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To Compare is to Despair? A Population-Wide Study of Neighborhood Composition and Suicide in Stockholm

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Abstract

Neighborhood context can change the effect of a socio-demographic attribute on the risk of suicide. Eight hypotheses about the interactions between neighborhood composition, ethnicity, income, and socially disadvantaged propositions are proposed based on social support, social comparison, and social regulation mechanisms. They are tested with a population-based dataset of all adults (1.4 million) who lived in the greater Stockholm area in the 1990s. On one hand, multilevel analysis shows that suicide risk increases with the level of affluence in one's neighborhood, particularly among individuals with low income. This supports the notion that income comparison can have negative consequences. On the other hand, social welfare recipients are less likely to commit suicide when there are other social welfare recipients in the neighborhood. Suicide risk among immigrants decreases with the proportion of co-ethnics in the neighborhood, confirming previous findings on social support and suicide. However, further analyses show that the protection effect of having co-ethnic neighbors is limited to immigrants from countries with low suicide rates. This study shows that administrative data can be used to examine neighborhood effects on rare outcomes. The findings are relevant to the contemporary trends towards rising income inequality and ethnic diversity.

1 Introduction

A person dies by suicide every 40 seconds somewhere in the world (World Health Organization 2014). Durkheim's theory (1897[2002]) on the roles of social integration and regulation remains to be the bedrock of sociology of suicide. Yet despite numerous studies and sociologists' long-time interest, whether neighborhood characteristics have any impact on suicide above and beyond the effects of individual attributes is still debatable (Agerbo, Sterne and Gunnell 2007; Mäkinen 1997). Does what kind of neighbors we have matter for our risk of committing suicide? Does "keeping up with the Joneses" leave us in despair? Can more friends in the neighborhood be lifesaving? Do people care about their neighbors' approval when they are thinking about suicide?

Durkheim's and other early macro-sociological theories (e.g., Gibbs and Martin 1964; Henry and Short 1954) have been criticized for a lack of attention to the macro-micro links. *Le Suicide* has been viewed by some as a 'crude, anti-psychological sociologism that ignores the individuals (Taylor 1994). This lack of specificity about the macro-micro links in the earlier work was partly due to a heavy reliance on aggregate level data. The bulk of ecological studies have mixed findings (see Stack 2000a; Stack 2000b for review): conflicting results have been reported on the macro-relationships between suicide rates and

area-level socioeconomic status (SES; see Rehkopf and Buka 2006 for review); religious denominations (Breault 1986; Pope and Danigelis 1981); unemployment rates (Platt 1984); and female labor force participation (Davis 1981; Hassan and Tan 1989; Stack 1987b). Mäkinen (1997) rightly questions whether social correlates of suicide truly exist when he failed to replicate the results from a large-scale study (Sainsbury, Jenkins and Levey 1980).

Making inference to individual-level processes based on ecological data is always problematic (Robinson 1950). With a large number of potential confounders and differences in geographical units, it is not surprising that the findings are mixed. Less well discussed is the possibility that neighborhood context may change the effects of sociodemographic attributes and consequently, lead to unstable macro relationships. For example, ethnic minority status has been shown to increase risk in predominately white neighborhoods, while it reduces risk in mixed neighborhoods (Neeleman and Wessely 1999). Such interactions can make the proportion of ethnicity minority in the neighborhood to appear to increase suicide rate in some samples but reduce it in others.

The increasing availability of large individual-level datasets and the advances in multilevel analysis allow us to examine the micro-macro links directly. Recent work has provided important insights on the micro-macro links. For instance, the effect of network structures (Bearman and Moody 2004), suicide contagion (Mueller, Abrutyn and Stockton 2015), social regulation (Maimon and Kuhl 2008; Thorlindsson and Bjarnason 1998; van Tubergen, te Grotenhuis and Ultee 2005), and social support (Pescosolido and Georgianna 1989).

This study focuses on the effects of neighborhood compositions: does the distribution of a sociodemographic characteristic in one's neighborhood affect its effect on suicide? First, it is reasonable to expect an individual interprets his/her social position with reference to the social context. Second, such distributions shape opportunities for social interactions. I focus particularly on income and ethnic compositions. Much attention has been given to religious and family integration in the literature, but not much is known about integration along the race/ethnicity and income dimensions. The increases in income inequality and ethnic diversity in many societies make the results relevant to policy debates.

To study such neighborhood processes, it is crucial to use ecological units that are theoretically relevant (Diez Roux 2001). Social interactions are unlikely to span large areas. Unfortunately, datasets that have enough statistical power to study suicide deaths usually only have information on large administrative boundaries, such as counties and municipalities. This may explain why existing multilevel studies on suicide found no or limited evidence of cross-level interactions when the geographical units were large (Agerbo, Sterne and Gunnell 2007; Martikainen, Mäki and Blomgren 2004; van Tubergen, te Grotenhuis and Ultee 2005).

This study is based on a population-wide dataset with detailed individual-level information on all 1.4 million adults who ever lived in the greater Stockholm metropolitan area between 1990 and 1998. It was compiled by Statistics Sweden by merging administrative and population registers. The data have detailed socio-demographic information on the individuals and are of very high quality; non-responses and missing items are virtually non-

existent. A residential variable was specifically created to identify socially defined neighborhoods (N=903; average population <2000), which is smaller than the geographical units used in other multi-level studies of suicide deaths (average population 8000–60,000). Because the dataset was based on administrative data, information on the actual social ties is unavailable. However, its large size and the availability of small geographical units make it suitable to study the effects of neighborhood compositions.

