemographic characteristics of all 26 municipalities that might be associated with suicide rate, such as population density [29], proportion of older people [28], annual divorce rate [33], unemployment rate [28], and proportion of workers engaged in primary industries [30], are drawn from the Statistics Bureau of the Ministry of Internal Affairs and Communications. We used these data for the closest survey year available for both the earlier and later periods.

2.5. Statistical Analysis

A descriptive analysis was conducted to describe the profile of the 26 municipalities separated by the earlier and later periods in the analysis. A paired T-test was used to test for differences between the earlier and later periods, and Pearson's correlation coefficients were calculated for social capital scales and suicide SMR, separately for males and females. A multiple linear regression analysis of the suicide SMR was conducted for each social capital scale, adjusting for the potential confounding factors (population density, proportion of older people, annual divorce rate, unemployment rate, and proportion of workers engaged in primary industries). First, we analyzed the data for each period separately. Then, we examined the temporal changes calculated as the scales of the later period divided by the scales of the earlier period. Finally, we evaluated the association between temporal changes in social capital and suicide mortality after adjusting for the potential confounding factors. R for Windows (version R-3.4.4) was used for the statistical analyses, and the significance level was set at less than 0.05 for all of the tests.

3. RESULTS

3.1. Social Capital, Sociodemographic Characteristics, and Suicide SMRs of the 26 Municipalities in Miyazaki Prefecture

Table **1** illustrates social capital, sociodemographic characteristics, and suicide SMRs of the 26 municipalities. We used the average SMRs for the five-year periods, 2004-2008 (earlier period) and 2012-2016 (later period), across the 26 municipalities. The average suicide SMR of the earlier period (2004-2008) was 162±73 (range: 81-414) for males and 153 ±81 (range: 0-395) for females. For the later period (2012-2016), the average suicide SMR was 109±43 (range: 45-206) for males and 97±60 (range: 0-279) for females. Thus, the average suicide SMR in the earlier period was significantly higher than the later period for both genders.

We calculated the proportion of high social capital across the 26 municipalities. The social cohesion was 47±20% (range: 21-100) in the earlier period and 53±25% (range: 0-100) in the later period. In addition, the social participation of older people was 72±13% (range: 50-100) in the earlier period and 61±12% (range: 45–100) in the later period.

The area-based sociodemographic characteristics (population density, proportion of older people, annual divorce rate, unemployment rate, and proportion of workers engaged in primary industries) were described separated by the earlier and later periods and were significantly different between the earlier and later periods, except for annual divorce rate.

Table 1. Social capital, sociodemographic characteristics, and suicide SMRs of the 26 municipalities in Miyazaki Prefecture.

-	**The earlier period (based on 2007)**	**The later period (based on 2014)**
-	**Mean (SD)**	**Mean (SD)**
Social capital scales	-	-
Social cohesion (%)	47 (20)	53 (25)
Social participation of older people (%)	72 (13)	61 (12) *
Sociodemographic characteristics	-	-
Population density (pop./km^2)	143 (145)	135 (144) *
Proportion of older people (%)	28.4 (6.3)	30.6 (4.7) *
Annual divorce rate (%)	2.1 (0.7)	1.9 (0.5)
Unemployment rate (%)	5.1 (1.6)	3.8 (1.3) *
Proportion of workers engaged in primary industries (%)	22.7 (9.6)	21.6 (10.4) *
-	The earlier period (from 2004 to 2008)	The later period (from 2012 to 2016)
Suicide SMR	-	-
Male	162 (73)	109 (43) *
Female	153 (81)	97 (60) *

*:$p<0.05$ (paired T-test).

3.2. The Associations between Social Capital and Suicide SMR Separated by The Earlier and Later Periods

We investigated the associations between social capital scales (social cohesion and social participation of older people) and suicide SMR after adjusting for confounders separated by the earlier and later periods (Table **2**). In the earlier period, only male suicide SMR was significantly and positively associated with social cohesion (β=2.48, p<0.01). However, in the later period, no significant relation was found between social capital scales (social cohesion and social participation of older people) and suicide SMR for males or females using multiple linear regression analysis.

3.3. The Association between Temporal Changes in Social Capital and Suicide SMR

We calculated the temporal change using social capital scales, sociodemographic characteristics, and suicide SMRs of the earlier and later periods (Table **3**). We indicated that temporal changes in male suicide SMR were negatively associated with temporal changes in the social participation of older people after adjusting for the confounding factors (β=-0.7, p<0.05), but not temporal changes in social cohesion (β=0.18, p=0.053).

Table 2. The associations between social cohesion, social participation of older people, and suicide SMR separated by the earlier and later periods in multiple linear regression analysis.

