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Social inequalities resulting from health risks related to ambient air quality—A European review

Séverine Deguen[1], Denis Zmirou-Navier[1,2,3]

Background: Environmental nuisances, including ambient air pollution, are thought to contribute to social inequalities in health. There are two major mechanisms, which may act independently or synergistically, through which air pollution may play this role. Disadvantaged groups are recognized as being more often exposed to air pollution (differential exposure) and may also be more susceptible to the resultant health effects (differential susceptibility). **Method:** European research articles were obtained through a literature search in the Medline database using keywords 'Socioeconomic Factors, Air Pollution, Health' and synonymous expressions. **Results:** Some studies found that poorer people were more exposed to air pollution whereas the reverse was observed in other papers. A general pattern, however, is that, irrespective of exposure, subjects of low socio-economic status experience greater health effects of air pollution. So far as we are aware, no European study has explored this relationship among children. **Conclusion**: The housing market biases land use decisions and may explain why some subgroups suffer from both a low socio-economic status and high exposure to air pollution. Some data may be based on inaccurate exposure assessment. Cumulative exposures should be taken into account to explore health problems more accurately. The issue of exposure and health inequalities in relation to ambient air quality is complex and calls for global appraisal. There is no single pattern. Policies aimed at reducing the root causes of these inequalities could be based on urban multipolarity and diversity, two attributes that require long-term urban planning.

Keywords: air pollution, environmental inequalities, health inequalities, social determinants

Introduction

There is now clear evidence of social inequalities in health in most industrialized countries:[1] in general, socio-economically disadvantaged people are more strongly affected by various health problems[2–4] than more affluent ones. Despite numerous factors already identified, some of these inequalities remain unexplained, leading to the hypothesis that environmental nuisances may also contribute to social health inequalities.[5,6] Assessing how environmental exposure may partly explain such inequalities is a major subject of public health research.

According to the literature,[5,6] there are two major mechanisms that may act independently or together, through which environmental exposure may contribute to social health inequalities. (i) Among the general population, disadvantaged groups are recognized as being more often exposed to sources of pollution (*differential exposure*), a situation that contradicts the principle of *environmental equity*, according to which no group of people should bear a disproportionate share of harmful environmental exposure. (ii) The general population may also be more likely to exhibit resultant health effects (*differential susceptibility*). To investigate this hypothesis, studies explored the assumption that exposure to environmental nuisances might give rise to greater health effects among socioeconomically disadvantaged groups; this issue of greater vulnerability is less well documented.

Many epidemiological studies, mostly in North America and in Europe, have demonstrated that both short- and long-term exposures are associated with several health events. In spite of the improvement of air quality during the recent decades, air pollution remains a major field for investigation and action in view to improving public health in Europe. In this context, this review deals with European studies that concern two issues: whether subjects or populations of poor socio-economical status (SES) live in areas with lower ambient air quality than richer ones; and whether the association between ambient air pollution and health is influenced by the SES assessed at an individual or ecological level.

Methods

European research articles were obtained through a literature search in the Medline database of the National Library of Medicine. Only articles written in English or in French were selected, up to the end of April 2009.

Three principal MeSH-terms were used for the literature search queries: 'Europe AND socioeconomic factors AND air pollution'. Numerous synonymous expressions of these two keywords were also used, such as 'social class, unemployment, income' for socio-economic factors and 'ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, particulate matter' for air pollution. We have also included more general expressions, environmental justice and environmental inequity dealing with the socio-environmental disparities. Were excluded papers investigating only indoor air pollution and occupational or exposure to environmental tobacco smoke. Were also excluded papers in which air pollution exposure was measured using a proxy-indicator such as distance to high traffic roads or to industrial plants, and papers where no result was presented on either

1 EHESP School of Public Health, Rennes, France
2 INSERM U954, Vandœuvre-les-Nancy, France
3 Nancy University Medical School, Vandœuvre-les-Nancy, France
Correspondence: Séverine Deguen, EHESP School of Public Health, Department of Environmental and Occupational Health, Avenue du Professeur Léon Bernard, 35043 Rennes cedex, France, tel: +33-2-99-02-28-05, fax: +33-2-99-02-26-75, e-mail: severine.deguen@ehesp.fr

socio-economically based 'differential exposure or differential susceptibility'.

Concerning the assessment of differences in response to exposure according to SES, were also excluded all papers which did not formally test this effect modification, either by a stratified analysis or through the introduction of an interaction term in some regression model. Studies where the SES was merely considered as a confounder were thus discarded.

The results section is structured according to the two mechanisms through which environmental exposure may contribute to social health inequalities, namely differential exposure and differential susceptibility. Papers are sorted according to the country where the study was conducted.

Results

A total of 129 papers assessed inequalities in exposure in Europe according to some measure of socio-economic status, and 23 explored the modification of the relation between air pollution and some health event, often mortality, by the socio-economic status. They are described in tables 1 and 2 that provide information on the study design, how exposure and SES were assessed and key results. Additional information is given in table 2 on the health events and the methods used to assess effect modification.

Differential exposure

The majority of European studies took place in the UK. In England and Wales, McLeod in 2000[7] investigated the relationship between PM_{10}, NO_2 and SO_2, and socio-economic indicators. They found that higher social classes were more likely to be exposed to greater air pollution, whatever the pollutants and the socioeconomic indicators they used. In contrast, Brainard *et al.*[8] found that the level of NO_2 and CO in Birmingham was higher in communities with a greater proportion of coloured people and deprived classes. Several years later, in Leeds, Mitchell[9] demonstrated social inequality in the distribution of NO_2 according to the Townsend index. Comparing the trend of NO_2 levels between 1993 and 2005, they demonstrated that the average difference between deprived and affluent communities declined from 10.6 $\mu g/m^3$ in 1993 to 3.7 $\mu g/m^3$ in 2005 as a result of city-wide improvements in air quality driven by fleet renewal. Wheeler and Ben-Shlomo,[10] also found in 2005 that air quality is poorer among households of low social class. More recently, social inequalities in NO_2 levels in Leeds were confirmed by Namdeo and Stringer[11] at the detriment of poorer groups. In London, a comparison before and after the introduction of the Congestion Charging Zone showed that, although air pollution inequalities persisted, there was a greater reduction in air pollution in deprived areas than in the most affluent ones.[12] Briggs *et al.*[13] concluded that the strength of the association of the deprivation index with air pollution tended to be greater than for other environmental nuisances.

Two studies were conducted in Oslo, Norway. Irrespective of the socio-economic indicators they used, Naess *et al.*[14] showed that the most deprived areas were exposed to higher $PM_{2.5}$ levels and revealed a clear dose–response relationship between $PM_{2.5}$ levels and the number of subjects living in flats. In contrast, no association between NO_2 levels and education or occupation was found in the cohort of Norwegian men.[15]

Within the EXPOLIS study, environmental inequalities arising from personal exposure to NO_2 and $PM_{2.5}$ were explored in Helsinki, Finland.[16,17] Personal levels of NO_2 decreased with a higher level of education. Much greater contrasts in exposure were observed between socio-economic groups for men than for women, both for NO_2 and $PM_{2.5}$. While the occupational status was not correlated with $PM_{2.5}$ globally, a stratified analysis by gender showed a strong association for men only: the mean $PM_{2.5}$ exposure was ~50% lower among white-collar workers than among the other occupational categories.

Two studies conducted in Sweden brought evidence of social inequalities related to NO_2. Stroh *et al.*[18] found that the strength and direction of the association between the socio-economic status and NO_2 concentrations varied considerably between cities. In another study, children from areas with low neighbourhood socio-economic status were shown more exposed to NO_2 both at home and at school.[19]

We found four other European studies that explored social inequalities related to air pollution. In Rijnmond (The Netherlands), according to Kruize *et al.*,[20] lower income groups live in places with higher levels of NO_2 than greater income groups. In a cohort of German women, Schikowski *et al.*[21] revealed the existence of a social gradient with higher PM_{10} exposures among subjects with <10 years of school education than among those with higher education. Inversely, in Rome, Italy, the higher social class appeared to reside in areas with high traffic emissions; this disparity was even stronger when SES rather than income was considered.[22] Using a French deprivation index and a fine census block resolution scale,[23] Havard *et al.*[24] found, in Strasbourg, France, that the mid-level deprivation areas were the most exposed to NO_2, PM_{10} and CO.

Differential susceptibility

Few studies have been published on the role of SES in the relationship between air pollution and health in Europe. In Rome,[22] social class clearly affected the relationship between PM_{10} and mortality: the upper social classes were not as affected by the harmful effects of air pollution as those in lower social classes. Since the former live in areas with higher air pollution, the authors interpreted their findings in terms of differential susceptibility. Supporting this hypothesis, they found a higher proportion of chronic diseases among the poor. They also argued that living in an area with a high level of air pollution, mainly in the city centre, did not necessarily result in greater exposure. Wealthier residents of Rome were said to spend less time in their homes than poorer social groups because they were more likely to have second residences outside the city.

In four Polish cities, Wojtyniak *et al.*[25] showed a significant association between exposure to black smoke and either non-trauma or cardiovascular mortality among subjects who had not completed secondary education. Significant associations between SO_2 or NO_2 and cardiovascular mortality were also present more particularly among subjects aged >70 years with education below secondary school level.

Finally, in France, five studies investigated the impact of the socio-economic level on air pollution effects. In Bordeaux, Filleul *et al.*[26] found a significant association between mortality among people aged >65 years and exposure to black smoke among blue-collar workers only. Also in Bordeaux, however, a cohort study[27] comparing the characteristics of people who died on days when the highest and the lowest black smoke concentrations were observed, did not found modification of the effect of air pollution on mortality by the SES. In Strasbourg, two studies explored the air pollution effects on myocardial infarction events[28] and on asthma attacks.[29] Results from the former supported the hypothesis that neighbourhood SES may modify the acute effects of PM_{10} on the risk of MI: differential susceptibility

Table 1 European Studies investigating the environmental inequalities regarding air pollution exposure

Authors	Population/country	Study design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Brainard *et al.*[8]	Birmingham, England	Geographical	Annual average hourly CO and annual (hourly) NO_2	At a enumeration district scale (medium population of 496 residents): ethnicity, male unemployment, households without a car, homeowners, pensioners, social class, deprivation index (carstairs, Jarman and Townsend)	The average CO and NO_2 emissions for districts with deprived populations are higher than in affluent ones: 2331 vs. 2112 $\mu g/m^3$ and 23.71 vs. 22.29 $\mu g/m^3$, respectively. The averages of these pollutants were also higher among districts with high proportion of blacks than among more white districts: 2919 vs. 2276 $\mu g/m^3$ for CO and 27.09 vs. 23.32 $\mu g/m^3$ for NO_2.
Briggs *et al.*[13]	England	Geographical	Annual average of NO_2, PM_{10}, O_3 and SO_2	Three geographical levels of analysis: super output areas (SOAs, an average of 1500 persons), wards (aggregations of SOAs, an average of 6200 persons) and districts (an average of 139,000 persons). Several indicators of deprivation: index of multiple deprivation: income, employment, education and access to housing and services	Positive correlations (varying around 0.3 and 0.2 at SOA and ward geographical scale) are found with all the air pollutants (except O_3): a high level of air pollution was associated with a high level of deprivation (inverse relation for O_3). Variation of the association strength was observed according to the geographical scale
Chaix *et al.*[19]	Children aged 7–15 years, Malmo, Sweden (2001)	Multilevel	Annual average of NO_2 estimated for the points of the 100 metre grid that were the closest to the building of residence and school of attendance	Annual mean of income of subjects aged $\geq$25 years in each residential building where children in the study lived in 2001 and in each neighbourhood of residence. The median number of people aged 25 years or older in buildings of residence was 2 and it was 1484 in neighbourhoods of residence.	Children from low SES neighbourhoods were more exposed to NO_2, both at their residence place (21.8 vs. 13.5 $\mu g/m^3$ for the lowest and the highest income classes, respectively) and at school (19.7 vs. 13.7 $\mu g/m^3$).
Forastiere *et al.*[22]	Only residents of Rome aged 35 years and older (1998–2001)	Geographical	PM, CO, NO_x, Benzene	Estimation at census block scale (480 inhabitants on average) of a median per capita income index and a socio-economic index (SES, including educational level, occupational categories, working-age unemployment rate, family size, crowding and proportion of dwellings rented/owned)	Concentrations increase with the average block income level for all traffic pollutants (PM: 16.7 vs. 21.7 $\mu g/m^3$, for the low- and high income categories, respectively; CO: 10.4 vs. 24.3 $\mu g/m^3$; NO_x: 10.4 vs. 26.7 $\mu g/m^3$; Benzene: 10.7 vs. 25.2 $\mu g/m^3$). Environmental inequalities are stronger using the SES index (PM: 9.2 vs. 39.6 $\mu g/m^3$, CO: 6.8 vs. 45.3 $\mu g/m^3$, NO_x: 11.2 vs. 41.6 $\mu g/m^3$, Benzene: 7.5 vs. 46.2 $\mu g/m^3$).
Havard *et al.*[24]	Strasbourg, France	Geographical	Annual average of NO_2	At a French census block scale (2000 inhabitants in average): socio-economic index (including 19 socio-economic and demographic variables)	There was an association between deprivation index and NO_2 levels: the mid-level deprivation areas were the most exposed (39.6 $\mu g/m^3$) whereas the most affluent areas were the least (30.6 $\mu g/m^3$). Same relations were observed with SO_2 and $PM_{10,}$ but inverse relationship with O_3.
Kruize *et al.*[20]	Rijnmond Region, Netherlands	Semi-Individual	Annual average of modelled NO_2 concentrations (25 $\times$ 25 m grid)	Income	There is a significant association between income and NO_2 level: the mean of NO_2 are 37.7 and 38.2 $\mu g/m^3$ for the higher and lower income categories, respectively.
McLeod *et al.*[7]	England and Wales	Geographical	NO_x, PM_{10}, SO_2	At local authority district scale and/or regional scale: social class index, population density and percentage of ethnic minorities.	The higher social classes are more likely to be exposed to greater air pollution, whatever the pollutant, the socio-economic indicator and the model that was implemented.
Mitchell *et al.*[9]	Leeds, UK	Geographical	Annual mean of NO_2	At a 200 m $\times$ 200 m cell level (3600 points spaced by 200 m intervals in a grid cell pattern throughout the 144 km^2 inner box): Townsend deprivation index	A clear association between deprivation and NO_2 level: in 2005, the mean of NO_2 is around 18 $\mu g/m^3$ for the most affluent areas vs. 22 $\mu g/m^3$ for the least ones.
Namdeo *et al.*[11]	Leeds, UK	Geographical	Annual mean of NO_2	At the Census Output Area level: cumulative deprivation index	Deprived population groups are disproportionately exposed to higher NO_2 level as compared with the affluent group: a scenario gives for example, 20.5 $\mu g/m^3$ vs. 19.2 $\mu g/m^3$, respectively.

(*continued*)

Table 1 Continued

Authors	Population/country	Study design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Naess *et al.*[14]	General population aged 50–74 years residing in Oslo, Norway on 1 January 1992	Multilevel	Average monthly concentrations of $PM_{2.5}$ during period 1992–95	Social deprivation at both individual and administrative neighbourhood levels: education, household income, occupational class, ownership status of dwelling, type of dwelling and crowded households	There is a gradual increase of $PM_{2.5}$ when the proportion of subjects living in a flat increases across neighbourhoods (mean value of $PM_{2.5}$ ranging from 12.1 $\mu g/m^3$ in the lowest category to 17.0 $\mu g/m^3$ in the highest).
Rotko *et al.*[16]	Population aged 25–55 years, Helsinki (Finland)	Individual	48-h exposure of NO_2	Occupational status, education level and employment status	There is an association between personal exposure to NO_2 and education level: less educated subjects have higher exposures than educated ones (mean of NO_2 equal to 26.3 and 24.4 $\mu g/m^3$, respectively). The same association is seen according to the employment status among men
Rotko *et al.*[17]	Population aged 25–55 years, Helsinki (Finland)	Individual	48-h exposure of $PM_{2.5}$	Occupational status, education level and employment status	There is an association between personal exposure to $PM_{2.5}$ and education level: less educated subjects have higher exposures than educated ones (mean of PM2.5 equal to 18.98 and 13.41 $\mu g/m^3$, respectively). There is also an association between $PM_{2.5}$ and occupational status, with low exposures for white-collar employees compared to other categories (mean $PM_{2.5}$ levels are 11.97 and 20.46 $\mu g/m^3$, respectively). Stratification analysis by gender demonstrates that associations persist among men but not among women. For men, unemployment dramatically increases $PM_{2.5}$ exposure (41.8 vs. 15.5 $\mu g/m^3$).
Stroh *et al.*[18]	Scania, Sweden		Annual average NO_2 modelled with a 250 × 250 m grid resolution	Individual data: country of birth, education level	Strength and direction of the association between NO_2 and social categories varies within cities. In Malmö, subjects born in Sweden tend to live in areas with lower concentrations of NO_2 than those born in other countries. Inverse conclusions are drawn in other cities. The association between NO_2 and education ended show the same discrepancy between Malmö and the four other cities.
Schikowski *et al.*[21]	Women aged 55 years at time of investigation, Ruhr, Germany	Semi-Individual	PM_{10}, NO_2 and TSP	Education level	Women with <10 years of school education are more exposed to PM_{10} than those with a higher education level. No association has been found with NO_2.
Tonne *et al.*[12]	London, England	Geographical	Annual average NO_2 and PM_{10}	At census ward scale: index of multiple deprivation	The mean of PM_{10} and NO_2 increases from the less deprived neighbourhoods (C1, class 1) to the most ones (C5, Class 5): the mean for C1 and C5 are 38.1 and 46.7 $\mu g/m^3$for NO_2 and 25.7 and 27.5 $\mu g/m^3$ for PM_{10}, respectively.
Wheeler *et al.*[10]	General population aged 16–79 years, England	Semi-individual (household)	Index of air pollution combining annual average of NO_2, PM_{10}, NO_2 and Benzene estimated at a ward geographical level. The air pollution index of each participant is equal to the level of their residential ward	Social class of head of household	Environmental inequity is observed among urban households: air quality is poorer among households of low social class. There is a suggestion of inverse relationship for rural and semi-rural households.

a: CO, carbon monoxide; NO_2, nitrogen dioxide; O_3, ozone; PM, particulate matter; PM_{10}, particulate matter with an aerodynamic diameter of up to 10 mm; $PM_{2.5}$, particulate matter with an aerodynamic diameter of up to 2.5 mm; SO_2, sulphur dioxide; TSP, total suspended particulates.

b: Geographical: socio-economic status and air pollution exposure were both estimated at a same geographical level; semi-individual: socio-economic status and air pollution exposure were estimated at a individual and geographical level, respectively; individual: socio-economic status and air pollution exposure were both estimated at a individual level; multilevel: socio-economic status was estimated at both individual and geographical level whereas the air pollution exposure was estimated at geographical level.