2 Roadmap

Against this background, I first explore mechanisms through which neighborhood compositions may modulate the effects of the individual characteristics. I focus particularly on ethnicity, income and socially disadvantaged propositions and propose a set of hypotheses that are testable with the Stockholm dataset. This is followed by a more detailed description of the data and the results. Finally, I explore more broadly the findings' implications on neighborhood processes and health.

To anticipate the main findings, this study shows that the effects of individual socio-demographic characteristics on suicide depend on how those factors are distributed in one's neighborhood. Having more neighbors from the same foreign countries tends to reduce suicide risk among ethnic minorities. Yet the protective effect is limited to groups with low suicide rates in the home countries. Social welfare recipients are found to have lower suicide risk when more of their neighbors are also social welfare recipients. In contrast, having rich neighbors increases suicide risk, particularly among those with low income. Taken together, the findings provide individual-level evidence for what Durkheim long argued: social context can have positive or negative effects on suicide. Macro-level associations are the aggregations of neighborhood-, individual-, and cross-level interaction effects, and therefore can vary greatly across samples. This helps explain the conflicting macro-level findings in the literature.

3 Neighborhood Mechanisms

3.1 Ethnicity

In Durkheim's theory, suicide rates are high when social integration or social regulation is either too high or too low. Whether social integration and regulation are distinct concepts is heavily debated (Johnson 1965; Pope 1976). Social regulation arguably cannot take place unless the individual is well embedded in social relations. Therefore, social integration precedes social regulation and perhaps has a more fundamental role. Attempts to measure social integration vary greatly in the ways it is operationalized. Aggregate-level studies use a wide range of proxies of social integration. For example, since modernized societies are assumed to be less integrated, indicators of modernization have been used to approximate the level of social integration. They include measures of economic development, unemployment, urbanization and industrialization, and the results are mixed (see Stack 2000b for review). Indicators of family and religious integration are also well studied, such as divorce rates, church attendance rates and proportions of the population in different religious denominations. While divorce rates are generally found to be positively associated with suicide rates, the findings on religious denominations are heavily contested and the

results depend on what control variables are included (Stack 2000b). There were also attempts to create indices of social fragmentation, but the results are also contradictory (Collings et al. 2009; Congdon 1996).

At the individual level, the operationalization of integration is less diverse and typically measures the utility/density of social ties. It is commonly accepted that a key role of social integration is to provide social support (Berkman et al. 2000). Following Durkheim, Pescosolido's network theory (1989) proposes that the integrative power of religion arises from the power of a religious affiliation to engage individuals in a stable social network. Bearman and Moody (2004) provide evidence that a stable social network reduces suicide risk. Psychological research has consistently demonstrated the effect of social support on suicide (e.g., Heikkinen, Aro and Lönnqvist 1994; Liu et al., 2007). The lack of social support is often included as a key vulnerability in diathesis-stress models of suicide that are commonly found in the psychological and medical literature.

In sum, empirical evidence suggests the availability of companionship and support from social networks can be a potential mechanism that links neighborhood contexts and suicide rates. Unfortunately, information on the presence of social ties is not available from register-based data. However, it is well known that race/ethnicity is an important determinant on the likelihood of social tie formation (McPherson, Smith-Lovin and Cook 2001). As mentioned above, Neeleman and Wessely (1999) show that having more ethnic minority neighbors decreases suicide rates among minorities. Similarly, Campbell and Troyer (2007) find that American Indian adults have lower rates of suicide ideation when they lived in a neighborhood with a bigger minority population. Following these previous studies, the following hypothesis assumes there is a positive association between the size of an ethnic minority group in a neighborhood and the availability of social support.

Hypothesis 1—The social support mechanism suggests that having more co-ethnic neighbors reduces the suicide risk of immigrants.

This is equivalent to predicting a negative cross-level interaction between an ethnic minority origin and the proportion of neighbors from the same ethnic group.

Yet social ties may provide different levels of protection against suicide depending on the social groups. In some cases (e.g., suicide contagion), they may even be harmful (Mueller, Abrutyn and Stockton 2015). This is because social ties do not only provide social support; they can also affect health by providing normative guidance (Berkman et al. 2000). This clarifies some of the confusion caused by Durkheim's separate treatments of social integration and regulation (Johnson 1965; Pescosolido and Georgianna 1989; Thorlindsson and Bjarnason 1998). Psychological research shows that self-reported normative pressure against suicide reduces suicide risk (e.g., Linehan et al. 2000). Van Tubergen, te Grotenhuis and Ultee (2005) take up the regulative function of social networks as an alternative to the network-support mechanism. They found that the proportion of church members in the community lowers the suicide risk among both members and non-members. This finding is interpreted as supportive of the claim that religious communities reduce suicide risk by providing community norms that can extend to non-members. Maimon and Kuhl (2008) also

find that the proportion of religiously conservative residents in a neighborhood reduces youth suicide attempts.

In other words, unlike the effect of social support, which is generally considered to be beneficial, group norms may increase suicide risk. While religious norms prohibit suicide, exposure to suicide can increase suicide risk by making it a more acceptable solution to one's problems (Shneidman 1987). Although Durkheim dismissed imitation as a potential explanation of regional patterns of suicide rates, empirical studies have consistently supported that exposure to suicide increases risk of suicide, especially among youths (Stack 1987a). It has also been shown that exposure to suicide in the workplace is associated with suicide deaths among adults (Hedström, Liu and Nordvik. 2008). Baller and Richardson (2002) argue imitation can generate geographical patterns of suicide even when multiple dimensions of social integration are controlled for. Interestingly, Mueller and Abrutyn (2015) show that only a friend's suicide attempts and ideation have any impact on one's suicidality only when disclosed. Their finding is strong evidence of a social influence process, possibly related to imitation and group values about suicide.

