Suicide risk in relation to level of urbanicity—
a population-based linkage study

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Background The extent to which the high suicide rate in urban areas is influenced by exposures to risk factors for suicide other than urbanicity remains unknown. This population-based study aims to investigate suicide risk in relation to the level of urbanicity in the context of other factors, and to study the risk variation in a sex, age, and calendar year perspective.

Methods The study is a nested case–control study comprising 21 169 suicides and 423 128 population controls matched for age and sex. Personal data on place of residence, socioeconomic status and psychiatric history were retrieved from various Danish longitudinal registers. Data were analysed with conditional logistic regression.

Results This study confirms that people living in more urbanized areas are at a higher risk of suicide than their counterparts in less urbanized areas. However, this excess risk is largely eliminated when adjusted for personal marital, income, and ethnic differences; it is even reversed when further adjusted for psychiatric status. Moreover, the impact of urbanicity on suicide risk differs significantly by sex and across age. Urban living reduces suicide risk significantly among men, especially young men, but increases the risk among women, especially women aged 24–35 or >65 years. In addition, during 1981–1997, the suicide risk associated with urbanicity remained rather constant among women, whereas it dropped significantly among men, a trend that seemingly gained strength during the last part of this period.

Conclusions Suicide risk associated with urbanicity varies significantly by sex and age groups and recent years have seen a decline in the urban–rural disparities among men. The increased risk in urban areas can largely be explained by the effects of marital status, ethnics, income, and psychiatric status.

Keywords Suicide, level of urbanicity, risk factors, nested case–control design, population registers

Suicide rates are generally higher in urban than in rural areas in most countries although there are noteworthy exceptions like China. Studies from Western countries have demonstrated that urban dwellers are at increased risk of suicide compared with their counterparts in rural areas. However, these studies have often failed to adjust risk estimates for possible confounding factors like marital status, income, and psychiatric illness, which are strongly associated with suicide and often distribute differently in rural and urban areas. So far no studies have used individual data for detailed investigation of the effect of degrees of urbanicity on suicide while controlling for differences in personal socioeconomic status and psychiatric history; nor have they explored the links between degrees of urbanicity and risk of suicide according to sex and age. In addition, changes in urban–rural disparities of suicide rates have been reported in studies from, e.g. Australia, UK, US, Norway, and Finland. Denmark has experienced a marked decline of suicide mortality since the early 1980s, but knowledge of how the risk of suicide associated with urbanicity has developed during this period remains sparse. The purposes of this large population-based study are to investigate suicide risk in relation to the level of urbanicity, defined according to the population density in the area, and to study the risk variation by sex and across age as well as its recent development by calendar year while controlling for confounding factors like personal socioeconomic status and psychiatric history.
Material and methods

Settings

This study is based on data from four Danish national longitudinal registers. The first register is the Cause-of-Death Register, which records the causes and dates of all deaths in Denmark. Suicide was recorded using codes E950-959 (ICD-8) before 1994 and X60-84 (ICD-10) after 1994. The second register is the Integrated Database for Labour Market Research (the IDA Database). It contains longitudinal information on labour market conditions for all residents in Denmark as well as their sociodemographic data. Personal data for a calendar year is complete when a person lives in Denmark on the last day of the year. The third register is the Danish Civil Registration System, which contains a personal identifier, the so-called CPR-number, for all individuals residing in Denmark. The CPR-number is used in all nationwide registers and is therefore the key to retrieval and merging of individual data from the different register databases in this study.

Participants

The study cases comprise all defined suicides recorded in the Cause-of-Death Register from January 1, 1981 to December 31, 1997, except those where the suicide case was not residing in Denmark on the 31st of December of the year before the year of committing suicide and socioeconomic data in the IDA Database were therefore incomplete. Inclusion criteria were met by 21,169 suicides and they accounted for 99.64% of the total number of completed suicides during this 17 year period in Denmark.

A nested case–control design was applied to recruit up to 20 live controls per suicide case. Controls were matched for birth year, sex, and calendar time of suicide and were randomly drawn from a 5% random sample of the national population in the IDA Database. This procedure produced 423,128 population controls matching the 21,169 suicide cases. For a few cases >93 years, it was not possible to find 20 eligible controls.