Table 2 European Studies assessing the potential modification effect by the socio-economic status on the relation health and air pollution exposure

Authors	Population/country	Health variables	Air pollution variables[a]	Geographical level and SES variables	Methods to evaluate effect modification	Main results
Filleul *et al.*[26]	Residents of Bordeaux (France), population older than 65 years (1988–97)	Non-trauma and cardiorespiratory mortality	Daily mean of BS	At individual level: educational attainment (without primary school diploma, primary school diploma, secondary validated or higher) and previous occupation (never worked, white-collar, blue-collar)	Stratified analysis and test for heterogeneity	Increase in mortality for a 10 mg/m^3 increment in BS concentrations. Non-trauma mortality: only blue collars show a significant association: OR = 1.41 (1.05–1.90). Cardiorespiratory mortality: association is greater among subjects with high education: OR = 4.36 (1.15–16.54).
Filleul *et al.*[27]	Residents of Bordeaux (France), population older than 65 years (1988–97)	Non-trauma mortality	BS (above 90th percentile or below 10th percentile of observed ambient air concentrations)	At individual level: educational level (no school, primary without diploma, primary with diploma) and previous occupation (domestic employees and women at home, blue-collar workers craftsmen and shopkeepers, other employees and intellectual occupations)	Stratified analysis and test for heterogeneity	No effect modification according to socio-economic indicators.
Forastiere *et al*[22]	Residents of Rome (Italy) aged 35 years and older (1998–2001)	Mortality	Daily PM_{10}	Estimation at census block scale (480 inhabitants on average) of a median per capita income index and a socio-economic index (including educational level, occupational categories, working-age unemployment rate, family size, crowding and proportion of dwellings rented/owned)	Interaction term in multivariate model	Effect modification of socio-economic status on the PM_{10}-mortality association: the effect is stronger among people with lower income and SES (1.9 and 1.4% per 10 $\mu g/m^3$, respectively) compared with those in the upper income and SES levels (0.0 and 0.1% per 10$\mu g/m^3$, respectively).
Havard *et al.*[28]	Residents of Strasbourg (France), population aged 35–74 years (2000–03)	Myocardial infarction events	24-h average PM_{10} concentrations	At a French census block scale (2000 inhabitants on average): socio-economic index (including 19 socio-economic and demographic variables)	Stratified analysis and test for heterogeneity	Significant influence of neighbourhood SES, with greater effect of PM_{10} observed among subjects living in the most deprived neighbourhoods (20.5% increase, 95%CI: 2.2–42.0).
Laurent *et al.*[29]	Residents of Strasbourg (France), general population (2000–05)	Astham attacks	The daily air pollution indicator considered for PM_{10}, NO_2, and SO_2 was the 24-h average concentration. It was the maximum daily value of the 8-h moving average for the O_3.	At a French census block scale (2000 inhabitants in average): socio-economic index (including 19 socio-economic and demographic variables)	Stratified analysis and test for heterogeneity	Socio-economic deprivation had no influence on the association between air pollution and asthma attacks, whatever the pollutant.

(*continued*)

Table 2 Continued

Authors	Population/country	Health variables	Air pollution variables[a]	Geographical level and SES variables	Methods to evaluate effect modification	Main results
Laurent *et al.*[31]	Residents of Strasbourg (France), general population (2000–05)	β-agonist sales for asthma	The daily air pollution indicator considered for PM_{10}, NO_2, and SO_2 was the 24-h average concentration. It was the maximum daily value of the 8-h moving average for the O_3.	At a French census block scale (2000 inhabitants on average): socio-economic index (including 19 socio-economic and demographic variables)	Stratified analysis and test for heterogeneity	Socio-economic deprivation had no influence on the association between air pollution and asthma attacks, whatever the pollutant.
Wojtyniak *et al.*[25]	Two group of population (i) between 0 and 70 years and (ii) >70 years, residents of Cracow, Lodz, Poznan and Wroclaw (Poland)	Non-trauma and cardiovascular mortality	BS, NO_2 and SO_2 (day of death or preceding day)	Educational	Stratified analysis and test for heterogeneity	Non-trauma mortality: significant effect of BS among the less than secondary education group in both age groups. Significant effect of NO_2 in the oldest age group and for those below secondary education only. Significant effect of SO_2 in the oldest age group and those with less than a secondary education.Cardiovascular mortality: significant effect of BS only for those with less than a secondary education in both age groups. Significant effect of NO_2 for secondary education and above, only in the oldest age group. Significant effect of SO_2 only among subjects >70 years with below secondary education level.

a: BS, Black Smoke; NO_2, nitrogen dioxide; O_3, ozone; PM_{10}, particulate matter with an aerodynamic diameter of up to 10 mm; SO_2, sulphur dioxide.

was suggested as the more plausible explanation since these most deprived population did not live in the more polluted place.[30] On the other hand, socio-economic deprivation did not modify the relation between emergency telephone calls for asthma and concentrations of PM_{10}, SO_2 and NO_2;[28] this finding was confirmed using the number of β-agonist sales for asthma.[31]

Discussion

This literature review bears on the still small number of papers that investigated exposure and/or susceptibility differentials in Europe according to the socio-economical status, a rather recent topic that is yet less documented than in the USA and Canada. The European studies yield mixed findings regarding exposure disparities: in some instances, the association between air pollution and SES translates into poorer populations or areas being at greater exposure. Inversely, richer populations have been reported at greater exposure in other studies. However, beyond these variations, the general pattern in terms of health consequences is that deprived populations, although not always more exposed, experience greater harmful effects of air pollution, because of vulnerability factors.

In contrast, more discrepant results are observed in the non-European literature.

For example, among recent papers, the study by Charafeddine and Boden[32] in the USA found that subjects living in the most affluent counties with high particulate levels are significantly more likely to report fair or poor health, compared to those in poorer counties who experience exposure to the same air quality, whereas Zeka *et al.*,[33] in 20 US cities, showed stronger associations between PM_{10} and mortality for the less educated subjects (although not statistically significant). Similarly, poorer education was associated with a greater impact of air pollution on mortality in Shangai,[34] whereas the Chinese Longitudinal Health Longevity Survey[35] showed that elderly subjects living in more privileged urban areas were more affected by air pollution than their counterparts in more deprived ones. By the same token, Gouvenia and Fletcher[36] found in Sao Paulo, Brazil, a slightly increased risk of mortality associated with PM_{10} among elderly people living in the most privileged areas, while Martins *et al.*[37] in the same city showed that poorer areas presented the strongest association between PM_{10} and mortality among the elderly. Generalization from these partial observations is clearly premature. Absence of consensus as to the methodology used when investigating environmental and social inequalities (geographic unit, methods of statistical analysis, exposure assessment procedures and definition of deprivation) renders most of the results non-comparable and might explain part of these discrepancies.[38,39]

Nonetheless, several pathways and mechanisms are discussed in the literature to explain these social differences. Inequalities in environmental conditions are often put forward. Residential segregation may be one major reason why communities differ in their exposures. In Europe, socio-demographic disparities, notably those related to racial segregation, are less marked than in the USA; here, social and economic resources are the main determinants of environmental disparities. The housing market biases land use decisions and might explain why some groups of people suffer from both a low socio-economic status and bad air quality at their place of residence. One reason is that the presence of pollution sources depresses the housing market and provides an opportunity for local authorities to construct council housing at low cost.[40,41] Symmetrically, the presence of council housing in a given urban area tends to depress the price of land over time, encouraging the setting up of activities and facilities that generate pollution.

'Differential exposure' beyond ambient air quality might partly explain why health effects of air pollution might be different across social classes. Living in a residential area with high air pollution levels does not necessary cause greater overall exposure. Affluent people are likely to have second homes outside cities and they may, therefore, spend less time at their main residence. Not taking this into account could yield exposure misclassification in that, while more affluent social categories may tend to live in central, more expensive, areas with higher pollution in some cities, their true year long exposure is probably overestimated.[22] Conversely, subjects in deprived areas live in old dilapidated homes with poor ventilation and insulation, factors which favour the concentration of indoor pollutants. Moreover, they may be more likely to spend time close to or in the traffic, for example, working on the street rather than inside office buildings, or doing long commuting in public transport. Hence, the true daily and long-term exposures of these groups are probably underestimated. It is well documented that poorer people are more likely to suffer from several types of environmental exposure. In the German study by Schikowski *et al.*[21] the authors demonstrated that, in addition to the increase of PM_{10} levels with poorer education, the prevalence of occupational exposures and of current smoking followed the same gradient. Along the same line, Bell and Dominici[41] suggested that factors other than ambient air exposure, such as residential or occupational exposures, might explain why areas with a high Afro-American population proportion and high unemployment might exhibit a greater impact of air pollution in US cities.

People with a low SES may be more sensitive to air pollution-related hazards because of the high prevalence of existing diseases, an attribute which refers to 'differential susceptibility'. For example, Forastiere *et al.*[22] raised this hypothesis to explain their results, having excluded the causal pathway of inequalities in environmental quality. They found a higher prevalence of chronic conditions such as diabetes, hypertensive diseases and heart failure in low than in high-income groups. The former may receive inferior medical treatment for their conditions.[35] They may also have more limited access to good food, resulting in a reduced intake of antioxidant vitamins and polyunsaturated fatty acids that protect against adverse consequences of particle or ozone exposure. In the particular case of infant mortality, Romieu *et al.*[42] suggested that both micronutrient deficiencies and concurrent illnesses might decrease the immune response and make children more vulnerable to the adverse effects of air pollution.

It has been suggested that the presence of competitive risk factors in poorer areas might explain why health risks associated with air pollution may in some instances be greater among wealthier groups.[31,35] Some authors argue that poorer people are affected by many other risk factors that tend to increase mortality rates owing to other causes such as violence and drug abuse. As a consequence, wealthier people may artefactually appear more vulnerable to air pollution in relation with their baseline risk level since they are relatively protected from other risk factors that affect disadvantaged groups.

Policy considerations

The issue of exposure and health inequalities in relation to ambient air quality is complex and calls for a global appraisal. There is no single pattern nor, of course, single

solution. However, urban planning policies that would look for 'spatial multipolarity and social diversity' might play at the very roots of these inequalities. Multipolarity refers to the structure of our large metropolitan areas. Currently, with some variation across and within countries, European cities tend to be laid out in a concentric pattern: historical and cultural areas concentrated in the centre, with also a high proportion of businesses and expensive housing, while low-cost residential areas are progressively expelled to the outskirts, where also industrial activities are located. In contrast to this concentric structure, 'multipolarity' calls for urban poles that provide a range of amenities (housing, workplaces, commercial, cultural or leisure sites) tending to reduce the need for long distance commuting in polluted environments. *Diversity* is a complementary principle of multipolarity, where each pole would provide the widest possible variety of activities and, most importantly, of housing profiles, places for the rich being intermingled with council residence. This diversity scheme would prevent the formation of peripheral clusters of poor housing, which is typically associated with lack of access to good education and other cultural amenities: the further they are from the city centres, the more likely they are to be let in a marginal status. As described above, this is how inequalities in exposure to ambient air interplay with inequalities in other environmental stressors and vulnerability factors.

Conclusion and perspectives

Few European studies investigated the effect modification of socio-economic factors on the association between air pollution and health and much is yet to be understood. However, the general pattern of the current evidence is that deprived populations, although not always more exposed, experience greater harmful air pollution effects, because of vulnerability factors. Two research directions seem particularly relevant. Comparative exposure studies that would aim to assess the relative contribution of outdoor air and of a variety of microenvironments (at home, at work, while commuting, during leisure activities) across different social categories would be very informative. These disparities may vary substantially across cities and countries. A European-wide study might help understand the core determinants of these inequalities. For such a study to be valuable, however, great efforts should be put on harmonization of methods and definitions. Further, very little data concern children. Now, poverty and deprivation in early childhood may have adverse health consequences throughout the entire life. Focused studies in children are needed to better understand mechanisms through which health inequalities could arise later in life, a call which is in line with the avenue proposed by the PINCHE project.[43]

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Key points

- Poor populations do not always live in areas with higher outdoor air pollution in Europe; results are country and city specific.
- Few European studies investigated the effect modification of socio-economic factors on the relation between air pollution and health and much is yet to be understood.
- Nevertheless, there is a general pattern: irrespective of the level of exposure to ambient air, the poor are more affected by effects associated with air pollutants.
- Policies aimed at reducing the root causes of these inequalities could strive to foster urban multipolarity and diversity, which require long-term urban planning.

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Environmental inequalities among children in Europe—evaluation of scientific evidence and policy implications

Gabriele Bolte[1], Giorgio Tamburlini[2], Martina Kohlhuber[1]

Background: Socio-economic inequalities in the living environment are major contributing factors to health inequalities. Consequently, protecting children from undesirable environmental exposures by taking socio-economic conditions into account has been identified as a policy priority area in Europe. This review aims to evaluate the evidence on environmental inequalities among children in Europe and to discuss its policy implications. **Methods:** A systematic literature search was conducted in various literature databases. Further sources for information were reviews, international reports and working documents for a WHO expert meeting on environmental inequalities in 2009. One major inclusion criterion for publications was consideration of socio-economic factors as influencing factors, not merely as confounder. **Results:** The overall pattern based on the available fragmentary data is that children living in adverse social circumstances suffer from multiple and cumulative exposures. A low socio-economic position is associated with an increased exposure of children to traffic-related air pollution, noise, lead, environmental tobacco smoke, inadequate housing and residential conditions and less opportunities for physical activity. For most topics and exposures reviewed here there were no studies investigating the modification of the exposure-response function by socio-economic factors. Due to a variety of methodological approaches and studies on one hand and lack of data for many topics and countries on the other hand it was not possible to quantify the magnitude of environmental inequalities. **Conclusion:** Action is needed along the whole causal pathway of the social divide in environmental hazards with priority to policy measures aiming at removing socially determined differences in environmental conditions.

Keywords: exposure, health inequalities, pollution, social determinants, socio-economic position

Introduction

Health inequalities are one of the main challenges for public health throughout Europe. People with lower levels of education, occupation and/or income tend to die at a younger age, and to have a higher prevalence of most types of health problems.[1,2] The impact of socio-economic inequalities in the living environment and in exposure to environmental pollution has increasingly been recognized as a major contributing factor in the production of health inequalities.[3–5] In addition to exposure variation by socio-economic position (exposure differential), socio-economic factors may modify the health effects by influencing individual's vulnerability (susceptibility differential).[6] Besides nutrition or access to quality health care, psychosocial stress has been proposed to be a key component. When not counterbalanced by resources, place-based and individual-level stressors may lead to increased vulnerability to environmental exposures.[7,8]

It seems to be a common pattern that poor children are confronted with widespread environmental inequalities in terms of accumulation of multiple environmental risks.[9] The cumulative risk of environmental exposures can contribute both directly and indirectly to a variety of adverse health outcomes in children.[10] The influence of socio-economic factors on exposure and susceptibility of children to environmental factors has been widely recognized and the burden of disease attributable to environmental factors among children and adolescents in Europe has been estimated.[11]

Consequently, protecting disadvantaged children from undesirable environmental exposures was identified as a policy priority area (Declaration and Children's Environment and Health Action Plan for Europe (CEHAPE), adopted at the Fourth Ministerial Conference on Environment and Health held in Budapest in 2004).[12] The CEHAPE recommends a multisector approach to address the multidimensional aspects of poverty as a necessary policy approach for protecting children's health.

The aim of this review was to evaluate the latest evidence on environmental inequalities among children in Europe and to discuss its policy implications.

Methods

This publication is a summary of a review which was prepared by the authors for the WHO expert meeting on 'Environment and health risks: the influence and effects of social inequalities' at the WHO European Center for Environment and Health in Bonn, Germany, in September 2009. The expert meeting was part of the preparatory process towards the forthcoming Fifth Ministerial Conference on Environment and Health taking place in Parma, Italy, in March 2010. The aims of the expert meeting were to review and discuss the evidence presented in the background documents and to develop policy recommendations on possible countermeasures.

One starting point of this work was the review of the impact of socio-economic factors on environmental exposures and children's health in Europe within the EU-funded network PINCHE (Policy Interpretation Network on Children's Health and Environment).[6,13] PINCHE focused on the four

[1] Department of Environmental Health, Bavarian Health and Food Safety Authority, Oberschleissheim, Germany
[2] Institute for Child Health IRCCS Burlo Garofolo and Centro per la Salute del Bambino - onlus, Trieste, Italy
Correspondence: PD Dr Gabriele Bolte, MPH, Department of Environmental Health, Bavarian Health and Food Safety Authority, Veterinaerstr. 2, 85764 Oberschleissheim, Germany, tel: +49-89-31560159, fax: +49-89-31560835, e-mail: gabriele.bolte@lgl.bayern.de

Table 1 Systematic literature search: terms and results

Database	Results: number of publications		
Search terms	**Published since 2000**	**Without duplicates, only Europe (after first scan of title and abstracts)**	**After application of exclusion criteria**
Medline (MeSH term)			
Socio-economic factors AND environmental pollution AND children[a]	877	364	54
Social justice AND environmental exposure AND children[a]	17	1	1
Social justice AND environment AND children[a]	15	2	2
Environmental justice (all fields) AND children[a]	150	8	8
PsychINFO			
Environment AND socio-economic AND child	15	1	1
environmental justice AND child	17	0	0
SocINDEX			
Child AND environmental pollution OR environmental exposure OR environmental justice	69	1	1
Current Contents Connect (CCC), Social Science Citation Index + Science Citation Index + Arts & Humanities			
Child AND environment AND social within categories: pediatrics OR public, environmental & occupational health OR environmental sciences & ecology OR geography	127	13	13
Total		390	80

a: includes the MeSH terms child; child, preschool; infant; adolescent

themes indoor and outdoor air pollution, carcinogens, neurotoxicants and noise.