Immigrants' suicide rates are known to correlate with suicide rates in the home countries (Johansson et al. 1997; Kliewer and Ward 1988). It is beyond the scope of this study to examine the many biological, historical, social and cultural factors (e.g., all aspects of social integration/regulation) that might account for cross-country differences in suicide rates. Instead, this study tests a specific hypothesis: the ability of an immigrant network to protect against suicide varies with the prevalence of suicide in the home country.

Among the ethnic groups in Stockholm, the Finish and the Eastern Europeans have higher suicide rates in their country of origin than Sweden: Suicide rates in Eastern Europe and Finland were about 27 per 100,000 and 20 per 100,000 respectively, compared to 13 per 100,000 in Sweden during the study period (Liu, 2009). Western countries' rate of 15 per 100,000 is only slightly higher than Sweden's 13 per 100,000. In contrast, Southern Europe had lower suicide rates of about 9 per 100,000. Reported suicide rates were extremely low in the Middle East (<5 per 100,000). It should be noted that there is a lack of mortality data from Middle Eastern countries, and the validity of the existing statistics has been questioned. Given the high suicide rates in the home countries, I expect the proportions of Eastern Europeans and Finnish in a neighborhood offer the least reduction in suicide risk of their immigrants. In contrast, having co-ethnics from Southern Europe and the Middle East should be particularly protective.

Hypothesis 2—The extent to which the proportion of neighbors from the same foreign countries reduces a minority's suicide risk is negatively correlated with the suicide rates in the home countries. Having neighbors from the same region offers the least protection against suicide among individuals from Eastern European countries. It is followed by those from Finland and Western countries. The protective effect of having neighbors from the same region is strongest among those individuals from Southern Europe and the Middle East.

3.2 Income Inequality

Although his focus was primarily on religious and familial integration, Durkheim briefly touched on the effect of economic positions on suicide as an example of anomic suicides. Durkheim contended that in times of economic recessions and expansions, the mismatch between aspiration and reality leads to high suicide rates. Durkheim's followers have proposed alternative theories on the relationship between the economy and suicide (c.f. Lester 2001). For example, Henry and Short (1954) expand Durkheim's theory by including homicide in addition to suicide as the response to thwarted aspirations. Individuals of high socioeconomic status turn their aggression inward and committing suicide during economic recessions. In contrast, individuals of low socioeconomic status turn their frustrations outward and commit homicide during economic expansions.

Contrary to what Durkheim predicted, empirical studies generally find that suicide rates rise during economic recessions and fall during economic expansions (e.g., Luo et al. 2011; Marshall and Hodge 1981). Such patterns appear to support Henry and Short's theory. However, there is little evidence that suicides concentrated among those of high status as predicted by their theory (Stack 2000a). However, Durkheim's and Henry and Short's theories are about economic changes and do not have specific predictions about the effect of economic inequality in cross-sectional data. In fact, Durkheim saw poverty as a form of social restraint that should reduce suicide risk; thus inequality outside times of economic expansions and contractions should not be an issue in Durkheim's view. However, recent work suggests income inequality have direct impacts on health, though the exact mechanisms are debated (Lynch et al. 2000). For example, the relationship between income inequality, homicide, and other violent crimes has received much attention (e.g., Blau and Blau 1982; Messner 1989).

One of the proposed mechanisms that link income inequality and health is the relative income hypothesis (Rodgers 2002; Wagstaff and van Doorslaer 2000; Wilkinson 1996). A high level of income inequality means the majority have incomes that are relatively low compared to the affluent. Despite the weak findings on the effects of relative income on health in general (see Wagstaff and van Doorslaer 2000), there is some empirical support for the relative income hypothesis in suicide research: Hawton et al. (2001) find that people who live in wealthy areas are more likely to cite financial difficulties as a reason for deliberate self-harm. Platt and Kreitman (1990) show that the risk of self-harm among the unemployed in Edinburgh decreased when the unemployment rates rose in the 1990s. As Wagstaff and van Doorslaer (2000) argue, only individual-level data can arbitrate between the relative income hypothesis and alternative explanations, e.g., the absolute income hypothesis (Rodgers 2002). If relative income matters, we should expect an increase in the average level of income in the neighborhood to increase everyone's suicide risk, even when the effect of personal income is controlled for. This is because everyone is relatively worse off when neighborhood income is high (Wagstaff and van Doorslaer 2000). In contrast, the absolute income hypothesis states that if there is a concave relationship between absolute income and health at the individual level, we will observe a negative correlation between income inequality and health at the population level. This is because the "deficit" of health caused by the high concentration of poor individuals cannot be fully compensated by the small

gains in the health of their wealthy counterparts. If the association between income inequality and health is simply caused by this concave relationship between income and health, controlling for the non-linear relationship at the individual level will eliminate the association between income inequality and health.

Hypothesis 3—The social comparison mechanism predicts that median neighborhood income increases suicide risk net of the effect of individual income.

While the relative income hypothesis predicts high average neighborhood income makes everyone worse off, there are reasons to expect it to be particularly impactful on individuals at the low end of the income distribution. The most obvious reason is that there can be a dosage-response relationship between low relative income and suicide. Second, although upward comparison can have a positive effect, such as providing motivation and information (Festinger 1954), the negative impact of upward comparison on self-esteem has been consistently demonstrated (Marsh 1987). Numerous studies have shown the link between low self-esteem, depression and suicide (e.g., Overholser et al. 1995). Third, although individuals have some say in who should be their reference group (Merton and Rossi 1950), the social environment may impose unwanted comparison (Wood 1989). Lastly, downward comparison, i.e. comparing oneself with someone of lower status, can be an important defensive mechanism that protects one's self-esteem (Wills 1981). Taken together, we have another prediction of the relative income hypothesis: the suicide risk of people in the low end of the income distribution is particularly sensitive to the level of income in the neighborhood.