Data assessment

Personal data on place of residence on 1 January of the year of suicide or matching time were retrieved from the IDA database using the uniform codes for the 276 municipalities listed with the Danish national statistic bureau, Statistics Denmark. In Denmark, all citizens are obliged to inform the authorities about any change of permanent address within 5 days. Failure to report this information would result in the inability to receive supplementary benefits. The mean population density of the Danish municipalities approximates 22 persons per square kilometre and the average population in each municipality is about 19,110 inhabitants. For the research purposes of this study, these 276 municipalities were grouped into five categories according to their degree of urbanicity: (i) the capital (referring the Copenhagen and Frederiksberg municipalities), (ii) suburb of the capital, (iii) provincial city with more than 100,000 inhabitants, (iv) provincial town with more than 10,000 inhabitants, and (v) rural areas. Taking into account population density of municipalities and routines of Statistics Denmark, classification of the degree of urbanicity of the capital region was based on both geographical location and city size, whereas the classification of urbanicity of the remaining municipalities was mainly based on city size in municipalities. The population densities (persons per square kilometre) and percentages of national residents were as follows: (i) capital 5220 (13%), (ii) suburb of capital 845 (13%), (iii) provincial city 470 (12%), (iv) provincial town 180 (21%), and (v) rural areas 55 (41%).

The data were adjusted for the following personal variables: (i) marital status (being single, cohabiting vs married); (ii) place of birth (born in a foreign country vs born in Denmark); (iii) annual gross income (the lowest, second, third quartile vs the highest quartile according to the yearly 5 year age-specific distribution in the general population); and (iv) psychiatric admission history (with a history of admission within 1 year, >1 year ago vs never admitted). Personal data on marital status, annual income, and birth country of the last year before the suicide were extracted from the IDA database, while data on psychiatric history updated to the time of suicide were retrieved from the Danish Psychiatric Central Register. These variables were chosen because they have been shown to be highly associated with suicide in Denmark.

Statistical analysis

The impact of urbanicity on the risk of suicide was analysed with the conditional logistic regression model using the PhReg procedure in SAS version 8.2, yielding odds ratio, 95% confidence intervals, and corresponding P-value. Interaction between variables was examined using the likelihood ratio test based on the adjusted analysis.

Because of the rarity of suicide and the method of sampling sex-age-matched controls from individuals at risk for suicide at the time, the estimated odds ratio can be interpreted approximately the same as a risk ratio or incidence rate ratio.

Approval for this study was obtained from the Danish Data Protection Agency.

Results

The 21,169 suicides comprise 13,681 (64.6%) men and 7488 (35.4%) women. Their age varies from 9 to 103 years (overall median 51 years, men 49, women 55).

Compared with people living in rural areas, persons living in urbanized areas are at higher risk of suicide. As indicated by the crude analysis of the data (Table 1), the risk of suicide in the general population increases progressively with the increase in the degree of urbanicity of the place of residence; and the highest risk ratio is 1.58 (95% CI 1.51–1.65) for people living in the capital. However, the excess risk is largely eliminated when adjusted for differences in marital status, birth country, and income, and even reversed when further more adjusted for psychiatric admission history.

Moreover, in reality, the general effect of urbanicity reflects the significantly different impact on suicide by sex (test of sex interaction: \( \chi^2 = 115.20, P < 0.0001 \)). As shown also in Table 1, the crude risk of suicide among women rises significantly with increasing degree of urbanicity, whereas such a trend is not obvious for men and the risk is significantly higher only for men living in the capital. After adjustment for socioeconomic and
prominent among women aged 25–34 and women across all age groups and the effect was particularly (Figure 1), living in urban areas raises the suicide risk among socioeconomic and psychiatric factors were taken into account women). Age-stratified analyses show that when the effects of risk for suicide among women but reduces the risk among men. Interaction test by sex:

\[
\chi^2 = 115.20, \text{df} = 4, P < 0.0001.
\]

At the same time, the suicide risk associated with urbanicity varies significantly across age (test of age interaction: \(\chi^2 = 65.29, P = 0.0202\) for men; \(\chi^2 = 64.54, P = 0.0234\) for women). Age-stratified analyses show that when the effects of psychiatric status the results even show an almost opposite pattern of suicide risk associated with level of urbanicity for men and women; living in a more urbanized area increases the risk for suicide among women but reduces the risk among men.