The literature for this review was retrieved from three sources:

(i) a systematic literature search of reviews and original articles published in peer-reviewed journals,
(ii) international reports by WHO, EU and other organizations (a list of these reports is given as supplementary data at *Eurpub* online) and
(iii) the drafts of topical review papers prepared 2009 for the above-mentioned WHO expert meeting.

The systematic literature search was conducted in May 2009 in the Medline database, in Science Citation Index, Current Contents, SocINDEX and PsychINDEX. Search terms and results are presented in table 1. Abstracts were further evaluated by using the following inclusion criteria:

(i) Original studies conducted in Europe (including countries of the former Soviet Union and Israel) or reviews;
(ii) English language, published 2000–May 2009;
(iii) Age group 0–18 years (children and adolescents);
(iv) Socio-economic differences in children's environmental exposures or environmental health at an individual- or area-level must be described in the abstract. The mere inclusion of indicators of socio-economic position as potential confounder in analyses or the description of the sociodemographic characteristics of the study population was not sufficient. Thus the focus of the literature search were the two basic mechanisms exposure variation and effect modification by socio-economic position and
(v) Exposures: in principle, all kinds of environmental exposures were considered with a focus on outdoor and indoor air pollution, environmental tobacco smoke, lead, noise, housing/built environment (including impact on physical activity), water pollution and waste.

After excluding duplicates and after the first screening of abstracts and titles to exclude original studies from outside Europe, in total, 390 abstracts were eligible for further evaluation. After this precise evaluation of the abstracts, 80 publications remained for further analysis (table 1, a list of these references is given as supplementary data at *Eurpub* online).

According to a definition by WHO,[14] throughout this review the term 'inequalities' is used for mere description of socio-economic differences in environment and health between groups of people without any further valuation. The term 'inequities', which is used in the section on policy implications, refers to those inequalities that are avoidable or can be redressed and are assumed to be unjust. The term 'socio-economic position' is used as comprehensive term regardless of which socio-economic indicator such as parental education or household income was used in a study.

Though this review concentrated on the period from birth until adolescence, it is acknowledged that the prenatal development is an important critical window for exposures.[15]

Results

Overall, the systematic literature search yielded among the 80 relevant publications only 21 original, peer-reviewed studies in Europe published since 2000 and analysing the relationship between socio-economic factors, children's environmental exposures and/or environmental health as a main topic. The remaining 59 studies were excluded for the following reasons: non-European country, socio-economic factors considered only as confounder without indication of numbers in table or text, no original study.

Evidence of socio-economic differences in the living environment and in exposure to environmental pollution (exposure variation)

Most of the studies on housing in several European countries demonstrated that poor and less affluent population groups are most exposed to environmental risks within the private home (e.g. biological and chemical contamination, temperature problems, sanitary equipment) as well as within the residential context (e.g. closeness to polluted areas, lack of urban amenities and public safety, neighbourhood incivilities such as litter) (Fairburn & Braubach, background document for the WHO expert meeting 2009, to be published on the occasion of the Fifth Ministerial Conference on Environment

and Health in Parma, March 2010). Especially in Eastern Europe deteriorating housing conditions were observed. Concerning waste sites for e.g. on community level hazardous sites and illegal waste disposals are disproportionately often located in more deprived areas in several European countries such as UK, France and Italy (Martuzzi et al., background document for the WHO expert meeting 2009, to be published on the occasion of the Fifth Ministerial Conference on Environment and Health in Parma, March 2010).[16]

A recent review of the evidence on environmental inequalities in Germany confirmed this overall pattern of more adverse housing conditions in socially disadvantaged.[17] For example, single oven heating, crowding, damp housing and living near roads with heavy traffic was associated with a lower socio-economic position in several cross-sectional studies in school beginners.[18,19]

There is some evidence in Europe that ethnically marginalised children tend to live, play and go to school in more environmentally hazardous areas. This has been described especially for central and eastern Europe and ethnic minority groups like Roma who live more often on or near waste sites, floodplains and suffer from lack of provision of basic utilities including clean running water.[20,21]

Characteristics of the built environment such as heavy traffic in residential areas and living in segregated marginalised neighbourhoods shorten the radius within which children can be active and reduce the activities in their living space. Socially disadvantaged people and those who live in neighbourhoods of lower socio-economic status (deprived areas) may have limited opportunities for physical activity.[22] Fear of traffic can be a powerful deterrent to parents' allowing their children to walk or cycle to school or play outdoors, especially in deprived areas, because poorer children are more likely to live in urban areas with poor road safety and high-speed traffic.[23]

Resources like parks or green areas which encourage physical activity and so indirectly influence health status are rare in disadvantaged residential areas, and when available, quality is usually low.[10] Data from Germany indicated that parents with a lower socio-economic position felt more often impaired by a lack of accessible green space in their living environment in both urban and rural settings.[19]

Environmental tobacco smoke (ETS) is an important and well-studied issue of children's exposure to indoor air pollutants. The evidence on social inequalities in children's ETS exposure is consistent across several countries: social disadvantage is associated with a higher or rather more frequent pre-natal and post-natal exposure of children to ETS.[13,17,24–26]

The protection of children against toxic chemicals in the environment is a major public health challenge[27] but scientific evidence on the relationship of socio-economic position and exposure to chemicals is scarce in Europe. One exception is lead: overall recent reviews of data in Europe showed that children from families living in adverse housing conditions or with lower socio-economic position have higher blood lead levels.[13,17] Poor housing quality and poor socio-economic position have been acknowledged as one of other determinants of higher blood lead levels in children.[28] However, single studies or certain populations may give conflicting results. For example, a study in Swedish adolescents found no social differences in blood lead levels.[29]

For children, recent reviews of data in Europe summarized that children in lower socio-economic position live more often in areas with decreased air quality and more often near streets with heavy traffic.[13,17] Chaix et al.[30] showed in a spatial scale study located in Malmö, Sweden, a gradient in the exposure of children to NO_2 at home and at school from the highest levels in children living in low income areas (mean roof level annual NO_2 concentration 21.8 $\mu g/m^3$ at home, 19.7 $\mu g/m^3$ at school) to lowest levels in high income areas (13.5 $\mu g/m^3$ at home, 13.7 $\mu g/m^3$ at school). A study in three districts in Moscow, Russia, demonstrated that children living in a highly polluted area were more disadvantaged than children in a district with low air pollution.[31] In Germany, social differences in terms of higher exposure mainly to traffic-related air pollution have been repeatedly shown for children.[17,19,25]

In accordance with the fact that socially disadvantaged families tend to live more often near busy roads, noise annoyance due to traffic is often higher in people with a lower socio-economic position.[17] The German Environmental Survey 2003/06 for Children demonstrated that socially disadvantaged children aged 8–10 years felt more often annoyed by road traffic noise than children in higher socio-economic position.[32] Moreover, besides social inequalities in noise annoyance there are social inequalities in exposure to noise: a recent study showed for children living in Munich that there is an association between relative poverty and high traffic noise exposure estimated by noise maps.[33]

Results of the Heathrow Airport Study, UK, showed that children from high-noise schools were more likely to be non-white and to speak another language than English as first language at home. The proportion of children from manual social class households and deprived households were also slightly higher in the high-noise schools.[13]

Evidence of socio-economic differences in children's susceptibility to environmental exposures (effect modification)

In general, due to the developing of their organs and systems children are more vulnerable to environmental exposures compared to adults. Children have disproportionately high exposures to many environmental toxicants because they drink more water, eat more food and breathe more air per unit of body weight compared to adults.[27] Young children also tend to have a living area closer to the ground or floor, resulting in a somewhat different exposure to some air pollutants or to contaminated soil than that in a large, upright person. Children's metabolic pathways, especially in foetal life and in the first months after birth, are immature. Therefore children's ability to metabolize, detoxify and excrete environmental agents differs from that of adults. Early exposure gives time enough for long latency agents to produce adverse health effects. Finally, children are less aware of the risk and have less control over their environment than adults.[34]

Thus, social inequalities impart a disproportionate elevation in hazard to deprived population groups at all ages, but again this is particularly true for children from poor households and deprived communities. The peculiar vulnerability of children to environmental agents acts by multiplying the effects of social inequalities.

Within this systematic literature search there have been no original studies among children in Europe identified which investigated the interaction between socio-economic factors and most of the environmental exposures. Therefore the question to what extent disadvantaged children, besides being disproportionally exposed to environmental risks, are also more vulnerable to its impacts cannot comprehensively be answered until now.

In case of lead exposure it has been stated that children growing up in disadvantaged circumstances showed lead associated developmental deficits at lower blood or tooth lead levels than more advantaged children. Also the deficits

were of greater magnitude in disadvantaged children and these children were less able to compensate or recover from lead associated neurodevelopmental deficits.[35]

The RANCH study on road traffic and aircraft noise exposure and children's cognition and health in schools around airports in the Netherlands, Spain and the UK gave mixed results for effect modification. On one hand there was no effect modification by socio-economic position concerning the association of aircraft noise exposure at school and impairment in reading comprehension.[36,37] On the other hand, van Kempen et al.[38] reported higher annoyance due to aircraft and road traffic noise at school in children of mothers with higher educational status and the effect of road traffic noise on cognitive tests on episodic memory was stronger for children living in crowded homes.[36]

Greater relative impacts of air pollution on mortality risk associated with long-term exposure have been demonstrated for disadvantaged adults.[39] Several studies in European countries have been published on the effect of socio-economic position on the air pollution—health relationship in adults (Deguen & Zmirou-Navier, background document for the WHO expert meeting 2009, to be published on the occasion of the Fifth Ministerial Conference on Environment and Health in Parma, March 2010). Data of a study on infant mortality in Mexico for example indicated a higher vulnerability of disadvantaged children to the adverse effects of air pollution.[40] However, there is no study explicitly investigating effect modification of socio-economic position on the relationship between air pollution and health among children in Europe.

Discussion

Methodological considerations

At several levels of compiling and evaluating the evidence for this review, insufficient information and bias may have led to an impairment of its significance. The systematic literature search based on key words and MeSH terms and the exclusion of articles with the mere statement in the abstract that analyses were adjusted for social factors might have resulted in the loss of some information on environmental inequalities given in a publication's main text. In environmental epidemiologic studies, socio-economic factors are mostly regarded as potential confounders and considered only for adjustment in statistical analyses.[41]

There is certainly a language bias of our review. Studies especially from Eastern Europe and not published in English might have been missed. There may be also a publication bias if only studies showing inequalities were published and thus retrieved in the systematic search. Bias might have already been introduced due to study design of the original studies included in this review: selection bias by socio-economic position is quite common in epidemiologic studies. There may be an underestimation of the extent of social inequalities in environmental exposures especially in secondary data analyses if socially disadvantaged people tend to take part less often. Otherwise, information bias due to underreporting of adverse environmental conditions by socially disadvantaged people may occur.

Comparability of studies may be limited due to variations in study design (including e.g. geographic measurement scales, study population, time frame) and in definitions of socio-economic indicators, environmental exposures and health outcomes. The main obstacle for quantifying the magnitude of social inequalities in environmental conditions is the diversity of concepts and methods to define socio-economic position on one hand and of estimating exposure on the other hand. Especially the differences between the European countries in the conceptualization of socio-economic position and in educational systems were a constraint to quantify the results. Moreover, there is no widely approved method to define socio-economic position of children and adolescents within and across countries. Therefore choice of indicators of socio-economic position, method of exposure assessment, and size and choice of a study area may affect the magnitude and even direction of associations observed.[42–44]

Due to the variety of methodological approaches and studies and lack of data for many topics and countries/European regions it was not possible to conclude an overall assessment and to quantify the magnitude of environmental inequalities among children and adolescents in Europe.

For the interpretation of evidence it has to be considered that not all observed socio-economic differences in environmental conditions and exposures may have a health impact on its own but may be only effective in situations of multiple exposures. Furthermore, the aspect of salutogenic (health promoting) impacts of the environment on children's health and how environmental resources may counterbalance

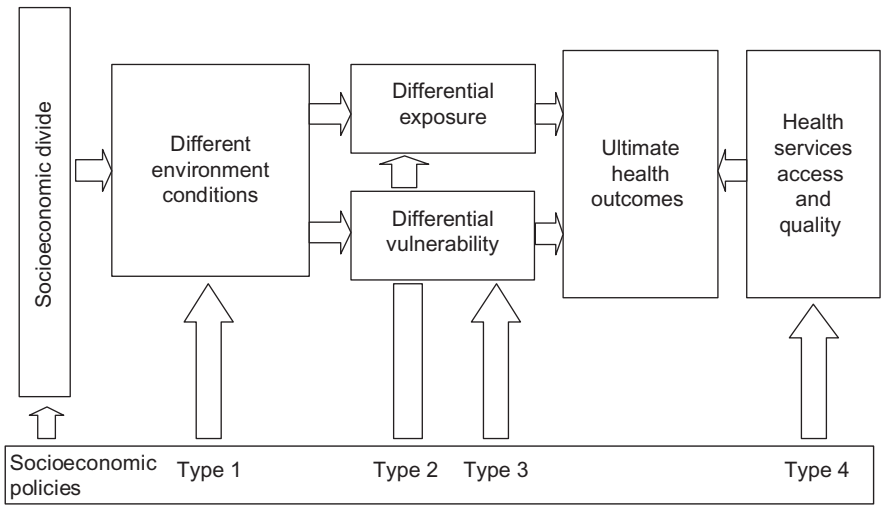

Figure 1 Policy approaches to address the main causal pathways of environmental inequity (modified from Commission on Social Determinants of Health[46])

Table 2 Addressing environmental inequity among children and adolescents in the CEHAPE priority areas: examples of four policy approaches and relevant responsible authorities

Policy approach	Action (examples)	Responsible authorities
CEHAPE priority area: indoor air pollution		
Reducing sources of pollution in deprived communities and households	– Plan urban development to minimize exposure to polluting industries and heavy road traffic	– Local administrative authorities
	– Provide financial incentives for improved heating systems and safer fuels at household level	– National and local legislating bodies
Reducing exposure at individual level	– Provide information, education and communication at community and household level on ways to reduce exposure in children with special emphasis on poor communities	– National and local health and environment authorities – Community health services
Reducing susceptibility to pollutants' effects	- Implement policies to prevent prenatal exposure to ETS, to reduce inborn susceptibility to post-natal exposure to air pollutants	– National and local legislating bodies – National and local health and environment authorities – Health professionals
Reducing health consequences	– Quality health services for respiratory diseases	– National and local health authorities – Health services
CEHAPE priority area: water and sanitation (W&S)		
Reducing sources of pollution in deprived communities and households	– Improve W&S facilities in poor communities (houses, schools and daycare centers) and provide financial incentives to W&S improved facilities in private houses	– National and local administrative authorities – National and local legislators
Reducing exposure at individual level	– Information, education and communication on ways to reduce exposure in children (e.g. washing hands, etc.) with special emphasis on poor communities	– National and local health and environment authorities – Health professionals
Reducing susceptibility to pollutants' effects	– Improve infant and young child nutrition	– National and local health authorities – Health professionals
Reducing health consequences	– Provide quality health services for diarrhoeal diseases	– National and local health authorities
CEHAPE priority area: chemicals		
Reducing sources of pollution	– Ban lead from gasoline, implement ban on PCBs and other POPs	– International agreements – National legislators
Reducing exposure at individual level	– Information, education and communication on ways to reduce exposure in children (e.g. monitor PCBs content of soil and food and advise accordingly) with special emphasis on poor communities	– National and local health and environment authorities
Reducing susceptibility to pollutants' effects	– Improve early child development by appropriate parental practices to reduce susceptibility to adverse neurodevelopmental effects caused by post-natal exposure to neurotoxicants	– National and local health and education authorities – Health professionals
Reducing health consequences	– Train health professionals in early recognition of signs and symptoms of lead intoxication – Implement biomonitoring in at risk populations	– National and local health and environment authorities
CEHAPE priority area: physical activity		
Reducing adverse environmental conditions	– Improve availability of playgrounds and safe walking or cycling paths to school	– Local administrative authorities
Reducing exposure at individual level	– Promote physical activity and reduce time of exposure to TV and computer screens	– National and local health authorities – Health professionals
Reducing susceptibility to risk factors	– Improve infant and young child nutrition	– National and local health authorities – Health professionals
Reducing health consequences	– Train health professionals and school personnel in promotion of physical activity and infant and young child nutrition	– National and local health and education authorities
	– Improve therapy of obesity and its health consequences	– Health professionals

environmental threats has not been comprehensively studied in the context of social inequalities.

Policy implications

This review nevertheless points to the importance of socio-economic factors in determining differential health outcomes in children as a result of environmental exposure. The need for action to address environmental inequity particularly among children has been recognized by the 53 WHO member states of the European region in the Fourth Ministerial Conference on Environment and Health, held in Budapest in 2004.

Actions to address environmental inequity among children may be included into four main policy approaches, according to their primary aim:

(i) policies aimed at reducing the socially determined differences in environmental conditions in settings where children live;
(ii) policies aimed at reducing the socially determined differences in individual children's exposure to hazardous environments;
(iii) policies aimed at reducing the socially determined differences in children's susceptibility to specific environmental pollutants and risk factors and

(iv) policies aimed at reducing the socially determined differences in the access to quality diagnostic, treatment and rehabilitation services for children who suffer the health consequences of being exposed to hazardous environments.

These four policy approaches should be seen as a continuum along the causal pathways of environmental inequity, from the distal socio-economic causes, to the increased susceptibility and exposure that characterize socially deprived children in particular, to the proximal factors related to access and quality of care (figure 1).