Hypothesis 4—The social comparison mechanism predicts that neighborhood median income increases the suicide risks of individuals with low income in particular.

This is equivalent to predicting a negative interaction between personal income and neighborhood median income, i.e., the higher the personal income, the smaller the increase in suicide risk when neighborhood income increases.

An alternative hypothesis is that neighborhood income as an indicator of community-level resources. Many empirical studies of the social correlates of suicide are implicitly or explicitly making the neo-materialistic assumption that a high neighborhood SES protects us from bad health outcomes. It is assumed that wealthy neighborhoods make more resources available to everyone, and therefore they are good for health. This predicts the exact opposite of what the relative income hypothesis suggests: Hypothesis 5: Net of the effect of personal income, a high median income in the neighborhood reduces everyone's suicide risk by increasing shared resources.

Neighborhood resources can have heterogeneous treatment effects. Following the long tradition of research on concentrated poverty (Wilson 1987), one can postulate that people of low income suffer from a "double jeopardy". Unlike their affluent neighbors, poor people cannot buffer the impact of a lack of resources in their neighborhoods with personal resources. Hence, we should expect a high neighborhood median income to be more beneficial to people of low income than people of high income.

Hypothesis 6—A high median income in the neighborhood reduces the suicide risk of individuals with low income.

This is to predict a positive interaction effect between personal income and neighborhood median income, i.e., the higher the personal income, the smaller the reduction in suicide risk that neighborhood resources can bring.

Other than the absolute income hypothesis and relative income hypothesis, social cohesion has been proposed as an explanation of the link between income inequality and health. I.e., income inequality is bad for everyone's health because it erodes social capital/social integration (Kawachi et al. 1997; Wilkinson 1996). Existing studies on the correlation between income inequality and suicide rates have mixed findings (e.g., Andres 2005; Blakely, Atkinson and O'Dea 2003). The problem of the existing studies is that they tend to focus on ecological relationships and do not control for the effect of personal income. We cannot tell whether any observed association between income inequality and suicide is merely caused by the presence of a high concentration of low-income persons in the high inequality communities, as proposed by the absolute income hypothesis. Nor can we tell whether it is caused by the low relative income for most people when income inequality is high, as the relative income hypothesis proposes. To arbitrate between the social cohesion explanation, the relative income hypothesis and the absolute income hypothesis, we need to simultaneously estimate the effects of income inequality, average level of income in the community, and personal income.

Hypothesis 7—The social cohesion mechanism predicts that income inequality is positively associated with suicide risk, net of the effects of individual income and neighborhood median income.

3.3 Disadvantaged Groups

Social comparison is not limited to income. To test whether cross-level interactions also extend to other social hierarchies, I test the cross-level effects of receiving social welfare, unemployment, and single parenthood. Gibbs and Martin's (1964) status integration theory suggests that people who deviate from the "typical" status or role configurations have a high suicide risk because of stress. There is no reason that only rare combinations of roles is stressful; any minority status may affect health negatively because of discrimination and stress (Karlsen and Nazroo 2002). The presence of similarly disadvantaged neighbors has been shown to mitigate the negative effect of stigma and discrimination by providing a reference group in similar situations (Crocker and Major 1989). At the same time, having neighbors in similar situations may reduce suicide risk through providing a network of social support.

Hypothesis 8—Disadvantaged groups, such as people who are receiving social welfare, unemployed, or single parents, have a lower suicide risk when there are more similar neighbors in the neighborhood.

4 Data and Methods

4.1 Sample

The dataset used in this study has information on the entire adult population (ages 16 to 65) who lived in the larger Stockholm metropolitan area between 1990 and 1998. The mean number of years of observation is 8.1. Annual demographic and socioeconomic information are available on all individuals in the dataset (1.4 million individuals and 10 million person-years).

Statistics Sweden divided the Stockholm metropolitan area into 878 Small Area Market Statistics (SAMS) areas to contain socially homogeneous residential areas. I exclude SAMS areas with fewer than 500 residents because neighborhood-level estimates based on small numbers of residents are unreliable. A robustness check shows that including all SAMs areas does not alter the results of in any substantive way. The multilevel analysis is based on the 578 SAMS areas with 500 or more residents; the mean population size is 2,397. To reduce the computational power required and model complexity for analyzing such a large database (10 million person-years), a control population was constructed by randomly selecting a one-year record (year t) from each of the adults in the data who had not committed suicide by the end of the study period. For those adults who committed suicide, data from the year prior to death (year t) were used. The usual practice of studies using large administrative datasets is to select a fixed number of controls per case. This current procedure has the advantage of using information from all individuals and thus maximizing the representation of the neighborhoods, which is appropriate given the aim of this study.

Excluding individuals with missing data on the individual-level variables ($N=809$, 0.06%), the analytic dataset has 1,384,473 individuals (691,062 men and 693,411 women). Of the total, 2,221 committed suicide (1,430 men and 791 women).