-	The earlier period			
-	Male		Female	
-	β	*P*	β	*P*
Social cohesion (%)*	2.48	0.005	-0.67	0.6
Population density (pop./km^2)	-0.0008	0.5	-0.0005	0.8
Proportion of older people (%)	-0.02	0.66	0.003	0.96
Annual divorce rate (%)	-0.16	0.51	0.08	0.83
Unemployment rate (%)	-0.05	0.66	-0.05	0.8
Proportion of workers engaged in primary industries (%)	-0.01	0.55	0.02	0.56
-	Male		Female	
-	β	P	β	P
Social participation of older people (%)*	-1.66	0.24	2.36	0.2
Population density (pop./km^2)	-0.001	0.44	-0.0004	0.85
Proportion of older people (%)	0.015	0.7	-0.007	0.89
Annual divorce rate (%)	-0.47	0.09	0.22	0.53
Unemployment rate (%)	-0.16	0.28	0.04	0.83
Proportion of workers engaged in primary industries (%)	-0.017	0.49	0.014	0.66

-	The later period			
-	Male		Female	
-	β	*P*	β	*P*
Social cohesion (%)*	0.57	0.29	-0.35	0.69
Population density (pop./km^2)	-0.0008	0.34	0.00002	0.99
Proportion of older people (%)	-0.008	0.81	0.03	0.56
Annual divorce rate (%)	-0.39	0.14	0.2	0.64
Unemployment rate (%)	0.06	0.58	-0.24	0.22
Proportion of workers engaged in primary industries (%)	0.002	0.92	-0.01	0.58
-	Male		Female	
-	β	P	β	P
Social participation of older people (%)*	-1.1	0.12	0.3	0.8
Population density (pop./km^2)	-0.0009	0.26	0.00008	0.95
Proportion of older people (%)	-0.008	0.8	0.03	0.56
Annual divorce rate (%)	-0.35	0.17	0.22	0.61
Unemployment rate (%)	-0.018	0.83	-0.19	0.2
Proportion of workers engaged in primary industries (%)	0.008	0.61	-0.015	0.58

Note: *Adjusted by population density, proportion of older people, annual divorce rate, unemployment rate, and proportion of workers engaged in primary industries.

Table 3. The association between temporal changes in social cohesion, social participation of older people and suicide SMR in multiple linear regression analysis.

-	-	Male		Female	
-	Temporal change*	β	*P*	β	*P*
Suicide SMR	-	-	-	-	-
Male	0.79	-	-	-	-
Female	0.63	-	-	-	-
Social cohesion**	1.2	0.18	0.053	-0.08	0.4
Social participation of older people**	0.87	-0.7	0.04	-0.18	0.6

Note: * Temporal change was calculated as the scales of the later period divided by the scales of the earlier period. **Adjusted by the temporal change in population density, proportion of older people, annual divorce rate, unemployment rate, and proportion of workers engaged in primary industries.

4. DISCUSSION

In this study, we demonstrated that male suicide SMR was significantly and positively associated with social cohesion in the earlier period, but no association was found in the later period. In addition, female suicide SMR was not associated with social cohesion in either period. The difference in the results for the earlier and later periods could be caused by differences between the average suicide SMR of both periods. The average suicide SMR was significantly higher in the earlier period than in the later period. Therefore, social cohesion might influence suicide during the period with higher suicide rates. Moreover, socioeconomic factors might strongly affect suicide during the period with lower suicide rates.

We demonstrated that the higher suicide SMR among males was significantly associated with higher social cohesion in the earlier period. Our result might support previous studies that have showed that suicide rates are often greatest among communities with high levels of social cohesion [22]. However, our findings were inconsistent with other studies. For example, Okamoto *et al*. found that male suicide rates were inversely related to social trust [18]. Kunst *et al*. also reported that male suicide rates were 8% higher in areas with low social capital [12]. We considered why the results from our study and other studies showed an opposite directionality of association. This could be attributed to the different measures of social capital. For example, Okamoto *et al.* used "social trust" as social capital from a single question focus on interpersonal trust asked, "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" [18]. Conversely, we identified "social cohesion" as social capital focus on the ties of community, that could be linked to the definition of social capital from the MGSS.