Type 1 actions, by acting upstream in the causal pathway of environmental risk, generally achieve a stable and sustainable risk reduction and therefore have the greatest long-term preventative potential. Type 2 and type 3 actions have a more limited scope and should not be seen as standalone interventions. Yet, the potential of nutrition and early child development policies to reduce the susceptibility and effects of exposure to unsafe and unhealthy environments cannot be neglected. Type 4 actions are clearly remedial rather than preventative, although they may still be quite important to save lives and prevent disabilities in the case of injuries and severe intoxications. Examples of type 1–4 actions addressing the four priority goals of the CEHAPE are provided in table 2. The table also provides a generic (the responsible authorities may not be the same across the 53 countries included in the WHO European region) indication of what kind of authorities could be responsible for developing and implementing the relevant policies and interventions.

Furthermore, an equity approach to children's environmental health should be adopted concerning environment and health information systems and IEC (information, education, communication) strategies. This could further enable stakeholders such as developers or teachers as well as parents to be aware of environmental inequalities and to contribute to improvement of children's environmental health.

Conclusion

Based on the available fragmentary evidence for Europe the main finding of this review is that there is a common pattern that children living in adverse social circumstances suffer from multiple and cumulative exposures, are more susceptible to a variety of environmental toxicants and often lack environmental resources/goods and other resources such as access to quality health care to counterbalance environmental threats and reduce their health consequences. This challenge requires a broad and cross-sectoral engagement to address the combination of factors, from the socially determined adverse environmental conditions to the social divide in exposure susceptibility and access to health care, which are responsible of environmental inequity among children. Children's health and environment lie at the centre of sustainable development. Protecting children from environmental hazards now will be of benefit to the well-being of the population as a whole in the long term.[45]

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Conflicts of interest. None declared.

Key points

- Children living in adverse socio-economic circumstances in Europe suffer more often from multiple and cumulative environmental exposures and are likely more susceptible to a variety of toxicants.
- There are still numerous knowledge and research gaps to fill to be able to assess the magnitude of environmental inequalities among children in Europe and the interaction between socio-economic position, multiple and cumulative environmental hazards, and community stressors.
- Research on social inequalities in exposure and susceptibility to hazardous environments should be complemented with research on social inequalities in environmental salutogenic resources and a community-based participatory research strategy.
- It is important to incorporate a child focused equity lens in environment information systems and in IEC activities.
- Specific actions to reduce socially determined differences in children's exposure, susceptibility and health consequences should be combined with upstream progressive policies to reduce the social divide, starting from the earliest years.

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Inequalities, inequities, environmental justice in waste management and health

Marco Martuzzi[1], Francesco Mitis[1], Francesco Forastiere[2]

Background: The scientific evidence on the health effects of waste-related exposure is not conclusive. Differential exposure to waste by socio-economic status (SES) is often documented, but the interplay between environmental and social factors, crucial for policy making, is not well known. This review aims at investigating the role of health inequalities and inequities in waste management. **Methods:** Grey and peer-reviewed literature, published after 1983, was reviewed from Europe and the USA. **Results:** Available data provide consistent indications that waste facilities are often disproportionally more located in areas with more deprived residents, or from ethnical minorities. This applies to waste incinerators, landfills, hazardous waste sites, legal and illegal. In studies considering health effects (mainly from Europe), risks are estimated with standardization for SES. Such standardization almost always decreases risk estimates for several cancers and reproductive outcomes. However, effect modification is not investigated in these studies. **Conclusions:** The patterns of association between waste-related environmental pressures and SES suggest that some of the observed inequalities in exposure and health represent a case of environmental injustice as they are the result of social processes and may be prevented, at least partly. Disentangling the possible health effects remains difficult, due to limitations in the methodology. It seems important to investigate if disadvantaged people are more vulnerable, i.e. risks differ in different social groups living in the same area. Notwithstanding these open questions, public health officers and decision makers should identify waste management policies to minimize their potential health impacts and their unequal distribution.

Keywords: adverse effects, environmental exposure, hazardous waste, health effects, social class, socio-economic factors

Introduction

Waste and health: scientific evidence and knowledge gaps

Given the growing production of waste, policy-makers are increasingly confronted with the necessity of developing more capacity to safely dispose of waste. Despite the lack of univocal evidence on the health implications of waste-related environmental exposures, there are concerns over the health effects of different waste management options, including land filling, incineration, disposal of healthcare and other hazardous waste.[1]

Further insights on health effects of landfills and incinerators are needed; it is important to investigate these possible effects in conjunction with other environmental hazards, as concurrent exposures can result in synergistic health effects. In particular, it is of interest to consider how possible health effects of waste may take place in combination with other powerful health determinants depending on lifestyle and the social environment. It is urgent to clarify how population distribution of waste-related exposures (i.e. how uneven are such exposures among different subgroups) can inform the policy response, affect its effectiveness and acceptance, and how these aspects can be taken into account more systematically in policy-making. In particular, it is of great interest to clarify what proportion of health *inequalities* (i.e. general differences in health status and in exposure levels due for example to age or individual predisposition) can be regarded as *inequities* (i.e. avoidable differences, for example in access to healthcare service, preventing individuals from attaining their full health potential, and carrying an ethical negative judgement) and as such result in environmental injustice.

The present contribution is dedicated to the role of socio-economic differences and environmental justice on the potential health burden due to exposure to hazardous waste facilities.

Role of social health determinants

Social determinants of health have a strong influence on virtually all health endpoints considered in studies designed to assess the role of waste–related exposure. As in many other fields in environmental health, this realization has resulted in the adoption of methodology to formally take into account these effects in epidemiological studies. Typically, socio-economic factors have a strong potential for acting as *confounders* of the parameter of interest, i.e. the association between health and waste exposure. This is because exposed subjects often have socio-economic characteristics that can differ from those of unexposed subjects, and thus create differences in risk that could be erroneously attributed to waste. This is why effects of socio-economic factors are often regarded, in epidemiological studies, as *nuisance factors*, and standardization techniques are applied to remove their contribution and assess the waste–health association, net of the influence of socio-economic factors.

This routine standardization reflects the strong expectation that socio-economic factors are associated with environmental exposures—a prerequisite for a confounding effect. The systematic adoption of this practice relies on an important assumption, and suggests a certain attitude: the assumption is hazard *proportionality*, i.e. health risks from socio-economic conditions act as multipliers of an independent

[1] World Health Organization (WHO) Regional Office for Europe, Rome Office, Rome, Italy
[2] Local Health Authority Roma E, Rome, Italy
Correspondence: Marco Martuzzi, World Health Organization (WHO) Regional Office for Europe, Rome Office, Via Francesco Crispi, 10-I-00187, Rome 00198, Italy, tel: +39-06-4877520, fax: +39-06-4877599, e-mail: mam@ecr.euro.who.int

risk due to environmental factors. In other words, through standardization for socio-economic factors the environmental risk is assumed constant across different social strata, and the possibility of *modification of effect* (for example, different risks for different socio-economic groups) is seldom investigated. The attitude is the one of considering the multiple effects as independent of each other and attaching less importance to the contextual ones. Admittedly, full, holistic consideration of the mutual action of different risks is very challenging and is often not feasible; however, a fuller understanding of how environmental risk factors operate in the reality of the social environment would be very informative especially for designing effective policy responses.

In this paper we examine the evidence and the implications of the confounding effect of socio-economic factors. First of all then, we address the question of how strong is the evidence that more deprived communities are more exposed to waste-related contaminants; later, we examine how these gradients, where observed, can influence the risks for several health endpoints, considering how risks differ before and after adjustment for socio-economic factors. Finally, we discuss the implications of these inequalities.

Methods

Grey and peer-reviewed literature, published after 1983, when an influential paper appeared,[2] was reviewed from Europe and the USA.

Keywords or references in the titles to 'waste', 'health effects', 'socio-economic factors', 'inequities', 'environmental justice', 'congenital anomalies' and 'mortality' were used to search the Medline database. All European studies were selected. With regard to US studies, given the large amount of literature dealing with social differences on the residence near waste facilities, only the most s studies were chosen and commented. The grey literature was searched with the same criteria using Google Scholar and looking at the key references listed in the peer-reviewed articles to identify nongovernmental organization (NGO) reports and studies published by other agencies. A total of 47 studies were included in the review.

Results

Residence near waste facilities: unequal and inequitable

The characteristics and main findings of the identified studies are summarized in Supplementary Table 1.

The first studies on environmental justice, contaminated sites and waste were carried out in the USA and were prompted by the concerns of civil activists on the disproportionate location of landfills in predominantly black communities.[3] The correlation between race, income and residence influenced several outcomes such as a higher likelihood of being exposed to environmental hazards, the disproportionate impacts of environmental processes and policies, the targeting and siting of noxious facilities in more deprived communities and inequalities in the delivery of environmental services such as rubbish removal.[4–6]

Other studies found skewed distributions around waste sites, with less affluent population subgroups, and with more black people, living in the surroundings of the facilities.[2,7–9] In a US national assessment[10,11] (later updated[12]), a correlation was found between proportion of black residents and the presence of hazardous waste sites in the surroundings. Although these results were criticized,[13–16] ethnicity was considered to be a stronger predictor of the presence of toxic dumps than other variables, such as household income, the value of homes and the estimated amount of hazardous waste generated by local industry.

Brown[17] reviewed (i) exposure to toxic hazards, including the presence of hazardous waste sites and facilities (ii) regulations, ameliorations and cleanups, including record of decisions and cleanups at National Priority List (NPL) sites and (iii) regulatory actions, as measured by assessed fines for environmental pollution; he concluded that 'the overwhelming bulk of evidence supports the ''environmental justice'' belief that environmental hazards are inequitably distributed by class, and especially race'. These results were confirmed by the most recent study,[18] and the underlying social processes were analysed in different settings.[15,19,20]

Compared to US studies, European data are based on a different approach to measuring socio-economic status (SES), based on composite indices built combining information on several domains, such as social class, education, unemployment, housing, family structure, rather than variables such as income or ethnicity.

The association between social characteristics and residence in the vicinity of waste sites has been repeatedly documented in England and Wales. Several studies analysed the correlation between income and deprivation with localization of solid waste and other polluting facilities, finding that facilities were disproportionally located in the more deprived areas.[21–23] The correlation was not always observed for landfills at the subregional level.[24]

At the national level, a study by Elliott *et al.*[25] showed that 'the area within two km of the 9565 landfill sites tended to be more deprived than the reference area: 34% (versus 23%) of the population were in the most deprived tertile of Carstairs score (36% for special waste sites)'.

A national study on environmental inequalities in France on the distribution of environmental burden tested the hypothesis that poor and immigrant communities are disproportionately exposed to environmental risks. Eight types of hazardous sites (industrial and nuclear sites, incinerators, waste management facilities) and the socio-economic characteristics of populations were associated at the *commune*, or town, level for all 36 600 French towns. The results of the spatial regression analyses showed that towns with high proportions of immigrants hosted more hazardous sites, even controlling for population size, income, degree of industrialization of the town and region.[26]

In the European Union project Integrated Assessment of Health Risks of Environmental Stressors in Europe (INTARESE), an integrated approach for the health impact assessment of landfills and incinerators on the population living in the surroundings has been applied in Italy, UK and Slovakia, for a total 905 municipal urban solid waste landfills and 53 waste incinerators.[27] A direct relationship was found between social class and residence near waste facilities in Italy and UK, and an inverse relationship was found in Slovakia (Table 1). For incinerators, this may be due to the location of the two facilities in urban areas, where most affluent Slovakian people live.

The results of European Collaborative Study of Residence near Hazardous Waste Landfill Sites and Risk of Congenital Malformations (EUROHAZCON),[28] a multisite study that considered 21 landfills in several countries, suggested 'no overall evidence that socio-economically more deprived communities live near to landfill sites'.

An inverse relationship was also found in a study of a Welsh landfill, where most affluent people were found to be living closer the site.[29]

Cancer mortality and congenital anomalies of populations living in 196 municipalities of two provinces of Campania

Table 1 Characteristics of residents living close to waste facilities[a] in Italy[b], Slovakia and England, by quintiles of deprivation index, 2001

	Landfills			Incinerators		
	Italy	Slovakia	England and Wales	Italy	Slovakia	England and Wales
Number of sites	619	165	232	40	2	11
Population within 2 km	1350 852	328 869	1425 350	1060 569	16 409	1203 208
Most affluent population (I group, %)	13.3	24.2	2.5	12.6	55.6	30.
II group	15.0	24.7	17.9	15.1	2.4	6.3
III group	22.4	22.6	18.7	21.0	9.8	12.5
IV group	23.0	16.4	19.1	24.2	29.6	22.8
Most deprived population (V group, %)	26.1	12.1	20.1	24.9	2.5	55.4
Missing information (%)	0.0	0.0	21.7	2.2	0.2	0.0

Source: adapted from Forastiere *et al.*[27]
a: 2 km from municipal urban solid waste landfills; 3 km from waste incinerators
b: 118 landfills were geocoded, for population of 257 513. Socio-economic data were then extrapolated to 619 landfills

Region, southern Italy, were recently investigated.[30] The study area was characterized by more than 20 years of waste mismanagement (with the involvement of organized crime), including uncontrolled waste disposal, release of toxic substances and illegal waste burning. A positive correlation ($r = 0.30$) was found at municipality level between a waste exposure indicator (built using 227 waste facilities sites–138 of which illegal) and a deprivation index.[30]

Interest in environmental justice and in unequal distribution of environmental hazards and benefits has recently grown in countries of central and eastern Europe. It has been documented that hazardous sites and illegal waste disposal activities are disproportionally located in the working-class areas, as in Hungary with illegal asbestos disposal,[31] and in communities of ethnic or national minorities, predominantly the Roma populations,[32–34] whose camps are often settled on (or near) contaminated sites. The Hungarian National Public Health and Medical Officers' Service reported, for example, that 15% of the 767 Roma colonies identified in Hungary, for a total of three million persons, are within 1 km of illegal waste disposal sites, and 11% within one km of animal carcass disposal sites.[35]

In addition, minority groups in European countries are more at risk of environmentally based discrimination because they are more likely to be object of discrimination, and be segregated in enclaves or in deprived zones along the borders, or in refugee camps.[33,36,37]

Finally, besides differential levels of exposure to waste-related contaminants by socio-economic levels at local or national level, inequalities in exposure might take place at the international level, through the transfer of related hazards from one country to another.[38,39] In fact, illegal shipment and disposal of hazardous waste is of growing relevance in some countries of central and eastern Europe.[40,41]

Exposure to waste and socio-economic factors: compounded effects

Many of the studies above, especially from Europe, document a pattern where deprived people are overrepresented in the vicinity of waste treatment facilities. In some of these studies, in addition, it is observed that health effects—notably mortality, congenital anomalies, low birth weight—are associated with socio-economic factors.

Several studies were performed in UK on congenital anomalies,[25,42] Down syndrome[43] and cancer[44] in population living near landfills. In a recent study on congenital anomalies and landfill density, risks were standardized by SES, presence of a congenital anomalies registry and maternal age. On adjusting for these factors, risks decreased for all the anomalies under study, more markedly in areas with the highest special waste sites density.[25]

In a subsequent study[43] a decreasing risk of Down's syndrome with increasing levels of socio-economic deprivation was observed; however, adjustment for SES resulted in a marginal correction of the estimates of the risks from landfills, perhaps not surprising because of the strong effect of maternal age.

In another UK study on cancer and residence near landfill sites,[44] adjustment for SES decreased the risk estimate for bladder cancer, which however remained significantly in excess. The same was observed for hazardous sites, but the adjusted risk for bladder cancer lost statistical significance.

In the EUROHAZCON multi-site study a positive association was reported in the UK between SES and non-chromosomal congenital anomalies close to landfills.[28] The risk in the most deprived group was 40% higher than in the most affluent quintile; an impact measure was also estimated: if the rates observed in the most affluent group prevailed in the whole exposed population, the 18% fewer anomalies would have occurred.[45] This pattern was not observed in other European sites.

In a study carried out in Campania a positive association was observed between mortality for various cancer causes and both illegal waste exposure and socio-economic factors. For both sexes, mortality risk estimates unadjusted by socio-economic deprivation were much higher than adjusted ones, as shown in Table 2. Risk estimates were markedly corrected across the five levels of waste exposure, and so were estimates of linear trends. The only exception was stomach cancer in men.[46]

In a study in the New York state near PCB-contaminated (i) superfund sites, (ii) NPL sites and (iii) the six areas of concern,[47] the risk of giving birth to a low-birth-weight and to a very low-birth-weight baby was investigated. Positive associations were observed between having a low-birth-weight baby and (i) low levels of income and (ii) mother's educational level less than (or equal to) high school while only a low-income level was associated to having a very low-birth-weight baby.