4.2 Measures

The outcome measure is whether the person committed suicide in year $t+1$. Given that the dataset used in the analyses is at the person-level rather than the person-year level, the dependent variable of the multi-level logistic regression model is equivalent to the log-odds for a person to commit suicide between 1991 and 1999. Information from the National Cause of Death Register (1991–1999) is used to identify the suicide cases. I follow the usual practice in suicide epidemiology and define a suicide on the basis of the following cause-of-death codes: E950-E959 or E980-E989 for 1991–1996 (International Classification of Diseases, 9th revision) and X60-X84, Y87.0, or Y10-Y34 for 1997–1999 (International Classification of Diseases, 10th revision).

Table 1 provides the definitions and descriptive statistics of the variables. Cross-level interaction terms between individual-level variables and their average values in the neighborhood are used to test the proposed hypotheses. The interaction between personal income and neighborhood median income is used to test the potentially heterogeneous effect of relative income. Personal income and neighborhood median income in year t are log-transformed because of their skewed distribution. Logged personal income is grand mean centered before being entered the model. The interactions between the country of origin

variables and the percentages of neighbors from the same region are used to test the hypotheses about social support and normative values about suicide. I classify the countries of origin into six groups following Hjern and Allebeck (2002). The interactions between being unemployed, a single parent, and receiving social welfare benefits and their prevalence in the neighborhood in year t are used to test whether having neighbors in similar situations can buffer the negative impact of belonging to a disadvantaged group.

Additionally, age and gender are included as control variables since they are consistently associated with suicide. Year is included to control for fluctuations in suicide rates over time. Born in “other countries” in the scheme of Hjern and Allebeck (2002) is included as a control variable, but no cross-level interaction is expected. Logged population and population density per kilometer are used to control for the size and urbanicity of the neighborhood. All neighborhood-level variables are grand mean centered.

To evaluate the effect of income inequality, a Gini coefficient is calculated for each SAMS area. Alternative measures of income inequality are used to test whether the result depends on the choice of inequality indices (Table A1 and A2 in the Appendix).

4.3 Statistical Methods

Empirical Bayes standardized mortality ratios (EBSMR; Clayton and Kaldor 1987) are used to establish that there are sufficient variations in suicide risk across the SAMS areas (See supplementary methods in the Appendix). 2-level logistic hierarchical regression models are fitted with the HLM 6 software (Scientific Software International, Inc., Lincolnwood, IL). The intercept and coefficients of all individual-level variables, except gender, age, and year, are allowed to have a random component. Results from a unit-specific model with robust standard errors are reported to account for the remaining possibility of spatial clustering in the errors.

5 Results

Figure 1 is a map of the EBSMRs. An EBSMR higher than 100 indicates excess risk; lower than 100 indicates reduced risk. The map shows that there is a large variation in suicide rates across the neighborhoods despite the relatively small size of the Stockholm metropolitan area. The level of spatial autocorrelation in suicide rates adjusted by age and gender is statistically insignificant. See Appendix for a more detailed discussion on the spatial variations.

Table 2 reports the multilevel regression results of the main model (Model III in Table 3). Except the Gini Coefficient, the model includes all the individual-, neighborhood- and cross-level interactions specified in Table 1.

5.1 Ethnicity (Hypotheses 1& 2)

There is some partial support for Hypothesis 1, which predicts having the proportion of co-ethnics in the neighborhood reduces suicide risk through the provision of social support. With the exception of the Eastern Europeans, the percentage of co-ethnics in a neighborhood reduces the suicide risk of immigrants, i.e., the cross-level interactions have the negative

sign as predicted. However, only the interaction between being born in Southern Europe and percentage of neighbors who were also born in Southern Europe is statistically significant. Instead of a general protective effect as proposed by Hypothesis 1, Hypothesis 2 suggests that ethnic networks have heterogeneous effects that correlate with the suicide rates in the home countries. Accordingly, the proportion of neighbors from the same home countries should offer the least reduction of suicide risk among the Eastern Europeans, followed by individuals from Finland and the Western countries. Southern European and Middle Eastern populations should benefit most from having neighbors also from those areas.

The findings are largely consistent with Hypothesis 2. The cross-level interaction for Eastern Europe has a positive coefficient. It means having the proportion of Eastern European neighbors increases rather than reduces the suicide risk of Eastern Europeans, although the result does not reach statistical significance ($p=0.2$). It is followed by the small negative coefficients for those individuals born in Finland and Western countries. As predicted, the proportion of co-ethnics leads to the greatest reduction of risk among the Southern European population. While the sizes of four of the five interaction parameters follow the predicted order, the Middle Eastern population is the exception. Despite the low suicide rate in the region, the proportion of Middle Eastern neighbors is not associated with a strong reduction in suicide risk among the Middle Eastern population. Unfortunately, the unreliability of the suicide statistics in the Middle East makes it difficult to interpret this result.

Figure 2(a) illustrates the effect of having neighbors from Southern Europe. Comparing two persons born in Southern Europe with the same measured personal and other neighborhood attributes, the person who lives in a neighborhood with very few residents from Southern Europe (5th percentile among the SAMS) has about four times the risk (0.4% vs 0.01%) of committing suicide than the one who lives in a neighborhood with a higher percentage (95th percentile) of neighbors from Southern Europe.

Unlike what van Tubergen et al (2005) have found about having church members in the community, the protective effect of having Southern European neighbors does not spill over to the native-born, nor to other ethnic groups. The percentage of residents born in Southern Europe has a statistically significant positive association with the suicide risk of the native born (O.R.=1.05, $p=0.03$). A supplementary analysis (results not shown) shows that none of the other ethnicities has a statistically significant interaction with the percentage born in Southern Europe variable.

5.2 Income Inequality (Hypotheses 3–7)

A series of models are used to test hypotheses 3 to 7. All the models control for the effects of the other variables in the main model (Table 2, also Model III in Table 3). Table 3 only shows the results on the income parameters as the coefficients of the other variables are almost identical across models.