The most commonly used measures are population size and population density,\(^7,9,10,23\) probably because these data are easily available for administrative purposes. Another measure is population potential, an index of the geographic remoteness from large concentrations of population, which may do slightly better than population density to characterize aspects of

### Discussion

This comprehensive study covering the entire national population of Denmark confirms that people living in more urbanized areas are facing a higher risk of suicide than their counterparts living in less urbanized areas. However, this excess risk is largely eliminated when adjusted for personal marital, ethnic, and income differences, and it is even reversed when further adjusted for psychiatric status. Moreover, the suicide risk associated with urbanicity varies significantly by sex and across age. Living in a more urbanized area reduces the risk of suicide significantly among men, especially young men, whereas it increases the risk among women, especially women aged 24–35 or >65 years. Moreover, during 1981–1997 the general effect of urbanicity remained rather constant among women, however, it changed significantly among men. The reduced risk for suicide among men living in urban areas became more prominent in the last part of this period.

Although many studies have examined urban–rural differences in suicide rate there is no standard measure of urbanicity. The most commonly used measures are population size and population density,\(^7,9,10,23\) probably because these data are easily available for administrative purposes. Another measure is population potential, an index of the geographic remoteness from large concentrations of population, which may do slightly better than population density to characterize aspects of

### Table 1

<table>
<thead>
<tr>
<th>Location</th>
<th>Numbers (%)</th>
<th>Odds ratio (95% CIs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Controls</td>
</tr>
<tr>
<td>All subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The capital</td>
<td>3453 (16.31)</td>
<td>49410 (11.68)</td>
</tr>
<tr>
<td>Suburb of the capital</td>
<td>2604 (12.30)</td>
<td>50449 (11.92)</td>
</tr>
<tr>
<td>Provincial city</td>
<td>2324 (10.98)</td>
<td>47308 (11.18)</td>
</tr>
<tr>
<td>Provincial town</td>
<td>6186 (29.22)</td>
<td>127732 (30.19)</td>
</tr>
<tr>
<td>Rural area</td>
<td>6602 (31.19)</td>
<td>148229 (35.03)</td>
</tr>
</tbody>
</table>

Crude odds ratios were only adjusted for age, gender, and calendar time through matching.

Adjusted odds ratio 1: Further adjusted for marital status, birth country, and annual income.

Adjusted odds ratio 2: Further adjusted for marital status, birth country, income, and psychiatric admission history.

Interaction test by sex: \(\chi^2 = 115.20, \text{df} = 4, P < 0.0001\).

\(*/P < 0.01; */*P < 0.05\).
urbanicity or rurality\textsuperscript{8} but has not been often used in suicide research. Whichever measure is used, a multilevel classification of urbanicity or rurality is recommended in order to be able to represent urban–rural differences in affluence, access to basic infrastructure, health services, and educational opportunities\textsuperscript{24}.

In this study, the degrees of urbanicity of living place were categorized on the basis of city size and population density in accordance with prevailing practices. Denmark is a small country where most people live within 25 km of a city with more than 30 000 inhabitants\textsuperscript{20}, therefore, this 5-level classification of urbanicity should be able to characterize the urban–rural differences to a large extent.

It is frequently postulated that cities have an adverse effect on people’s health. Urban and rural suicide may thus vary with regard to the prevalence of some mental disorders, physical illnesses, and the individual’s prior exposure to risk behaviours and psychological stressors accompanying the increased density and diversity of city populations. A psychological autopsy study has demonstrated that urban suicides are more frequently associated with various psychiatric disorders and psychiatric comorbidity and with stressful life events such as separation, whereas rural suicides are more often associated with physical problems.\textsuperscript{6} Locality bound exposures (e.g. high traffic densities and pollution),\textsuperscript{25} risk behaviours (e.g. alcohol and drug abuse)\textsuperscript{26,27} and stressors (e.g. neighbourhood relationship, and job competition)\textsuperscript{28} are confronted more frequently and are often of a more severe nature in urbanized than rural areas. Moreover, many, but not all, population studies have demonstrated a dose–response relationship between the level of urbanicity and rate for, e.g. schizophrenia,\textsuperscript{29,30} psychotic disorders,\textsuperscript{31,32} depression,\textsuperscript{32,33} and admission rate to psychiatric hospital.\textsuperscript{34} At the same time, statistics have shown that people with lower socioeconomic status and minorities are often overrepresented in urban areas.\textsuperscript{20} These factors may largely contribute to the increased risk of suicide among people living in urban areas, which may explain the significant elimination of the increased risk of suicide associated with urban living after the adjustment for the inequalities in personal socioeconomic and psychiatric status in this study.