Another US study[48] considered only ethnic minorities (Black/African American, Hispanic/Latino, American Indian/Alaska Native and Asian/Pacific Islander) and found a positive association between a range of anomalies and residence in the census tracts near the NPL hazardous waste sites. The largest association was found between potential exposure and neural tube defects [odds ratio (OR) = 1.54, 95% confidence

Table 2 Waste exposure, SES and mortality outcomes in Campania region[a]

	Mortality excess (%) risks by waste exposure group[b]										
	I	II		III		IV		V		*Trend*	
		Unadj	Adj[c]	Unadj	Adj	Unadj	Adj	Unadj	Adj	Unadj	Adj
Cause of death—men											
All causes	—	**9.2**	**5.4**	**6.9**	**7.9**	**7.1**	**3.9**	**13.6**	**9.2**	**2.2**	**1.7**
All cancers	—	**9.3**	**4.2**	3.2	**5.6**	**9.3**	**4.9**	**11.0**	4.1	**2.2**	**1.5**
Lung cancer	—	**11.4**	**5.5**	4.2	6.4	**11.1**	6.1	**14.0**	6.7	**2.7**	**1.9**
Liver cancer	—	−0.1	−9.2	12.7	**20.6**	7.0	0.7	35.5	**19.3**	**5.6**	**4.3**
Stomach cancer	—	−1.5	3.0	0.1	2.8	**17.0**	**19.4**	16.2	15.7	**5.0**	**5.2**
Bladder cancer	—	**17.3**	11.7	−11.0	−6.4	10.8	7.1	4.6	−4.1	0.8	−0.7
Kidney cancer	—	4.4	−2.8	−4.3	−0.6	−8.5	−14.9	−7.6	−16.7	−3.0	−4.0
Soft tissues sarcoma	—	10.6	−9.8	−7.2	−20.4	−23.6	−31.0	18.7	25.0	−3.1	−3.9
Non Hodgkin lymphoma	—	**24.2**	9.4	29.8	25.4	18.7	6.8	2.8	−3.7	2.3	1.3
Other cancers	—	**9.1**	**4.7**	2.4	4.3	**7.6**	3.3	6.2	0.3	1.4	0.7
Cause of death—women											
All causes	—	**3.1**	1.7	**7.2**	**8.1**	**5.6**	**4.8**	**14.4**	**12.4**	**2.6**	**2.4**
All cancers	—	**9.8**	**5.1**	2.3	2.4	**6.7**	3.6	**10.0**	**6.6**	**1.6**	**1.0**
Lung cancer	—	**63.8**	**45.4**	10.2	14.4	14.1	5.6	**22.7**	9.4	0.2	−2.3
Liver cancer	—	−3.5	−9.3	5.0	9.1	13.6	9.6	**39.5**	**29.1**	**7.3**	**6.6**
Stomach cancer	—	−8.1	−8.3	−2.3	−6.4	1.0	2.2	10.7	16.7	2.1	2.6
Bladder cancer	—	17.9	7.7	−6.5	−12.7	3.2	−2.8	−17.3	−16.7	−2.8	−3.3
Kidney cancer	—	19.2	6.9	2.4	11.2	8.7	3.4	36.2	19.1	3.8	1.7
Soft tissues sarcoma	—	4.3	7.7	76.0	84.1	35.2	33.6	4.2	−0.3	7.8	8.3
Non Hodgkin lymphoma	—	9.8	10.1	3.3	3.5	15.9	19.7	−2.1	−0.2	1.8	1.6
Other cancers	—	**7.4**	3.5	1.3	1	5.2	2.3	6.3	3.7	1.1	0.7

Source: Adapted from Martuzzi *et al*.[30]
a: In bold, statistically significant risks are reported (95% CI)
b: I group is used as reference, i.e. no waste-related exposure; V group has highest exposure
c: Mortality excess risks (%) = (relative risk −1) × 100. Risks adjusted by SES

interval (CI) = 0.93–2.55]. The strongest association between birth defects and potential exposure was among American Indians/Alaska Natives (OR = 1.19, 95% CI = 0.62–2.27). This study design, however, does not allow a comparison with the effects in the majority population.

Discussion

Waste and health: same risk for everyone?

The evidence summarized above indicates that there is a tendency in poorer, less educated, disadvantaged people or ethnical minorities to live closer to waste treatment facilities of any kind and, in addition, that when adverse health effects due to such proximity are detected, these are often compounded (usually multiplicatively) with the adverse effects of social disadvantage. This pattern may occur for other localized source of environmental pollutants, but is not systematically documented. On the whole, the evidence suggests marked inequalities in the health pressures and impacts due to the combination of environmental and social factors. Some of these inequalities are due to socially driven processes, for example residential segregation or differential access to health-promoting resources, amenable to mitigation.

Some questions arise from these observations.

- Are disadvantaged people, besides being disproportionally exposed to waste-related environmental risk, also more vulnerable to its impacts?
- Do risks differ in different social groups living in the same exposed place and, if so, to what extent?
- In other words, is there an interactive, synergistic relationship between the adverse health effects of waste exposure and of the disadvantaged social environment, or conversely does the proportionality assumption hold?
- How preventable are the observed inequalities?

The available information on the health effects of waste facilities by social groups, needed to address these questions, is limited. First, not all the studies carried out to evaluate the potential associations between exposure to waste facilities and health have considered SES; in some studies, socio-economic-adjusted risks are estimated but unadjusted risks are not published, or are indistinguishable from those due to other factors (for example, maternal age or the presence of a dedicated registry in studies of congenital anomalies). Secondly, and crucially, in no cases are interaction effects between socio-economic factors and waste exposure tested and reported. Some studies are designed with selected populations either highly exposed[47] or from socially disadvantaged,[48] making the assessment of the interaction impossible.

For waste and health as well as for many other cases in environment and health, these issues are central; together with better quality data on waste-related exposures, recognized as a prerequisite for more informative studies,[1] more detailed information on exposure and health by the socio-economic group would not only shed light on the nature of the interrelationship between the social and the physical environment but would also allow the identification of more effective strategies to prevent or reduce the impacts.

There are, however, substantial difficulties in estimating the joint effects of different risk factors, for example, low power to estimate interactive effects, given the high collinearity between environmental exposures and deprivation. This is one facet of environmental justice: different risk factors, such as environmental contamination, social disadvantage, unhealthy lifestyles, are often observed to insist on the same subgroups. This makes the assessment of the interplay between these different factors difficult and represents an important reason to consider inequalities

(in exposure and in health outcomes) as inequities. Other relevant considerations in terms of equity include the following.

- While a certain degree of inequalities are inevitable, at least a part (arguably a substantial one) of the observed inequalities is preventable. Exposure inequalities can and must be reduced by appropriate measures of mitigation and abatement of emissions from potential sources. This includes not only established noxious agents (for example, particulate matters, persistent organic pollutants, heavy metals) but also emissions interfering with residents' quality of life (for example, odours, noise). Inequalities can be further countered by primary prevention and health promotion initiatives undertaken in conjunction.
- It is possible that people who bear the most part of the adverse impacts from waste disposal activities (in terms of health and well-being) produce less waste. This might occur, for example, when residential exposures are disproportionately distributed towards population strata with lower income, lower purchasing power and lower rates of consumption of material goods. There are examples, in other domains, where this unfair, negative correlation between benefits and negative impacts is obvious (for instance, greenhouse gas emission at global level) and similar mechanisms may take place at more local level too.

Currently, both of these dimensions of environmental justice are, by and large, speculative. Data and evidence to assess the extent of these inequities would be highly informative.

Conclusions

Numerous studies in Europe and in the USA have documented that disadvantaged communities often suffer disproportionately from the impact of waste facilities. Several questions are unresolved that should be addressed with the collection of targeted data and research. Uncertainties include the presence and magnitude of environmental different waste-related risks, the possible synergistic effects with the social environment, the extent to which inequalities are preventable and the degree to which benefits and adverse impacts are differentially distributed in the population. However, while these knowledge gaps are being filled, public health professionals should contribute to the identification and development of waste management policies that minimize health impacts and inequalities. In the words of Mohan:[49]

> Health inequalities should be one of the key considerations when developing waste management strategies or when conducting HIAs of waste sites. If waste management installations are to be located in an area, every effort should be made to mitigate any potential adverse health effects. [...] Every effort should also be made to ensure that the local community enjoys any potential benefits from waste management.

For waste management as well as for other domains, a direct participation of the health sector in the decision-making process is desirable. Participatory processes are necessary to achieve fairer policies, where the interests of all stakeholders are taken into consideration. In view of the various limitations hampering our ability to characterize all risks, policy decisions on new facilities and remediation schemes should be inspired by a precautionary approach,[9] where health and equity are put at the centre of the debate.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Key points

- The expectation that waste-related environmental exposure is stronger in disadvantaged population subgroups is confirmed by most studies available in Europe and the USA.
- The effects of socio-economic health determinants are often removed, through standardization, in epidemiological studies; the possible occurrence of modification of effect would be of great interest, but is not documented.
- Despite the limited understanding of the interplay between waste-related exposures and social health determinants, observed patterns raises a question of environmental justice, which require adequate policy responses.

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Living longer and feeling better: healthy lifestyle, self-rated health, obesity and depression in Ireland

Janas Harrington[1], Ivan J. Perry[1], Jennifer Lutomski[1], Anthony P. Fitzgerald[1], Frances Shiely[1], Hannah McGee[2], Margaret M. Barry[3], Eric Van Lente[3], Karen Morgan[2], Emer Shelley[2]

Background: The combination of four protective lifestyle behaviours (being physically active, a non-smoker, a moderate alcohol consumer and having adequate fruit and vegetable intake) has been estimated to increase life expectancy by 14 years. However, the effect of adopting these lifestyle behaviours on general health, obesity and mental health is less defined. We examined the combined effect of these behaviours on self-rated health, overweight/obesity and depression. **Methods:** Using data from the Survey of Lifestyle Attitudes and Nutrition (SLÁN) 2007 (), a protective lifestyle behaviour (PLB) score was constructed for 10 364 men and women (>18 years), and representative of the Republic of Ireland adult population (response rate 62%). Respondents scored a maximum of four points, one point each for being physically active, consuming five or more fruit and vegetable servings daily, a non-smoker and a moderate drinker. **Results:** One-fifth of respondents (20%) adopted four PLBs, 35% adopted three, 29% two, 13% one and 2% adopted none. Compared to those with zero PLBs, those with four were seven times more likely to rate their general health as excellent/very good [OR 6.8 95% CI (3.64–12.82)] and four times more likely to have better mental health [OR 4.4 95% CI (2.34–8.22)]. **Conclusions:** Adoption of core protective lifestyle factors known to increase life expectancy is associated with positive self-rated health, healthier weight and better mental health. These lifestyles have the potential to add quality and quantity to life.

Keywords: lifestyle behaviours, self-rated health, obesity, depression, protective factors.

Introduction

It has been known for some time that adoption of a number of core protective/health promoting lifestyle behaviours at an individual level has a potentially large positive influence on population health. There is increasing recognition of the value of these behaviourally defined protective behaviours for health promotion and population health monitoring,[1–8] and advice on smoking cessation, healthy diet, physical exercise and moderation in alcohol consumption has been a pillar of health education for many years. While anecdotally a perception exists that adoption of a healthy lifestyle may impair quality of life as evidenced by the admonition 'You won't live forever, it will just feel like it', recent evidence suggests that quality as well as quantity can be added to life through the adoption of relatively minor lifestyle changes.[5]

Results from the Nurse's Health Study[9] reported the positive effects of a limited number of core protective lifestyle behaviours (PLBs) [body mass index (BMI) $< 25\,kg\,m^{-2}$; a diet high in cereal fibre and polyunsaturated fat and low in trans fat and glycaemic load; engagement in moderate-to-vigorous physical activity for at least half an hour per day; no current smoking and the consumption of an average of at least half a drink of an alcoholic beverage per day] in relation to the decreased risk of type 2 diabetes. This work has been replicated in a cross-sectional study with markers of cardiovascular risk including hypertension, dyslipidaemia and insulin resistance.[4,5,10] More recently, Khaw *et al.*,[1] in their work from the European Prospective Investigation into Cancer (EPIC) study, focused on behaviourally defined measures. They identified four lifestyle behaviours: being physically active, a non-smoker, having a moderate alcohol consumption and an adequate fruit and vegetable intake and found that the combined effect of these health behaviours predicted a 4-fold difference in total mortality in men and women,[1] equating to a 14-year difference in life expectancy between individuals practising none of these behaviours relative to those practising all four of them. In further work from the EPIC study, Myint *et al.*[11] concluded that behavioural factors were associated with substantial differences in age-related decline in functional health and the prevalence of those in good and poor functional health in the community.

Examining the effects of individual risk factors for chronic disease and poor physical and mental health is not a new concept; however, their combined effect on general health, obesity and mental health is less well defined. The aim of this study was to examine the combined effect of practising four non-clinically defined lifestyle behaviours (being a non-smoker, being physically active, being a moderate drinker, and consuming five portions of fruit and vegetables daily) on self-rated health, overweight/obesity and mental health.

Methods

Based on the work by Khaw *et al.*,[1] we constructed a PLB score. Participants scored one point for each of the following health behaviours: being a non-smoker, being physically active (moderate/high activity score), being a moderate drinker (1–14 alcohol units per week) and consuming five or more servings

1 Department of Epidemiology and Public Health, University College Cork, Ireland
2 Division of Population Health Sciences, Royal College of Surgeons in Ireland, Ireland
3 Department of Health Promotion, National University of Ireland, Galway, Ireland
Correspondence: Janas Harrington, Department of Epidemiology & Public Health, University College Cork, Room 2.62, Brookfield Health Sciences Complex, College Road, Cork, Ireland, tel: +353-21-4901597, fax: +353-21-4901604, e-mail: j.harrington@ucc.ie

of fruit and vegetables daily. Respondents could score from zero to four on protective health behaviours.

General study design

The study was the third national Survey of Lifestyle, Attitudes and Nutrition (SLÁN) in Ireland conducted in 2007,[12–14] involving a nationally representative sample of 10 364 respondents (62% response rate) to whom a detailed health and lifestyle questionnaire was administered by face-to-face interview. In addition, 9223 (89%) completed a Willett Food Frequency Questionnaire (FFQ). The FFQ was an adapted version of the EPIC study,[15] validated for use in the Irish population.[16] Participants who did not complete a FFQ were excluded from this analysis.

Sampling

The population for the survey was defined as adults aged 18 years and over living in residential households in Ireland (residents of institutions, nursing homes, hospitals, prisons and homeless hostels were not included). Full details of the sampling frame and weighting can be found elsewhere.[12] In summary, the sampling frame used for the survey was the GeoDirectory, a list of all addresses in the Republic of Ireland, which distinguishes between residential and commercial establishments. The sample was a multi-stage probability sample, where each dwelling has a known probability of selection. The sample was weighted to closely approximate the Census 2006 figures for gender, age, marital status, education, occupation, region, household size and ethnicity.

Health and lifestyle questionnaire

A single question was included on self-rated health, respondents were asked to rate their health on a 5-point scale ranging from 'excellent' to 'poor'. Being a current smoker was defined as smoking either 'every day' or 'some days'. Non-smokers were classified as those who had never smoked; former smokers were those who had smoked 'at least 100 cigarettes in their lifetime' but do not currently smoke. For the purpose of this article, current smokers are compared with non-smokers. Average alcohol consumption was estimated as the units of alcohol consumed per week. For the purpose of this article, a moderate drinker was defined as someone who consumed between 1 and 14 units a week. A unit is defined as either 'a half pint of beer; a single measure of spirits; or as a single glass of wine, sherry or port'. Respondents were also asked if they had experienced any chronic illness from a pre-defined list in the previous 12 months.

International physical activity questionnaire (IPAQ)

Respondents were asked a series of questions relating to the time they spent being physically active. The responses were used to calculate a physical activity score (IPAQ score) for each respondent. These scores were classified as high (over 10 000 steps per day), moderate (5000–10 000 steps per day) or low (less than 5000 steps per day). For this analysis, a binary variable was created; 'low' or 'moderate/high', 'low' was defined as being physically inactive.

Composite international diagnostic interview (CIDI)

Respondents were asked a series of questions pertaining to their mental health status. The CIDI-SF (short form) Version 1.1 health interview survey, part of which was incorporated in the main SLÁN interview, provides a probable diagnosis (CIDI-SF yields a likelihood of having a major depression rather than a full diagnosis; hence, the term 'probable Major Depressive Disorder' is used throughout this article) of major depressive disorder.[17] Full details of the mental health measures have been reported elsewhere.[18]

Food frequency questionnaire

The dietary habits of respondents who completed a FFQ were analysed in relation to food groups. Full details of the FFQ have been documented elsewhere.[19] For this analysis, fruit and vegetable intake was collapsed to a binary variable with participants categorized as consuming 'five or more servings daily' or 'less than five servings daily'.

BMI

SLÁN 2007 respondents were also asked to self-report their own height and weight. BMI was calculated based on the standard formula [height (m)/weight (kg) × weight (kg)], they were classified as overweight or obese based on a BMI score of $\geq$25 or 30 kg m^{-2}, respectively.

Statistical analysis

Data were analysed using SPSS^{TM} (Version 15.0). Logistic regression was used to examine the relationship between PLB score, self-rated health, probable depressive disorder and obesity levels after adjusting for age, sex, education and social class. Additionally, we examined the relationship between PLB score and past diagnoses of medically diagnosed chronic illness.

Results

Demography

Table 1 shows a breakdown of the relevant participant characteristics differentiated by gender. Higher proportions of women were of normal weight and consumed five or more daily servings of fruit and vegetables compared with men. Men were more likely to be smokers, to consume more alcohol and to be physically active compared with women. Women were more likely to have adopted more of the PLBs. Table 2 shows the age, gender, social demographic profile and the distribution of key outcome variables in five groups of study participants defined on the basis of number of PLBs. Clear and highly significant trends were seen for age, gender, education and social classification status. Those with three and four PLBs were more likely to be female, in the younger/middle age group to have tertiary education and to be in the 'large employers/professional/manager' socioeconomic classification group. Respondents with a lower PLB score were significantly more likely to have a depressive disorder ($P < 0.01$).