Hypothesis 3 predicts a positive relationship between neighborhood median income and suicide while Hypothesis 5 predicts a negative relationship. The results support Hypothesis 3. Logged neighborhood median income increases suicide risk even after controlling for a host of individual and neighborhood-level variables, including other SES indicators (Model

I). The positive association remains robust after controlling for the effect of logged personal income (Model II). It suggests that relative income is more relevant to suicide risk than neighborhood resources. Measuring income in quadratic form instead of logarithmically does not alter the conclusion (Table A3). Thus, the absolute income hypothesis does not explain the association between neighborhood median income and suicide.

Hypothesis 4 predicts individuals with low income are more adversely affected by a high neighborhood median income than people with high income due to the unfavorable social comparison. Model III shows that the interaction between logged personal income and logged neighborhood median income is negative as predicted ($O.R.=0.737$; $p<0.05$).

Figure 2(b) illustrates the interaction effect. It plots the levels of predicted suicide risk among individuals at the 5th and the 95th percentile of the income distribution of the Stockholm population. The suicide risk of those with low income increases more rapidly with neighborhood median income than those with high income. The result is consistent with a dosage-response relationship between relative income and suicide risk. However, people with high income is still affected by relative income. A supplementary analysis shows that even the richest 10% are negatively affected by neighborhood median income (Table A4).

The negative interaction between median neighborhood income and personal income contradicts Hypothesis 6, which predicts a positive interaction due to a buffering effect of shared resources. In fact, Figure 2(b) seems to indicate that, instead of being particularly vulnerable due to “double jeopardy”, low-income people in poor neighborhoods have a lower suicide risk than their wealthy counterparts. A robustness check confirms that those who earned less than the 10th percentile of the income distribution have a lower suicide risk than their neighbors who earned more ($O.R.=0.82$, $p=0.03$, Table A5) in the poorest neighborhoods (lowest quintile of the neighborhood median income distribution).

Models IV – VII unpack the association between income inequality and suicide (Hypothesis 7). Model IV shows that the Gini coefficient does seem to have a positive relationship with suicide risk when the personal- and neighborhood-level income are not included in the model. The association persists after controlling for personal income (Model V). Modeling personal income as a quadratic function does not alter the result (result not shown). Thus, the positive effect of the Gini Coefficient cannot be explained by a curvilinear relationship between income and health, i.e., the absolute income hypothesis. However, controlling for personal income alone does not control for the effect of relative income, which requires controlling for neighborhood median income and its interaction with personal income (Hypotheses 3& 4). The results show that inequality is no longer statistically significant once the effect of relative income is controlled for (Models VI& VII). In other words, the association between income inequality and suicide is mediated by relative income, and the results do not support the claim that income inequality directly increases suicide risk through erosion of social capital/integration. Using other measures of income inequality yield the same result (Table A2). In sum, among the hypotheses about income, only Hypotheses 3 and 4, the two concerning social comparison, are supported.

5.3 Disadvantaged Groups (Hypothesis 8)

Hypothesis 8 suggests that disadvantaged groups have a lower suicide risk when there are more similar neighbors in the same positions, which can be due to the effects of social comparison and/or social support. There is some limited support for the hypothesis. The interactions between unemployment, single parenthood, and receiving social welfare and the percentages of neighbors in the same situations all have the predicted negative sign. However, only the interaction between receiving social welfare and the percentage of neighbors also receiving social welfare benefits is statistically significant.

Figure 2(c) illustrates how the suicide risk of social welfare recipients depends on how many recipients there were in a neighborhood. The probability of a social welfare recipient living in a neighborhood with very few social welfare recipients (5th percentile among the SAMs) to commit suicide during the study period is 0.43%. In comparison, a social welfare recipient with the same attributes living in a neighborhood with the highest concentration of social welfare recipients (95th percentile among the SAMs) has 16% less chance of committing suicide (0.36%).

The lack of significant cross-level interactions concerning unemployment status and single parenthood may be due to their lack of variations across the SAMS areas, which make cross-level effects difficult to estimate. As Table 1 shows, the standard deviations of percentage unemployed and percentage being a single parent in the neighborhood are only half the size of the standard deviation of percentage receiving social welfare benefits.

5.4 Other Covariates

Table 2 reports the coefficients of other covariates. At the individual-level, age and gender have the expected effect. Suicide risk increases with age and is lower among women than men. Year reduces suicide risk. Among these three potential indicators of social disadvantage, receiving social welfare benefits is the only one with a statistically significant association with suicide at the individual level. In contrast, people who were unemployment benefits recipients might come from more diverse backgrounds in Sweden, perhaps making unemployment less relevant to suicide. Having children is known to be a protective factor against suicide, which may explain the negative, albeit statistically insignificant, association between being a single parent and suicide.

As expected, those born in Finland have a higher suicide risk, while those born in Southern Europe, the Middle East, and other non-European countries have a lower risk compared to the native-born. The suicide risk among individuals born in a Western country is not statistically significantly different from that of the local born, which is not surprising given the similar suicide rates. Surprisingly, suicide risk among those born in Eastern Europe does not differ statistically significantly from the native-born.

Logged personal income does not have a statistically significant effect—personal income has either a positive or negative effect depending on neighborhood median income and thus has no clear relationship with suicide on average. It demonstrates that the absence of an association at the individual level does not mean the cross-level interaction is irrelevant.