On the other hand, many positive aspects of urban living should be taken into account when considering the factors affecting suicide. Living in a big city may entail better job...
opportunities, easier access to social services, etc. that may benefit residents in the catchment area. Another advantage of urbanicity may lie in the claimed easier accessibility to psychiatric services in urban than in rural areas which may serve to reduce suicide rates. However, this is not likely to be the case in Denmark where the distance to a psychiatric hospital or ward is generally small, psychiatric treatment is free of charge for all residents, and there are no urban–rural differences in age at onset of psychiatric illness. Hence, there is no evidence of urban–rural differences in the threshold for psychiatric hospitalization. On the other hand, like elsewhere in the world, internal migration in Denmark has resulted in a selection of the more healthy and competent people to move into the cities for education and jobs, which may be instrumental in lowering the overall risk among people inhabiting urban areas. Similarly, gender and age-specified results indicate that men, especially young men, may be benefited more from the advantages of living in big cities than other groups, whereas women may be more vulnerable in urban competitive environments than their male counterparts.

The growing pace of urbanization or social transition has recently triggered research into corresponding changes in suicide risk according to place of residence. This study, to our knowledge, is the first to examine the development of suicide risk associated with urbanicity in the context of other risk factors like socioeconomic status and psychiatric history. This study indicated that during 1981–1997 while suicide rate was declining, the suicide rate of women declined at approximately the same speed all over the country, but the suicide rate of men experienced a more rapid decline in urbanized areas, particularly the capital area, than rural areas. These findings are comparable with reports using population data from Norway, Australia and UK, which highlighted the rise in rural suicides. It is not easy to fully capture reasons for the secular trends of urban–rural differences in suicide risk. The improvement in psychiatric services, reduced availability of lethal compounds for suicide and more effective treatment of intoxications are likely to contribute to the general decline of suicide rate in Denmark. However, we cannot ascertain their contribution to the declining differences in urban–rural suicide rate among men. Other factors like changes in socioeconomic conditions and lifestyle may also play an important role. Given the fact that the effects of socioeconomic and psychiatric status have been taken into account, these findings may suggest that men are likely to be benefited more than women from being residents of urbanized areas in the contemporary society.

**Figure 2** Development of suicide risk associated with level of urbanicity of living place from 1981 to 1997. Odds ratios were adjusted for marital status, birth country, income, and psychiatric admission history as well as age through matching.
Denmark is a small homogeneous country with a population of 5.3 million and a total area of 43 000 km² with relatively small distance from countryside to a city. The findings from this study may, to a large extent, be applicable to other Nordic countries and some other Western countries, but probably not countries with different social settings. Moreover, urbanicity cannot be easily quantified and different measures of this concept have been used in previous investigations.8,24 The classification of the level of urbanicity according to population density in this study is probably inadequate for characterizing urban and rural environments. Nevertheless, this study, with precise personal data covering an entire national population, sheds new light on knowledge of suicide risk in relation to urbanicity. The results indicate that the progressive rise in suicide risk with the level of urbanicity can largely be explained by the effects of marital status, ethnic composition, income and, in particular, by the effect of psychiatric status. This may suggest that these factors, rather than urbanicity per se, are more fundamental risk factors for suicide. However, more studies are needed to reveal, in detail, pathways of urbanicity or rurality influencing suicide.

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KEY MESSAGES
• The risk of suicide in the general population increases progressively with increasing degree of urbanicity of the living place. However, the excess risk is largely eliminated when adjusted for differences in marital status, ethnicities, income, and psychiatric history.
• Suicide risk associated with urbanicity varies significantly by sex and across age. Living in a more urbanized area reduces the risk of suicide significantly among men whereas it increases the suicide risk among women.
• The difference in urban–rural suicide rate has recently declined among men. There has been a greater decline in the risk of suicide among men living in urban areas.

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