Associations between PLBs and feeling healthy

The association between PLB score, self-rated health, healthy weight and better mental health adjusted for age, sex, education and social class is shown in table 3. For self-rated health and depressive state, clear and highly significant trends in odds ratios were observed across the five groups of study participants. These trends were not as obvious for body weight. Relative to those with zero PLBs, those with four were almost seven times more likely to rate their general health as excellent/very good [OR 6.8, 95% CI (3.64–12.82)]. These trends persisted even when the model was adjusted for depressive disorders. Those with four PLBs were also four times more likely to have better mental health [OR 4.4, 95% CI (2.34–8.22)] indicating a better overall general health

Table 1 Distribution of variables for SLÁN 2007 participants included in this analysis (participants who did not complete a FFQ were excluded from the analysis)

Variable	Category	Men ($N=4511$) Mean (SD)	Women ($N=4661$) Mean (SD)	Total ($N=9172$)
Age (years)	–	43.4 (16.9)	44.3 (17.8)	43.8 (17.4)*
		N (%)	*N* (%)	*N* (%)
BMI (kg m^{-2})	Underweight (15–18.5)	60 (1.4)	128 (3.0)	188 (2.2)*
	Normal weight (18.5–24.9)	1745 (40.4)	2397 (55.8)	4142 (48.1)
	Overweight (25–29.9)	1831 (42.4)	1217 (28.3)	3048 (35.4)
	Obese (≥30)	684 (15.8)	557 (13.0)	1241 (14.4)
European socio-economic classification	Large employers, professional, managers	1541 (34.2)	1482 (31.8)	3023 (33.0)*
	Intermediate, lower supervisory occupations and technicians	593 (13.1)	758 (16.3)	1351 (14.7)
	Self-employed and small employers	800 (17.7)	561 (12.0)	1361 (14.8)
	Lower sales/service, lower technical and routine occupations	1379 (30.6)	1344 (28.8)	2723 (29.7)
	Unknown/unclassified	198 (4.4)	516 (11.1)	714 (7.8)
Education	Primary	1712 (38.0)	1594 (34.2)	3306 (36.6)*
	Secondary	1217 (27.0)	1289 (27.7)	2506 (27.3)
	Tertiary	1582 (35.1)	1778 (38.1)	3360 (366)
Smoking status	Former	1023 (22.9)	720 (15.6)	1743 (19.2)
	Never	2110 (47.2)	2672 (57.9)	4782 (52.6)
	Current[a]	1335 (29.9)	1224 (26.5)	2559 (28.2)
Physical activity	Low	913 (24.3)	1266 (32.7)	2179 (28.6)*
	Moderate/high	2844 (75.7)	2606 (67.3)	5450 (71.4)
Alcohol drinking	Above weekly recommended units	1975 (52.21)	2214 (62.2)	4189 (57.0)*
Fruit and vegetable consumption	More than five servings per day	2691 (59.6)	3318 (71.2)	6009 (65.5)*
No. of protective lifestyle behaviours	0	54 (2.4)	40 (1.6)	97 (2.0)
	1	388 (16.2)	259 (10.4)	647 (13.3)
	2	727 (30.4)	675 (27.2)	1402 (28.8)
	3	802 (33.5)	920 (37.1)	1722 (35.3)
	4	419 (17.5)	589 (23.7)	1008 (20.7)
Self-reported general health	Excellent/very good/good	3955 (87.8)	4100 (88.3)	8055 (88.0)
Probable major depressive disorder		210 (4.7)	349 (7.5)	559 (6.1)*
Any chronic illness in the previous 12 months excluding CVD events		1517 (33.7)	1832 (39.4)	3349 (36.6)*

a: Smoker was classified as someone who smokes either everyday or some days
*Significant gender difference $P<0.01$; ***Significant gender difference $P<0.05$

Table 2 Demographic breakdown by number of protective lifestyle behaviours practised

		Number of protective behaviours					
		0 $N=153$ % (*N*)	1 $N=919$ % (*N*)	2 $N=1954$ % (*N*)	3 $N=2159$ % (*N*)	4 $N=1008$ % (*N*)	*P*-value trend
Gender	Male	85 (55.9)	566 (61.6)	1063 (54.4)	1025 (47.5)	419 (41.6)	0.000
	Female	67 (44.1)	353 (38.4)	891 (45.6)	1134 (52.5)	589 (58.4)	
Age group	18–29	35 (23.2)	242 (26.3)	574 (29.4)	598 (27.7)	324 (32.1)	0.000
	30–44	46 (30.5)	307 (33.4)	661 (33.8)	733 (33.9)	321 (31.8)	
	45–64	38 (25.2)	271 (29.5)	554 (28.3)	644 (29.8)	287 (28.5)	
	>65	32 (21.2)	100 (10.9)	166 (8.5)	185 (8.6)	76 (7.5)	
Education	Primary	84 (54.9)	349 (38.0)	624 (31.9)	543 (25.2)	193 (19.1)	0.000
	Secondary	36 (23.5)	265 (28.8)	580 (29.7)	628 (29.1)	277 (27.5)	
	Tertiary	33 (21.6)	305 (33.2)	751 (38.4)	988 (45.8)	538 (53.4)	
European socio-economic classification	Large employers, professional, managers	37 (24.2)	280 (30.4)	694 (35.5)	863 (40.0)	438 (43.5)	0.000
	Intermediate, lower supervisory occupations and technicians	23 (15.0)	143 (15.5)	299 (15.3)	356 (16.5)	149 (14.8)	
	Self employed and small employers	22 (14.4)	153 (16.6)	279 (14.3)	270 (12.5)	138 (13.7)	
	Lower sales/service, lower technical and routine occupations	59 (38.6)	298 (32.4)	600 (30.7)	556 (25.7)	221 (21.9)	
	Unknown/unclassified	12 (7.8)	46 (5.0)	83 (4.2)	115 (5.3)	62 (6.2)	
Self-rated health	Excellent/very good/good	122 (79.7)	796 (86.9)	1780 (91.0)	2112 (93.3)	971 (96.7)	0.000
	Fair/poor	31 (20.3)	120 (13.1)	175 (9.0)	144 (6.7)	33 (3.3)	
BMI	≥25 kg m^{-2}	86 (61.9)	484 (55.2)	952 (51.5)	983 (47.9)	411 (42.7)	0.000
Probable major depressive disorder		19 (12.5)	66 (7.2)	116 (6.0)	117 (5.4)	47 (4.7)	0.001
Any chronic illness in the previous 12 months		74 (48.7)	366 (39.9)	685 (35.1)	694 (32.2)	310 (30.8)	0.000

and well-being. While similar trends were not as obvious in relation to BMI status, those with four PLBs had an elevated likelihood of being normal weight (BMI < 25 kg m^{-2}) than overweight/obese (BMI > 25 kg m^{-2}) compared with those with fewer PLBs.

Discussion

We know from longitudinal studies that PLBs increase longevity[1]; this article shows that they are also associated with better self-rated health, better mental health and healthier

Table 3 Respondent's likelihood of self-rated general health being excellent/very good/good; likelihood of BMI <25 kg m^{-2} and the likelihood of not having depressive disorder compared with having depressive disorder by number of protective lifestyle behaviours adjusted for age, gender, education and social class

	Excellent/very good/good self-rated health vs. fair/poor			BMI <25 kg m^{-2} vs. BMI >25 kg m^{-2}			Not having depressive disorder vs. depressive disorder		
	Odds ratio	95% CI	*P**	Odds ratio	95% CI	*P**	Odds ratio	95% CI	*P**
0	1	–	–	1	–	–	1	–	–
1	1.7	0.95–2.95	0.07	0.85	0.52–1.38	0.52	2.0	1.12–3.77	0.02
2	2.8	1.60–4.82	0.00	0.95	0.59–1.51	0.83	3.2	1.75—5.69	0.00
3	3.3	1.89–5.70	0.00	1.07	0.68–1.69	0.77	3.6	1.98–6.40	0.00
4	6.8	3.64–12.82	0.00	1.18	0.74–1.89	0.49	4.4	2.34–8.22	0.00

*For trend significant $P < 0.01$

body weight; conversely, those who had fewer PLBs were 'not only' leading unhealthier lifestyles, but they also perceived their overall health to be poorer, had a higher likelihood of having depression and were heavier than those with higher numbers of PLBs. Higher scores were also less likely to be associated with being diagnosed with a cardiovascular event and being diagnosed with any illness by a doctor in the last 12 months. While our results are congruent with the work by Khaw *et al.*[1] and Myint *et al.*[11] who examined the relationship between PLBs and mortality[1] and PLBs and functional health,[11] this is one of the first studies to look at self-rated health, depression and overweight/obesity in relation to PLBs.

Limitations of the study include the cross-sectional design, and the relatively low response rate (62%). However, this is similar to response rates seen in other major National Health and Lifestyle Surveys.[13,14] It is increasingly difficult to get high response rates from national general population surveys due to the sociodemographic trends in the modern society including longer working days and the phenomenon of gated communities, particularly in urban areas. Unfortunately, data on non-participation are not available. However, sample weights were used derived from the most recent Census.[20] Interpretation of the data must be cautious; since exposure and outcome were measured at the same time, it is not possible to ascertain which is the cause and which is the effect. It can be argued that persons with better than average self-rated health and better mental health are more likely to engage in health seeking behaviour. The issue of reverse causation cannot be resolved in this study; however, it is likely that the causal effects of these health seeking behaviours flow in both directions are mutually beneficial: better mental health and better self-rated health leading to increased health seeking behaviours and vice versa. What is clear is that there is no evidence to suggest that the presence of health seeking behaviours is associated with poorer mental health and well-being.

Our findings add to the evidence that we can achieve progress to address the 'causes of the causes' of all-cause mortality, mental ill health and cardiovascular disease through small achievable lifestyle behaviour modifications. A key challenge for future research is to better understand the individual and societal determinants of health-seeking behaviour. For instance, there is emerging data highlighting the importance of adverse childhood experiences as a determinant of health-related behaviour in adult life.[21] Data from the USA[22–24] show that children with low rates of childhood adversity not only have better mental health in adult life but better physical health with lower rates of high-risk behaviours and conditions e.g. obesity.

Conclusion

Given the association between self-rated health, better mental health and higher numbers of PLBs, we propose that the four lifestyle behaviours detailed in this article be used as outcome measures from which effectiveness of public health policy can be gauged.

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Conflicts of interest: None declared.

Key points

- Being a non-smoker, being physically active, having a moderate alcohol intake and consuming five portions of fruit and vegetables daily are associated with better self-rated health, better mental health and a healthier weight.
- We would propose that the four lifestyle behaviours detailed in this article be used as outcome measures from which effectiveness of public policy can be gauged.

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Living longer, working longer? The impact of subjective life expectancy on retirement intentions and behaviour

Hanna van Solinge, Kène Henkens

Background: Virtually all Western countries are seeking to bring retirement ages more in line with increases in longevity. The central question in this article is whether individuals choose a retirement age that fits their life expectancy. This would be ideal from a public policy perspective. The present study aims to test empirically whether retirement planning varies with expectations of survival among a sample of older employees in the Netherlands. Two questions are addressed: (i) what are older employees' expectations of their remaining lifetime, and what factors influence this subjective life expectancy? (ii) Are individuals who perceive longer life horizons (high subjective life expectancy) more inclined to retire later than people who expect to live shorter? **Methods:** Using data from a panel study on retirement behaviour in the Netherlands ($N = 1621$ older employees aged 50–60 years), regression and survival models are estimated to examine the effect of subjective life expectancy on retirement planning and behaviour. **Results:** The results indicate that subjective life expectancy is a factor that is taken into account in retirement decision making, at least as far as retirement intentions are concerned. Older employees with longer time horizons have a preference for later retirement. When it comes to actual behaviour, however, time horizon does not appear to play a role. **Conclusion**: The results suggest that particularly employees with a high perceived life expectancy and an intention to work longer do not succeed in carrying their intentions into effect.

Keywords: older employees, retirement intentions, retirement timing, subjective life expectancy.

Introduction

There is a growing interest in subjective measures of health and survival. People have expectations about their remaining length of life, and these expectations make sense.[1] They tend to base their expectations of their remaining life years on their family's longevity, in particular parental mortality experiences.[2] Subjective—or self-rated—life expectancy shows systematic variation across individuals in accordance with known risk factors, such as poor health conditions or diagnosed diseases and socio-economic circumstances.[3,4] Moreover, there is evidence that individuals adapt subjective life expectancy in response to new information, such as health change and onset of diseases.[5] The notion that people have an expectation of their remaining lifetime and that this horizon may affect behaviour is not new.[6,7] Subjective life expectancy has been studied in relation to a broad range of human behaviour, such as investment in human capital,[8] saving and consumption[9] and health behaviour[10] but few studies relate this issue to retirement decision making.[11,12]

Retirement is a formalized transition within the life course, granting employees agency in directing that transition.[13] Retirement has become an increasingly complicated process of labour force withdrawal, influenced by push and pull factors inside and outside the workplace. The extant literature, however, has focused primarily on the impact of resources—health and wealth in particular—on retirement decision making. Few studies have examined the role of subjective life expectancy. The few examples postulate that individuals expecting to live long will retire at a later age than those expecting to die early as they will need greater wealth to finance more years of retirement.[11] The results are mixed, with both negative,[11,14] non-linear[12] and no effects of subjective life expectancy on retirement timing.[15] These inconsistent findings may reflect the fact that many older employees have limited control over the timing of retirement and that retirement is not always voluntary.[16,17] Observed retirement behaviour may differ from retirement intentions.[18–20] The age of actual retirement may represent limited or restricted choice rather than the employee's retirement intention.[21]

This study examines the impact of individual subjective life expectancy on both retirement intentions and actual retirement behaviour, addressing two questions. First, what are employees' subjective expectations of life, and which factors determine this subjective life expectancy? Second, are individuals who perceive longer life horizons more inclined to retire later than people who expect to live shorter? We benefited from two waves of a prospective study on retirement to examine the effect of subjective life expectancy on retirement planning and behaviour.

Methods

Population

The data have been taken from a prospective study on retirement behaviour in the Netherlands. Wave 1 (2001) collected data from two sources: civil servants and employees working for four large Dutch multinational companies active in information and communication technology (ICT), retail, trade, industry and banking. A questionnaire was sent to a

Netherlands Interdisciplinary Demographic Institute (NIDI), Social Demography Department, PO Box 11650 2502 AR The Hague, the Netherlands
Correspondence: Hanna van Solinge, PhD, Netherlands Interdisciplinary Demographic Institute (NIDI), PO Box 11650 2502 AR The Hague, the Netherlands, tel: +31 70 3565244, fax: +31 70 3647187, e-mail: solinge@nidi.nl

random sample of employees aged 50 years and older in these organizations ($n = 3900$). The total number of individuals who completed the survey at Wave 1 was 2406. In 2006–07 (Wave 2), a follow-up survey was conducted, in which all surviving Wave 1 participants were re-surveyed by mail questionnaire. The survey asked respondents about changes in employment status, including retirement, since Wave 1.

Measurements

Outcome variables

In the first wave of the study older employees were asked about their retirement intentions. Participants were asked three questions. (i) Do you intend to stop working before age 65? (=state pension age) [answer categories: '1' yes, '2' no, '3' don't know (yet)]; (ii) do you intend to work after age 61? (answer categories ranging from '1' no, certainly not to '5' yes, most certainly) and (iii) at what age do you plan to stop working? (continuous variable). On the basis of the responses to questions [(i, scores recoded as follows: 1 = 1, 2 = 3, 3 = 2), (ii) and (iii, reverse coded)], we constructed an aggregate measure by summing the standardized and unweighted items. Reliability of the scale was satisfactory (Cronbach's $\alpha = 0.82$). The scale was subsequently linearly transformed into a 0–10 range, where higher values represent a stronger intention to retire early.

In the Wave 2, participants were asked whether they had retired between survey waves. Individuals who responded affirmatively were then asked in what year and month. On the basis of this information the timing of retirement was determined. The duration between age 50 and taking (early) retirement (in years) was used as the dependent measure. Participants who had not retired between Waves 1 and 2 were treated as right-censored.

Primary explanatory variable

Subjective life expectancy is the explanatory factor of interest in this study. To create this measure, we combined the responses from two survey questions. Participants were first asked to express the likelihood that they would live to age 75 on a 5-point scale ranging from 1 (highly unlikely) to 5 (highly likely). Later in the questionnaire they were presented the statement (ii) 'I think that my chances of living to a very old age (90+) are considerable'. The 5-point Likert-scaled responses ranged from 1 (totally agree) to 5 (totally disagree). On the basis of the responses to (i) and (ii—reverse coded) we constructed a single measure by summing the unweighted items. The scale, which ranges from 1 to 5, represents subjective life expectancy. Higher values represent a longer life horizon.

Covariates

Retirement decision making is contingent on several factors, some of which also influence subjective life expectancy. Factors taken into account are established determinants of retirement decision making and life expectancy, including age, family longevity, gender, socio-economic status, health status, partner status and job characteristics. Parental longevity was constructed on the basis of each parent's actual age at the time of the survey, or the age at death if the parent had died. On the basis of the participant's gender, this information was transformed into two other variables indicating age (at death) of the same-sex parent and age (at death) of the other-sex parent. Furthermore, two dummy variables were constructed indicating whether or not the same-sex or other-sex parents were still alive (information obtained at Wave 1). Educational attainment was rated from 1 (primary school) to 7 (university graduate). Wealth was rated from 1 (<500 euros) to 7 (>500 000 euros). In the analyses we used class averages. Health status was based on the participant's self-assessed health and ranged from 1 (very poor) to 5 (very good). In order to control for work environment we included job pressures. This is a 3-item scale (range 1–5; Cronbach's $\alpha = 0.75$) based on the responses to the following three statements: 'the workload is so great that it creates tension'; 'at times, there is so much work to be done that I am unable to do everything well'; 'I often have to push myself to the limits to be able to do my job well'. Unweighted, 5-point Likert-scaled responses ('totally agree', 'agree', 'neither agree nor disagree', 'disagree', 'completely disagree') were first summed, and subsequently linearly transformed into a 0–5 range, where higher values represent greater pressure.

Analyses

We described characteristics of the sample and provided descriptive statistics for subjective life expectancy and retirement intentions. We used a linear regression model to estimate the impact of subjective life expectancy on retirement intentions. In model B1, we estimated the zero-order correlation of subjective life expectancy with retirement intention. In model B2, we included the covariates in order to investigate whether or not the association between the two variables of interest could be traced back to confounding factors, variables that may be related to retirement planning, to subjective life expectancy, or to both. In addition, we estimated Cox proportional hazard ratios to determine the impact of subjective life expectancy, adjusted for the above-mentioned covariates, on the timing of retirement.

Results

For the follow up, we approached all surviving Wave 1 participants. There was some attrition due to company takeovers ($N = 116$) and mortality ($N = 45$). A total of 2240 questionnaires were sent out. Of these, 1678 surveys were returned, providing complete or virtually complete data. The Wave 2 response rate, following two reminder notices, was 75%. Of the total potential sample of 1678, we excluded 56 individuals aged ≥61, and people with missing information on survival expectations and parental longevity. The final sample thus included 1621 individuals. Item non-response was low (<3%). Missing data were imputed using the MVA option in SPSS.[22]

Mortality information was available for all Wave 1 participants (except for the 116 employees whose company had been taken over). Sensitivity analysis provided further evidence for the hypothesis put forward by Siegel *et al.*[1] and Van Doorn & Kasl.[2] Also in this study, subjective life expectancy turned out to be a predictor of mortality, even after controlling for subjective health status in Wave 1. We discovered limited selective non-response. Whereas neither Wave 1 health nor gender nor subjective life expectancy predicted participation likelihood at Wave 2, younger and less educated people were somewhat less likely to participate in the follow-up survey.