At the neighborhood level, the percentage of residents who are unemployed and the percentage receiving social welfare have a marginally significant positive effect on suicide risk. The effect of percentage of single parents is also positive but is statistically insignificant. Among the ethnicity variables, only the percentage born in Southern Europe has a statistically significant positive association with suicide risk, although being born in Southern Europe is negatively associated with suicide at the individual level. Logged population and population density do not have any effect.

6 Discussion

Following calls to develop mechanisms connecting neighborhood characteristics and health outcomes (e.g., Entwisle 2007; Sampson, Morenoff and Gannon-Rowley 2002), this study examines how the effects of socio-demographic attributes on suicide vary with neighborhood composition. Results from multi-level analyses show that suicide risk of social welfare recipients decreases when the proportion of social welfare recipients in the neighborhood increases. Individuals with low income have a higher risk of suicide when they live among rich neighbors, net of the effect of personal income. Having neighbors from the same home countries reduces suicide risk among ethnic minorities, but the level of reduction depends on the suicide rates in the home countries. Through these interactions, neighborhood composition affects suicide risk above and beyond the effects of the characteristics of the residents. Durkheim argued that suicide rates increase when social integration/ regulation are too low or too high. The current study highlights another source of complexity: a neighborhood context can be a risk or a protective factor, depending on individual characteristics.

In a time of rising income inequality in many countries, research on its effect on health is highly relevant. This study shows that relative income matters more to suicide than absolute income and neighborhood resources. The results are consistent with the notion that social comparison can be an important mechanism, in addition to the better-known effect of social support. Considering these alternative mechanisms can enrich the research agenda on social networks and health (Tsai and Papachristos 2015). In this study, income inequality does not have any statistically significant effect when the effect of relative income is controlled for. This is not to say income inequality does not affect suicide risk; just that in this data the causal pathway linking income inequality and suicide is likely to be relative income. Moreover, the current findings do not imply social cohesion has no impact on suicide. Studies with more direct measures have shown that social cohesion and collective efficacy are particularly relevant to crime (Sampson, Morenoff and Gannon-Rowley 2002). Similar research with direct measures of social cohesion, i.e., the intensity and quality of neighborhood interactions, are needed to fully evaluate its impact on suicidality.

Among different health outcomes, there are reasons to suspect suicide is particularly affected by subjective status. Depression is a major risk factor for suicide (Lonnqvist 2000). Beck's (2005) cognitive theory proposes depression is the result of negative views of oneself, the world, and the future. Social comparison is crucial to how these views are formed. Subjective status may also be relevant to psychological health in general—research has shown neighbors' income lowers the level of self-reported happiness (Luttmer 2005).

Compared to research on homicide, income inequality has received much less attention in suicide research. Research using new data and methods (e.g., Chon 2013) should be used to test integrated models of inequality, self-directed and other-directed violence.

Increasing ethnic diversity is another trend that has been observed in many societies. This study finds that the protective effect of having neighbors of the same ethnic origin varies with the suicide rates in the home countries. Future studies on geographical patterns of suicide and ethnicity should consider the dynamics between network density and prevalence of suicide in the home countries. Social learning theory is prominent in the literature on suicide contagion (Mueller and Abrutyn, 2015). The current results are consistent with the literature on social learning and delinquent behaviors. Many factors that can affect an ethnic group's values about suicide, e.g., religiosity (Stack and Kposowa 2011) are unmeasured in the current study and should be further investigated. Besides, this study does not control for factors that can affect the assimilation process. Most importantly, this study does not control for the level of social integration across ethnic groups. Studies with more detailed information on the social ties (e.g., Maimon and Kuhl 2008) and the level of assimilation (e.g., Wadsworth and Kubrin 2007) are needed to disentangle the social integration and regulation effects.

Most of the predictors in this study have opposite effects at the individual- and neighborhood-levels. It demonstrates that one can easily commit an ecological fallacy (Robinson 1950) in inferring individual-level processes from aggregate-level findings. Moreover, this study shows that the effect of an individual attribute depends on the social context. Under such contextual dependencies, macro-level correlations can vary greatly across samples, and are very sensitive to the choice of geographical units. Instead of trying to identify stable social correlates of suicide, recent sociological studies on suicide respond to the need for middle range theories (e.g., Merton, 1968) and focuses on the underlying mechanisms (e.g., Pescosolido and Georgianna 1989; Van Tubergen, te Grotenhuis and Ultee, 2005; Mueller, Abrutyn and Stockton 2015). The main obstacle is a lack of suitable data. Administrative datasets have the advantage of a complete survey of the population, and thus the statistical power to study rare outcomes such as suicide. This study contributes to the literature by showing administrative data can be used to study the effect of small-area interaction on rare outcomes. In contrast, survey data may have more detailed information on the actual social ties as well as health behaviors compared to administrative datasets. Efforts to merge survey data to death records represent new opportunities to study suicidal behavior. Such data and other innovations are needed to shed light on the mechanisms.