Social cohesion was associated with suicide rates for males but not for females in the earlier period. Okamoto *et al.* found that male suicide rates were inversely related to social trust, but they did not observe this for females [18]. Kunst *et al.* also reported that suicide rates were 8% higher in areas with low social capital, and males were affected more strongly by social capital than females [12]. Ono *et al.* indicated that community-based suicide prevention programs for preventing suicide and suicide attempts were more effective for males than for females in rural areas [34]. However, a previous study on social capital obtained contrary results [16], and it indicated that area-based social capital was more effective in preventing suicidal ideation and suicide attempts among female students than male students. It argued that social capital might be more important for preventing suicide among females than males. The reason for the different impacts of social capital on suicide based on gender is still unclear. A possible hypothesis is that differences in the traditional gender roles in Japan influence social cohesion and suicide in the earlier period. Traditionally, most males work outside of the home in organizations, which causes psychological distress and requires them to manage social relationships in both the community and their organization. Thus, social cohesion might induce adverse effects for males in the earlier period.

Moreover, we illustrated that suicide SMR was not significantly associated with the social participation of older people in either period. Although many researchers objectively measured the social participation of an individual as a scale of structural social capital, we used the social participation of older people as cognitive social capital, not structural social capital. For example, Han *et al.* classified organizational participation as structural social capital associated with suicidal ideation [21]. Okamoto *et al.* investigated the association between social capital and suicide rates and found suicide rates to be inversely related to social trust, which is classified as cognitive social capital, but not to organizational membership, which is structural social capital [18]. Kunst *et al.* reported that suicide rates were 8% higher in areas with low cognitive social capital, but associations with the structural social capital were in the same direction, but not statistically significant [12]. Langille *et al.* also found significant associations of perceived trustworthiness and helpfulness, which are cognitive social capital, with self-reported suicide ideation and suicide attempts in adolescents, but not with participation with others, which are all structural social capital [16]. Thus, the relation between structural social capital and suicide remains controversial, and further studies measuring social participation objectively as a scale of structural social capital need to be conducted.

This study evaluated the temporal change (the tendency of change between the earlier and later periods) of social capital and suicide SMR. The results indicated that temporal changes in male suicide SMR were negatively associated with temporal changes in the social participation of older people. Suicide mortality rates were influenced by socioeconomic factors and have changed over the years. In general, suicide is related to employment rates and business conditions, and an increase in employment rates and better business conditions are associated with reduced suicide rates. Social participation refers to working in a company and participating in community activities. According to our results, this social participation can be important for older people.

The strength of this study is that it is the first to examine the association between temporal changes in social capital and suicide rates. However, there are several limitations to this study. First, our findings were based on local prefectures, and therefore, generalization is limited. Second, despite a random sampling of residents, the participants might not represent the entire population of Miyazaki prefecture, because the response rate varied across municipalities. Third, the timing of collecting social capital and sociodemographic data did not match entirely because of the limited availability of data. Fourth, other factors, such as income, education attainment, and prevalence and management of mental disorders, were not considered. This was a community-level ecological study that adjusted for limited sociodemographic variables, and therefore, we could not adjust for unknown confounding factors. Fifth, our study adopted only two scales of social capital (social cohesion and social participation of older people) and did not evaluate the strength of social capital. Further studies are required to examine other elements of social capital, and its strength quantitatively. Sixth, due to the ecological nature of this study, we could not determine the causal relationship between social capital and suicide mortality rates. Thus, our results should be interpreted cautiously. Finally, we evaluated the temporal

changes in the association between community social capital and suicide mortality rates only for the last ten years, which is too short a period to evaluate temporal change. Subsequently, a longer study is required to evaluate temporal changes in the association between social capital and suicide mortality.

CONCLUSION

The present findings indicate that the social participation of older people might reduce suicide among males. However, further research is required to confirm these findings. Research is also necessary to measure structural social capital objectively and adjust for income and educational attainment as well as other covariates at the individual level. Such studies may help determine interventions for preventing suicide.

LIST OF ABBREVIATIONS

MGSS	=	The Miyazaki General Social Survey
SMR	=	Standardized Mortality Ratio

AUTHORS' CONTRIBUTIONS

NK performed study design, data collection, data analysis, and paper writing. YK performed paper writing and supervised the research. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

We submitted a request to Miyazaki Prefecture by stating the objectives of this analysis. The MGSS data was anonymized, did not include any personal information. The privacy and anonymity of the participants were strictly protected. Therefore, no ethical approval was needed for this study because it was based on the secondary analysis.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the Suicide Statistics of the Ministry of Health, Labor and Welfare at https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000140901.html, and the National Census of the Statistics Bureau Ministry of Internal Affairs and Communications at http://www.stat.go.jp/data/kokusei/2015/index.html, http://www.stat.go.jp/data/kokusei/2005/index.html.
The datasets used and analyzed concerning social capital are available from the corresponding author, [N.K], on reasonable request. The datasets generated and analyzed concerning study population, suicide mortality rate, and adjustment factors are publicly available from the Ministry of Health, Labor and Welfare, and the Statistics Bureau Ministry of Internal Affairs and Communications.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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