Descriptive results

Table 1 provides a description of the sample, of which 74% were men and 87% had a partner at the time of the interview. Baseline age ranged from 50 to 60. The average age of the participants in 2001 was 54.2 years. Six percent of the participants had low values on subjective life expectancy (corresponding with a short life horizon), and 8% had high

values (corresponding with a very long life horizon). Sixty percent of the older employees had taken (early) retirement in between the two waves.

Table 2 shows retirement intentions, both for the full sample and by subjective life expectancy. Results for the full sample indicate that the majority of employees (81%) intended to take early retirement and that there was only limited interest in working beyond the company's early retirement age (21%). Comparing individuals across life horizon categories, higher proportions of participants reported that they intended to retire early among people with a low subjective life expectancy (very short life horizons) compared with people with a medium and very long life horizon.

Table 1 Characteristics of the sample of Dutch older employees

Male (%)	74
Age at baseline (average)	54.2
Wealth	
Low (1–3)	27
Medium (4, 5)	58
High (6, 7)	25
Education	
Low (1–3)	40
Medium (4, 5)	27
High (6, 7)	33
Health	
Poor (1, 2)	5
Medium (3)	14
Good (4, 5)	81
With partner (%)	87
Job pressures (average)	2.9
Family longevity	
Age same-sex parent (average)	74.0
Age other-sex parent (average)	76.5
Same-sex partner still alive (%)	27
Other-sex partner still alive (%)	38
Subjective life expectancy	
Low (<2)	6
Medium (2–4)	86
High (>4)	8
Taken (early) retirement between Waves 1 and 2 (%)	60

Multivariate results

The results of the multivariate analyses are presented in tables 3 and 4. Column 1 in Table 3 provides the results of the ordinary least squares (OLS) regression explaining subjective life expectancy (Model A). As shown, subjective life expectancy is correlated with age and gender, which is consistent with current-table actuarial estimates. The expected impact of health on subjective life expectancy was also confirmed. Individuals in good or excellent health were much more optimistic about their survival than those in poor health. Furthermore, the results indicated that individuals take their parents' longevity—same-sex parent's age in particular—into account when assessing their own life horizons. Finally, we did not find significant effects of partner status. Nor did we find an effect of individuals' socio-economic position (wealth and education) on their survival expectations.

Table 2 Descriptive statistics for items constituting the retirement intentions scale, full sample and by subjective life expectancy (%)

	Subjective life expectancy			
	Low (<2)	**Medium (2–4)**	**High (>4)**	**Full sample**
Do you intend to stop working before age 65?				
Yes	93	80	76	81
Don't know (yet)	5	13	10	12
No	2	7	14	7
Total	100	100	100	100
Do you intend to work after you reach the age of 61?				
No, definitely not	64	38	39	39
No, probably not	17	24	16	23
Maybe	10	18	12	17
Yes, probably	6	13	19	13
Yes, most certainly	3	8	14	8
Total	100	100	100	100
At what age do you plan to stop working?				
Average	59.5	60.2	60.8	60.2
N	90	1401	130	1621

Table 3 Estimates of regression analyses predicting older employees' subjective life expectancy and retirement intentions, estimates and standard errors

	Model A		**Model B1**		**Model B2**	
	Subjective life expectancy[a]		**Retirement intention[b]**		**Retirement intention[b]**	
	Unstandardized coefficient	**SE**	**Unstandardized coefficient**	**SE**	**Unstandardized coefficient**	**SE**
Subjective life expectancy			0.23***	0.04	0.13**	0.05
Gender (male = 1)	−0.04**	0.05			0.09	0.08
Age at baseline	0.02***	0.00			0.10***	0.01
Wealth	0.00	0.00			−0.02***	0.00
Education	0.00	0.01			0.16***	0.02
Health	0.34***	0.02			0.11**	0.05
Partner (1 = yes)	0.03	0.06			−0.55***	0.11
Job pressures	−0.09***	0.02			−0.23***	0.04
Family longevity						
Age same-sex parent (/10)	0.10***	0.00			0.00	0.00
Age other-sex parent (/10)	0.02	0.00			−0.00	0.00
Same-sex parent alive (1 = yes)	0.20***	0.05			0.00	0.09
Other-sex parent alive (1 = yes)	0.09*	0.04			0.08	0.08
Constant	−0.27	0.45	−2.0	0.15	−2.35	
R^2	20.3		1.6		11.5	

N = 1621

a: Subjective life expectancy (1–5)—high scores indicate that respondents have a very long life horizon

b: Retirement intention (1–10)—high scores indicate that respondents are more inclined to retire later

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Table 4 Estimates for Cox regression model predicting age at retirement, hazard ratio and standard errors

	Model C	
	Timing of retirement[a]	
	Hazard ratio	SE
Subjective life expectancy	1.01	0.04
Gender (male = 1)	1.23*	0.11
Wealth	1.01***	0.00
Education	0.93***	0.02
Health	0.85***	0.04
Partner (1 = yes)	1.06	0.11
Job pressures	1.09*	0.04
Family longevity		
Age same-sex parent	1.00	0.00
Age other-sex parent	1.00	0.00
Same-sex parent alive (yes = 1)	0.91	0.08
Other-sex parent alive (yes = 1)	0.87	0.07
Log likelihood	–6128.24	

$N = 1621$

a: Duration between age 50 and taking (early) retirement (in years). Participants who had not taken early retirement between Waves 1 and 2 were treated as right-censored

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Columns 2 and 3 present the results of the OLS regression explaining retirement intentions. The results of the baseline model (Model B1) confirm the descriptive findings: participants with higher values on subjective life expectancy (longer life horizons) are less inclined to retire early. In Model B2 we controlled for potentially confounding factors that may influence both subjective life expectancy *and* retirement intentions. The findings confirm the strong impact of social, economic and health resources on retirement planning, as well as the importance of job pressures. After controlling for these possible confounding factors there is still a substantial and significant effect of survival expectations on retirement intentions, suggesting a direct effect of longevity itself.

Table 4 presents the results of a Cox regression model, with the timing of retirement as the dependent variable. The findings confirm the strong impact of economic and health resources on actual retirement timing, as well as the importance of job pressures. There is, however, no evidence that subjective life expectancy has an effect on the timing of retirement. Older employees with longer perceived time horizons do not retire later.

Additional analysis, comparing older employees' retirement intentions and behaviour, discloses a substantial discrepancy between stated and revealed preferences. The data suggest that there is a huge tendency to advance the moment of retirement: on average, older employees retired 1.6 years earlier than originally intended.

Discussion

In this article, we studied the impact of subjective life expectancy on retirement planning and behaviour using a 6-year follow-up study among 1621 older employees in the Netherlands aged 50–64 at baseline in 2001. The results support our hypothesis that individuals' expectations of their remaining lifetime influence the retirement decision making process. We established that employees who expect to live longer, intend to retire later than those who expect a shorter life span. This finding may encourage governments striving to bring retirement age more in line with increased longevity.

When it comes to actual retirement behaviour, however, we did not find empirical support for our hypothesis. There is no evidence that older employees who expect to live longer retire later. Apparently, older employees with longer perceived time horizons have a preference for later retirement, but in the end they do not retire later. This is an important result as it may indicate that particularly employees with a high perceived life expectancy and an intention to work longer do not succeed in carrying their intentions into effect. Further research should make clear what forces prevent these employees from achieving their career goals. Several explanations could be explored. Research on older retirees' perceptions of involuntary retirement suggest that social pressures in the workplace are among the main forces that limit individual agency in retirement decisions.[16,23] At the organizational level, there is generally a lack of managerial support for later retirement.[24] But even if retirement is not perceived as forced, employees often have to make retirement decisions in a social context that does not give them a large degree of freedom. The Netherlands can be characterized as a country with a strong *early exit culture*. Until recently, early retirement programmes were designed in such a manner that leaving the labour force at the early retirement age was an offer employees could not refuse. Though the official (and mandatory) retirement age is still 65, very few employees (<10%) reach that age while still active in the labour force.[25]

This study has several noteworthy strengths. The most obvious strength is its capacity to examine retirement intentions in tandem with actual retirement behaviour, which enabled us to gain more insight into the role of subjective life expectancy in the retirement decision making process. This is an important advancement of the extant literature, which has focused exclusively on actual retirement behaviour. Our findings suggest that the mixed results in earlier studies may be due in part to the fact that the timing of retirement is not as free a choice as is often assumed, and that one may question in particular the degree of choice there is in delaying retirement. Next, several pre-retirement employment characteristics enabled us to control effectively for theoretically important confounding factors in testing the impact of subjective life expectancy on retirement. Moreover, the longitudinal design of the study, including the mortality information about Wave 1 respondents, enabled us to validate the main explanatory variable in this study, namely subjective life expectancy. Our results provide additional evidence for the predictive power of subjective expectations of life with respect to mortality at the individual level.[1,2]

This study also has a number of limitations, however. A first point that deserves attention is the fact that although the data were collected with the intention of investigating numerous retirement-related antecedents and outcomes, they are not nationally representative and may not be entirely generalizable to the Dutch population as a whole. The sample does, however, contain substantial variation in terms of important variables such as gender, educational level, socio-economic status and health. As a result, the explanatory mechanisms described in this article—i.e. the responsiveness of retirement planning to survival expectations—are assumed to be representative, at least for the population working in large companies. A second and related drawback is the lack of variation in the companies' pension plans. The overall design of the schemes was quite similar in the sense that they are all defined benefit plans. As a result, we were not able to examine whether the responsiveness of retirement planning to survival expectations varies across pension design, as has been suggested by O'Donnell *et al.*[12]

Our results suggest that there *is* a potential for extending one's working life, and that perceived longevity is a factor in this respect. As life expectancy increases, employees may be more inclined to continue working until a more advanced age. The anticipated gains in life expectancy at age 65 as projected by the statistical offices in Europe and the US amount to one month per year in the coming decades. Though only part of this increase may concern gains in life expectancy in good health, communicating the positive message that at age 65 individuals may expect to live, on average, another 20 years may stimulate older adults to remain gainfully employed until an older age.

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Conflicts of interest: None declared.

Key points

- Individuals' expectations of their remaining lifetime influence the retirement decision making process.
- Employees who expect to live longer, intend to retire later than those who expect a shorter life span. There is, however, no evidence that subjective life expectancy has an effect on the actual timing of retirement. Older employees with longer perceived time horizons do not retire later.
- On average, older employees retired 1.6 years earlier than originally intended. The results suggest that particularly employees with a high perceived life expectancy and an intention to work longer do not succeed in carrying their intentions into effect.

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component of END is a talk by one or more volunteers with experience of mental illness; the volunteers recount their life experiences before, during and after the onset of their mental illness, discuss their recovery and relay instances in which they have felt discriminated against or stigmatized and how these instances have affected their lives. This type of social contact differs from that involved in the Living Library and Get Moving! because it is indirect and involves a targeted group. Although it is less likely that direct conversations will occur between people with and without mental illness, one advantage of END over the other two projects is that it is issued in an educational, easily reproducible format and can reach large groups of students, something that may be considered to be a limitation of direct social contact interventions.

Implications for future research and interventions

Each of these three projects provides a novel and potentially promising way to facilitate social contact. As such, it is important to clarify and evaluate the impact of these various interventions and their underlying mechanisms. Given the significant effects found to be associated with social contact and the growth in interest across Europe in developing mental health-related anti-stigma campaigns, further exploration of population interventions which incorporate social contact is an important area for future research. While 'Time to Change' is making a start in the right direction towards employing social contact on a large scale, there is a need for evaluation to assess which methods of delivering social contact are effective. In general, there is a need to reduce the gap between the theory of stigma reduction and the practice of employing it through various anti-stigma campaigns; exploring the ways in which to utilize the theory of social contact in practice is thus a crucial step towards eradicating mental health stigma in years to come. Given the magnitude of the discrimination which currently exists against people with mental illness, and the fact that one in four of us will have a mental illness in our lifetime, we would be remiss in our duties as public health advocates to ignore the possible benefits of social contact and the impact it could have on millions of lives.

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Jillian London, Sara E. Evans-Lacko
Health Services and Population Research, Institute of Psychiatry, King's College London, London SE5 8AF, UK

Correspondence: Jillian London, e-mail: Jillian.London@iop.kcl.ac.uk

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Rethinking 'Mental Health Stigma'

The stigma of mental illness is devastating for both sufferers and their families, and can affect every area of life including interpersonal relationships, access to employment and other desired social roles and quality of health care.[1] It is certainly a problem in contemporary Britain where half the population believes that people with eating disorders feel different from 'normal' people, more than 60% of the population believes that people with severe depression are hard to talk to and more than 70% of the population believes that people with schizophrenia are a danger to others.[2]

London and Evans-Lacko[3] evaluate Time to Change 3—a large-scale intervention, based on contact theory, aimed at reducing prejudice against persons with mental illnesses in Britain. From an intervention standpoint, the three strategies mentioned—Get Moving!, Living Libraries and Education Not Discrimination (END)—are likely quite sound. Contact is one of the most robust and reliable means of reducing intergroup prejudice. It has been shown to work with a variety of outgroups and under varied circumstances, despite many of them being less than ideal.[4]

Furthermore, contrary to London and Evans-Lako's assertion that, 'social contact research in the past has mostly been conducted in experimental rather than naturalistic settings', a recent meta-analysis of all available contact research[4] showed that the majority of contact research conducted thus far involved participants reporting (albeit retrospectively) on their experiences of *actual* contact with members of outgroups in their day-to-day lives and their attitudes towards these groups. A more naturalistic setting would be difficult to imagine.

However, what *is* missing from the research is a detailed and structured look at when and how contact reduces prejudice against people with mental health problems. Part of the difficulty is that research on the effect of contact on prejudice against those with mental

illnesses is rarer than similar research concerning other outgroups. However, the more challenging part of the problem lies in the amorphous and poorly formed concept of 'mental health stigma'.

What exactly does 'mental health stigma' mean? Does it imply a stereotype of dangerousness? In some cases, yes; most Britons believe that people with schizophrenia are a danger to others. However, in other cases it does not; far fewer Britons believe that people with severe depression are dangerous, and almost none believe that about people with eating disorders.[2] Does it imply that the sufferers have themselves to blame for their conditions? Again, in some cases, yes; an estimated third of all Britons believe that about people with eating disorders. And again, in other cases, no; only a tenth of all Britons believe that people with severe depression have themselves to blame, and even fewer believe it about people with schizophrenia.[2]

The problem of poor definition is very common in research and interventions concerning the reduction of what is termed mental health stigma. Some research has investigated whether lower perceptions of 'the mentally ill' being dangerous predict less fear and avoidance of people with mental health problems—a model that is largely irrelevant for the majority of those who suffer from mental illnesses (e.g. those with depression or eating disorders). Other studies investigate whether lower perceptions of personal responsibility predict more helping behaviours—a model that is largely irrelevant for people with schizophrenia. Given the noise in the data, it is unsurprising that these models meet with mixed results.[1]

A curious and inexcusable gap in the research is that, for some groups, there has never been a single study in which contact with members of that group has been used to predict prejudice against members of that group (e.g. using contact with people with schizophrenia to predict reduced prejudice against people with schizophrenia). This is particularly difficult to excuse when it has been known for some time that members of the public have sharply contrasting and often directly conflicting stereotypes of persons with different types of mental illness, and widely varying attitudes towards persons with mental illness depending on 'which' mental illness is being considered.[2]

This non-specificity may go a long way towards explaining why the aforementioned meta-analysis revealed that the effect of contact on prejudice was weaker for the mentally ill than for most other outgroups.[4] While we can say that contact reduces prejudice 'in general' and that contact reduces prejudice against the mentally ill 'in general', due to a lack of clarity concerning which of the many varied subsets of mental illness are being investigated or what type of prejudice is being reduced, we cannot say with a reasonable measure of accuracy when, under what conditions, by which means or for which groups contact works best in this context.

Interventions such as those put forth by Time for Change 3 are bold and necessary. Furthermore, given the robust nature of contact as a prejudice-reducing mechanism, it is reasonably likely that positive, cooperative contact will reduce prejudice against persons with various types of mental health problems, at least to some degree. These strategies offer other specific benefits as well: Get Moving! encourages re-categorization, or the re-drawing of group boundaries in a way that includes in the ingroup people who were formally part of the outgroup. Living Libraries combines contact and education in ways that have been successfully used by researchers before,[1] and Education Not Discrimination functions like Living Libraries, but on a larger, less personal scale.

However, both Get Moving! and Living Libraries appear open to self-selection bias, since people have to volunteer for the former or choose to select a particular 'human book' from the latter. Those with stronger prejudices are unlikely to do either. END may hold out more promise, because, for example, all members of a school class, irrespective of the strength of their prejudices, are exposed to a talk by someone with the experience of mental illness. One aspect we predict to be particularly beneficial is that all three forms of intervention can function as 'indirect' or 'extended' forms of contact,[5] whereby those who have experienced direct contact with people with mental health difficulties can then positively impact others via their positive reports of the experience.

However, until researchers and policy makers begin conceptualizing of, and combating, 'mental health stigma' in more focused, specific ways, there will be no way of knowing which groups are benefited the most or the least from current strategies. Indeed, such a lack of clarity may inadvertently serve to perpetuate prejudice in this area by allowing the prejudice to remain a vague, fuzzy problem. If this is the case, then the most effective strategies will continue to elude us, and the finer points of when and how interventions like contact reduce mental health stigma will remain mysteries. Conversely, defining and delineating such stigmas promises to help those of us who will be affected by mental illness at some point in our lives.