This study has other limitations. First, the SAMS areas are not direct measures of the actual fields of neighborhood interactions. Thus, the effects of neighborhood compositions may have been underestimated. Second, this study only focuses on the effects of neighborhood compositions; other social settings are beyond its scope. Third, country of origin is not a direct measure of ethnicity. Third, there is no information about suicides committed by the individuals who moved outside the Stockholm metropolitan area. Fourth, like any observational study, there may be omitted variables at the individual and neighborhood levels. It is possible that self-selection into neighborhoods according to some unobserved characteristics could have biased the results. Sweden's egalitarian housing policies, such as

the availability of public housing with no eligibility requirements and collective rent setting, make individual characteristics less important in sorting people into different neighborhoods than in other countries (SABO, 2016). It is conceivable that such policies lead to other forms of selection. However, self- or social selection is less of a concern in this study than in ecological studies because its goal is to test specific hypotheses on neighborhood interactions, rather than to yield crude estimates of area-level effects. Lastly, the findings may not generalize to countries that are vastly different from Sweden. E.g., neighborhood resources might be important to suicide in less developed countries. The mechanisms of social comparison, social integration, and social regulation may be universal; but how they affect suicide risk depends on the local contexts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Empirical Bayes Estimated Standard Mortality Ratio in Stockholm Metropolitan Area,
1991–1999

Figure 2.
Interactions between individual and neighborhood attributes on suicide

Table 1

Descriptive statistics of the individual-level and neighborhood-level variables

Individual-level (N=1,383,009)		Neighborhood-level (N=578)	
	mean (s.d.)		mean (s.d.)
(A) Individual and neighborhood variables with cross-level interaction terms:			
Logged disposable income ^a	0.95 (0.93)	Logged median disposable income of the neighborhood	1.12 (0.12)
Received unemployment benefits	0.09	% received unemployment benefits	0.08 (0.03)
Received social welfare benefits	0.1	% received welfare benefits	0.08 (7%)
Being a single parent	0.06	% single parent	0.06 (0.02)
Born in an Eastern European country	0.02	% born in Eastern European countries	0.02 (0.01)
Born in Finland	0.05	% born in Finland	0.06 (0.03)
Born in a Western country	0.03	% born in Western countries	0.03 (0.02)
Born in a Southern European country	0.02	% born in Southern European countries	0.02 (0.02)
Born in a country in the Middle East	0.04	% born in Middle East countries	0.03 (0.05)
(B) Individual and neighborhood variables without cross-level interaction terms:			
Calendar year	1994	Ln(Number of adults ages 16–65 years in the SAMS area)	7.46 (0.76)
Age at year t	37.86 (13.99)	Number of adults in the SAMS area ages 16-65 years per km ²	2886 (3574)
Female	0.5	Gini Coefficient	0.26 (0.05)
Born in other non-European country	0.05		

^aIn base amount.

One base-amount equals approximately 33,000 Swedish Krona

Table 2

Results of multilevel model with individual-, neighborhood- and cross-level predictors

	O.R.	95% C.I.	p-value
Neighborhood-level			
Logged median income	3.97*	(1.81–8.70)	<0.01
% Unemployment benefits	1.08*	(1.05–1.11)	<0.01
% Social welfare benefits	1.02	(1.00–1.04)	0.05
% Single parent	1.02	(0.99–1.05)	0.21
% born in Eastern Europe	1.02	(0.97–1.08)	0.45
% born in Finland	1.01	(0.98–1.03)	0.71
% born in Western countries	1.01	(0.97–1.04)	0.71
% born in Southern Europe	1.05	(1.02–1.09)	<0.01
% born in the Middle East	1.01	(0.99–1.02)	0.47
% born in other non-European countries	0.98	(0.95–1.00)	0.09
Logged population	1.03	(0.95–1.11)	0.50
Population density per km ²	1.00	(1.00–1.00)	0.23
Individual-level			
Year	0.96*	(0.94–0.97)	<0.01
Female	0.55*	(0.50–0.60)	<0.01
Age	1.03*	(1.03–1.03)	<0.01
Logged personal income	0.98	(0.92–1.03)	0.35
Received unemployment benefits	0.99	(0.82–1.21)	0.94
Received Social welfare benefits	4.34*	(3.82–4.92)	<0.01
Being a single parent	0.87	(0.72–1.05)	0.18
Born in:			
Eastern Europe	0.77	(0.54–1.09)	0.13
Finland	1.31*	(1.13–1.53)	<0.01
Western country	0.79	(0.61–1.03)	0.09
Southern Europe	0.69	(0.48–0.99)	0.05
Middle East	0.31*	(0.22–0.46)	<0.01
Other non-European countries	0.33*	(0.25–0.45)	<0.01
Cross-level			
Logged personal income by logged neighborhood median income	0.74*	(0.56–0.97)	0.03
Received unemployment benefits by % received unemployment benefits	0.99	(0.94–1.04)	0.61
Received social welfare benefits by % received social welfare benefits	0.97*	(0.96–0.98)	<0.01
Single parent by % single parent	0.95	(0.90–1.02)	0.16
Born in Eastern Europe by % born in Eastern Europe	1.15	(0.93–1.40)	0.20
Born in Finland by % born in Finland	0.99	(0.95–1.03)	0.59
Born in a Western country by % born in Western countries	0.97	(0.84–1.13)	0.63
Born in Southern Europe by % born in Southern Europe	0.79*	(0.70–0.89)	<0.01
Born in the Middle East % born in the Middle East	0.99	(0.97–1.02)	0.70

Table 3
Odds ratios associated with the effects of neighborhood median income, personal income, and income inequality

	I	II	III	IV	V	VI	VII
Ln(median income)	3.86* (<0.01)	3.95* (<0.01)	3.97* (<0.01)			3.32* (<0.01)	3.34* -0.01
Ln(personal income)		0.98 (0.42)	0.98 (0.34)	0.98 (0.52)		0.98 (0.34)	0.97 (0.34)
Ln(median income) × Ln(personal income)			0.74* (0.03)				0.74* (0.03)
Gini coefficient				3.76* (0.01)	3.83* (0.01)	1.85 (0.29)	1.95 (0.24)

Number of neighborhoods=578; Number of individuals =1,383,009
* =p<0.05
p-values in parentheses
All models control for the effects of the variables listed in Table 1 and other cross-level interactions.