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Keon West[1], Miles Hewstone[1], Emily A. Holmes[2]
[1]Department of Experimental Psychology
[2]Department of Psychiatry, University of Oxford, Oxford, England

Correspondence: Keon West, e-mail: keon.west@balliol.ox.ac.uk

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Value for money or making the healthy choice: the impact of proportional pricing on consumers' portion size choices

Willemijn M. Vermeer, Esther Alting, Ingrid H. M. Steenhuis, Jacob C. Seidell

Background: Large food portion sizes are determinants of a high caloric intake, especially if they have been made attractive through value size pricing (i.e. lower unit prices for large than for small portion sizes). The purpose of the two questionnaire studies that are reported in this article was to assess the impact of proportional pricing (i.e. removing beneficial prices for large sizes) on people's portion size choices of high caloric food and drink items. M**ethods**: Both studies employed an experimental design with a proportional pricing condition and a value size pricing condition. Study 1 was conducted in a fast food restaurant ($N = 150$) and study 2 in a worksite cafeteria ($N = 141$). Three different food products (i.e. soft drink, chicken nuggets in study 1 and a hot meal in study 2) with corresponding prices were displayed on pictures in the questionnaire. Outcome measures were consumers' intended portion size choices. **Results**: No main effects of pricing were found. However, confronted with proportional pricing a trend was found for overweight fast food restaurant visitors being more likely to choose small portion sizes of chicken nuggets (OR = 4.31, $P = 0.07$) and less likely to choose large soft drink sizes (OR = 0.07, $P = 0.04$). **Conclusion**: Among a general public, proportional pricing did not reduce consumers' size choices. However, pricing strategies can help overweight and obese consumers selecting appropriate portion sizes of soft drink and high caloric snacks. More research in realistic settings with actual behaviour as outcome measure is required.

Keywords: environmental interventions, food portion sizes, pricing strategies, obesity.

Introduction

Environmental influences may contribute to a caloric intake that exceeds the daily requirements.[1,2] One aspect of this environment is that people are exposed to large food portion sizes.[3] Although the long-term effects of large portion sizes on body weight have not been experimentally investigated, it is observed that in the decades in which the prevalence of overweight and obesity has drastically increased, portion sizes of especially high-energy foods have augmented as well.[4,5] There is empirical evidence to support the position that large portion sizes enhance the consumption of food and beverages and that this is not sufficiently compensated for overtime.[6–11]

One of the reasons why large portions are preferentially consumed is value for money. As a marketing strategy, people can purchase a larger portion size for only a small surplus. Therefore, in many settings, prices per gram are lower for large packages or portions than for small packages or portions.[11] This phenomenon is known as value size pricing. After taste, consumers regard costs as the most important factor determining dietary choices.[12] Furthermore, experimental research has shown that large packages encourage people to consume larger quantities, partly due to perceived lower food costs.[11] Another issue is that people find self-regulation of large portion sizes difficult at the moment of consumption. Once the food is stockpiled or served, many people are tempted to eat it all.[13] Hence, it seems that addressing consumers' size choices at the moment of purchase is more feasible than that at the moment of consumption. In this respect, portion size pricing is likely an influential factor.

Institute for Health Sciences, VU University Amsterdam, The Netherlands
Correspondence: Willemijn Vermeer, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands, tel: +31 20 59 82797, fax: +31 20 59 86940, e-mail: willemijn.vermeer@falw.vu.nl

Pricing strategies could be used to stimulate smaller size choices by proportional pricing of small and large portions (i.e. removing beneficial prices for large sizes by keeping the price per gram stable along different sizes). On the whole, pricing strategies related to portion sizes are considered innovative[14] and might be a promising environmental intervention aimed at limiting people's consumption of large portion sizes of high caloric foods and drinks (Steenhuis and Vermeer, in press). Studies have demonstrated the effectiveness of pricing strategies targeted at altering the *type* of food that consumers purchase.[15,16] To our knowledge, only one American study is available on the impact of pricing strategies on portion size choices.[17] The current study took into account additional explaining mechanisms such as value consciousness, sex and income.

As the feasibility of implementing pricing strategies related to portion size might be challenging, a first step is to test its possible effectiveness on consumers' size choices by means of a questionnaire study. The purpose of the two studies reported in this article was to assess the impact of proportional pricing on people's portion size choices of high caloric food and drink items. We expected that compared to value size pricing, proportional pricing would increase the preference for small sizes and decrease the preference for large sizes. The first study was conducted among fast food restaurant visitors and the second study among employees visiting a worksite cafeteria.

Study 1

Methods

Participants and procedures

Participants were recruited on different weekdays in a Dutch fast food restaurant. People older than 18 years were requested to complete a questionnaire. Out of the 151 fast food restaurant visitors who received the questionnaire, 150 (99.3%) returned the questionnaire.

Table 1 Study conditions and prices in studies 1 and 2

	Condition	Small (in €)	Medium (in €)	Large (in €)
Study 1—Fast food restaurant				
Soft drink	Proportional pricing	1.15	1.80	2.25
	Value size pricing	1.65	1.80	2.00
Chicken nuggets	Proportional pricing	2.35	3.50	5.80
	Value size pricing	2.75	3.50	5.00
Study 2—Worksite cafeteria				
Hot meal	Proportional pricing	2.35	3.50	
	Value size pricing	2.80	3.50	

Study design and procedures

The study employed an experimental design with a proportional pricing condition (experimental condition) and a value size pricing condition (control condition). In the value size pricing condition, prices were representative of market place prices. In the proportional pricing condition, prices were converted from the price of the medium size to the small and large sizes. Visitors of fast food restaurants were approached after they had purchased their meal and asked to complete the questionnaire. The two versions of the questionnaires were randomly handed out to the participants.

In the questionnaire, photographs of different sizes of foods and drinks were presented with corresponding prices that differed depending on the study condition. In order to give participants an impression of the actual size, a pair of dice or cutlery was displayed on each picture. In the study among fast food restaurant visitors, participants were asked to choose a portion size of soft drink and chicken nuggets. Table 1 gives an overview of the prices under the different conditions.

Food products and available sizes

Soft drinks and chicken nuggets were chosen as stimuli as they contain many calories and have been found to be associated with obesity.[18,19] For soft drinks, three sizes (i.e. 250, 400 and 500 ml) were available. Guidelines from the Netherlands Nutrition Centre (an institution funded by the Dutch government that provides information and education about healthy nutrition) define one serving portion of soft drink as 225 ml. However, as 225 ml cups were not the market standard, we designated 250 ml as the reference portion.

With respect to chicken nuggets, three basket sizes (i.e. containing 6, 9 or 15 chicken nuggets) were available. Based on the fact that chicken nuggets are high in calories (i.e. 42 calories per nugget[20]), the basket containing six chicken nuggets was chosen as the reference size.

Measures

The questionnaire started with asking participants which portion size they would choose from the options that were presented.

In addition, several control variables, that were expected to be related to size choices, were included in the questionnaire. First, hunger and thirst at the moment of completing the questionnaire were measured with two Visual Analogue Scales (VAS) ranging from 0 cm (not at all hungry/thirsty) to 10 cm (very hungry/thirsty).

Second, the dietary restraint and external disinhibition scales derived from the Dutch Eating Behaviour Questionnaire (DEBQ[21]) were included in the questionnaire. Both scales have been proven to be reliable and valid.[22] The dietary restraint scale consisted of 10 five-point scaled items (e.g. 'Do you try to eat only a little when you want to eat a lot?'), with $\alpha = 0.93$. External disinhibition was measured with 10 five-point scaled items (e.g. 'If food smells yummy, do you eat a lot of it?'), with $\alpha = 0.79$.

Third, value consciousness was measured with seven, seven-point scaled items (e.g. 'I always check prices at the retail store to be sure I get the best value for the money I spend')[23] with $\alpha = 0.73$.

Fourth, participants were asked a number of questions regarding their soft drink and chicken nuggets consumption (i.e. general consumption frequency, and whether they made a habit of drinking diet or regular soft drinks).

Last, a number of questions were included in the questionnaire about gender, age, length, body weight and gross annual income (i.e. between €0 and €10 000, €10 000 and €20 000, €20 000 and €30 000, €30 000 and €40 000, €40 000 and €50 000 or €50 000 and higher).

Data analysis

The main outcome variables in this study were participants' soft drink size and chicken nuggets size choices. To assess the impact of pricing, participants' size choices were dichotomized and coded in two different manners. First, the size choices were dichotomized in order to assess whether labelling *encouraged* participants to choose the reference size. Therefore, participants' size choices were either coded as the reference sizes (i.e. 250 ml of soft drink and six pieces of chicken nuggets) or as being larger.

Second, size choices were dichotomized in order to assess the effect of labelling on *discouraging* participants from choosing the largest size. Data were either dichotomized as choosing the largest size (i.e. 500 ml of soft drink and 15 pieces of chicken nuggets) or not. Logistic regression analyses were conducted with the likelihood of choosing the reference sizes or largest size as outcome variables. As there was a significant difference in value consciousness between the experimental and the control condition, in the logistic regression analysis we adjusted for value consciousness. Interaction effects were assessed between pricing and age, sex, overweight status, value consciousness and income.

Results for main effects were considered significant with $P < 0.05$, and for interaction effects results were considered significant with $P < 0.1$.

Results

Descriptive statistics

The majority of the participants were female (66.4%). The participants' mean age was 25.22 years (SD = 9.88). Based on self-reported height and body weight, 3.5% of the participants were underweight (BMI < 18.50), 72.7% had a normal weight (BMI 18.50–24.99), 17.5% were overweight (BMI 25.00–29.99) and 6.3% were obese (BMI ≥ 30.00). The overweight and obesity prevalence was lower than that in the general Dutch population (i.e. 46% are overweight or obese[24]). Participants' mean incomes were low with 12.4% reporting a gross annual income higher than the Dutch modal annual income (i.e. €30 000 in 2007[25]). With respect to participants' consumption patterns, 54.4% have made a habit out of eating chicken sometimes or more frequently. Furthermore, 82.3% drank soft drink on a regular basis. Other participant characteristics can be found in table 2.

Table 2 Participant characteristics

Sample	Fast food restaurant Mean (SD)	Worksite cafeteria Mean (SD)
Age	25.2 (9.9)	35.9 (10.9)
BMI	23.3 (4.4)	23.5 (3.5)
Hunger	3.9 (2.8)	4.2 (2.4)
Thirst	5.4 (2.9)	5.0 (2.5)
Dietary restraint	2.5 (0.9)	2.7 (0.8)
External disinhibition	2.9 (0.6)	2.9 (0.4)
Value consciousness	3.7 (1.2)	3.2 (1.2)

Table 3 Participants' size choices in study 1

	Soft drink			Chicken nuggets		
	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)
Entire sample ($N = 137$)						
Overall	28.2	53.0	18.8	49.0	44.3	6.7
Proportional	29.3	56.0	14.7	47.3	47.3	5.4
Value size pricing	27.0	50.0	23.0	50.7	41.3	8.0
	χ^2 (1) = 0.1, $P = 0.8$			χ^2 (1) = 0.2, $P = 0.7$		
Participants with a healthy weight ($N = 104$)						
Overall	26.9	52.9	20.2	49.5	41.7	8.7
Proportional	28.6	51.0	20.4	41.7	50.0	8.3
Value size pricing	25.5	54.5	20.0	56.4	34.5	9.1
	χ^2 (2) = 0.16, $P = 0.9$			χ^2 (2) = 2.60, $P = 0.3$		
Participants who are overweight or obese ($N = 33$)						
Overall	33.3	50.0	16.7	44.1	52.9	2.9
Proportional	33.3	66.7	0	55.0	45.0	0
Value size pricing	33.3	33.3	33.3	28.6	64.3	7.1
	χ^2 (2) = 2.67, $P = 0.3$			χ^2 (2) = 3.31, $P = 0.2$		

Soft drink size choices

Overall, 28.2% chose the reference size of soft drink; see table 3. Neither main effects nor interaction effects for pricing were found on the likelihood to choose the reference size.

With respect to the likelihood to choose the largest size, a significant interaction effect of overweight status and pricing was found ($P = 0.06$). Among normal weight participants, pricing strategies had no effect on the likelihood to choose the largest size. However, among participants who were overweight or obese, proportional pricing reduced the likelihood to choose the largest size (OR = 0.07, $P = 0.04$, CI 0.01–0.83).

Chicken nuggets size choices

Table 3 shows that overall 49.0% chose the reference size of chicken nuggets. With respect to the impact of pricing on the likelihood to choose the reference size, two significant interaction effects were found. First, there was an interaction between sex and pricing ($P = 0.01$). Men seemed more likely to choose the reference size when confronted with proportional pricing (OR = 3.35, $P = 0.06$, CI 0.96–11.73). However, for women, the opposite was found with proportional pricing decreasing the likelihood to choose the reference size (OR = 0.41, $P = 0.04$, CI 0.18–0.94). Second, an interaction effect was found for overweight status and pricing ($P = 0.02$). Among participants with a normal weight, pricing did not have any effect. However, among participants who were overweight or obese, there was a trend of proportional pricing increasing the likelihood to choose the reference size (OR = 4.31, $P = 0.07$, CI 0.88–21.12).

With respect to the impact of pricing on the likelihood of choosing one of the largest sizes, neither main effects nor interaction effects were found.

Study 2

Methods

Participants and procedures

Participants were recruited on different weekdays in a worksite cafeteria located in a hospital. Out of the 143 worksite cafeteria visitors who received the questionnaire, 141 (98.6%) completed the questionnaire.

Study design and procedures

The study design and procedures were comparable to study 1; see table 1 for an overview of the study conditions and prices.

Food products and available sizes

A hot meal was chosen as test food. Although hot meals constitute of valuable nutrients, in worksite cafeterias they are generally offered in one large size only (i.e. ~500 g). Small hot meals (i.e. ~300 g) might be more suitable for people with a sedentary lifestyle and/or who are overweight or obese better than large meals. For instance, Spaghetti Bolognese consists of 121 calories per 100 g.[26] Consequently, if not compensated for, selecting a small portion of this dish would reduce the caloric intake with 242 calories. Even small reductions in daily caloric intake can prevent long-term weight gain. For instance, Hill and colleagues estimated that reducing the daily energy intake with 100 calories could prevent weight gain in most of the population. The same researchers suggest that this can be achieved by, for instance, eating a few less bites at each meal.[27]

Measures

The questionnaire was similar to the questionnaire used in study 1. The dietary restraint scale was reliable with $\alpha = 0.93$, the external disinhibition scale had a reliability of $\alpha = 0.73$ and for value consciousness $\alpha = 0.84$.

Data analysis

The main outcome variable was participants' portion size choices of a hot meal. Logistic regression analyses were conducted with the likelihood of choosing the small meal as outcome variable. Furthermore, the same data analysis procedures were applied compared to study 1.

Results

Among worksite cafeteria visitors, the majority of the participants were female (65.7%). The participants' mean age was 35.85 years (SD = 10.94). Based on self-reported height and body weight, 5.3% of the participants were underweight (BMI < 18.50), 67.9% had a normal weight (BMI 18.50–24.99), 22.9% were overweight (BMI 25.00–29.99) and 3.8% were obese (BMI ≥ 30.00) In addition, 49.6% of the participants reported a gross annual income higher than the Dutch gross modal annual income. Furthermore, 21% sometimes consumed a hot meal in the worksite cafeteria (4.3% often and 2.9% almost always). Other participant characteristics can be found in table 2.

Table 4 Participants' size choices in study 2

	Hot meal	
	Medium (%)	**Large (%)**
Entire sample ($N = 121$)		
Overall	86.2	13.8
Proportional	90.0	10.0
Value size pricing	82.4	17.6
	χ^2 (1) = 1.70, $P = 0.2$	
Participants with a healthy weight ($N = 87$)		
Overall	88.5	11.5
Proportional	95.3	4.7
Value size pricing	81.8	18.2
	χ^2 (1) = 3.91, $P = 0.05$	
Participants who are overweight or obese ($N = 34$)		
Overall	82.4	17.6
Proportional	85.0	15.0
Value size pricing	78.6	21.4
	χ^2 (1) = 0.23, $P = 0.62$	

Hot meal size choices

In the worksite cafeteria sample, irrespective of the experimental condition, the majority (86.2%) of the participants chose the reference size. Furthermore, table 4 shows that for participants with a healthy weight, proportional pricing led to an increase of 13.5% that chose the reference size, $\chi^2(1) = 3.91$, $P = 0.05$. However, the logistic regression analysis neither showed significant main effects nor interaction effects for pricing strategies.

Discussion

The purpose of both studies reported in this article was to assess the impact of proportional pricing of high caloric food and drinks on consumers' portion size choices. Results show that among the general population, proportional prices did not have an effect on consumers' size choices. However, among specific subgroups, pricing strategies related to portion size were effective. Among fast food restaurant visitors who were overweight or obese, proportional pricing led to fewer choices for the largest soft drink size and more choices for the reference size of chicken nuggets. Surprisingly, proportional pricing of chicken nuggets had a (marginally significant) beneficial effect on men but a detrimental effect on women. We do not have an explanation for this finding. Among worksite cafeteria visitors with a healthy weight, proportional pricing increased the likelihood to choose the reference size of a hot meal.

Although based on a small sample, it is promising that in the fast food restaurant study proportional pricing seemed effective among participants who were overweight or obese, as these consumers comprise an important target group for this type of environmental interventions. However, no such effect was found among worksite cafeteria visitors. More research is necessary to gain insight into the question *why* people who are overweight would be more sensitive to such pricing strategies than people with a healthy weight. We assessed whether overweight and obese participants were more value consciousness, externally disinhibited or dietary restrained than participants with a healthy weight. Indeed, overweight fast food restaurant visitors were more strongly restrained than visitors with a normal weight. However, no differences were found in value consciousness and external disinhibition. Our data also ruled out the possibility that, irrespective of pricing, participants with a healthy weight were more likely to choose smaller sizes than participants who were overweight, which could have overridden the effect of pricing. More research among overweight and obese people is necessary to gain insight into the question why these individuals seem more sensitive to proportional pricing of fast food than people with a healthy weight. Quantitative studies among specific target groups are necessary to replicate these results and to assess whether pricing strategies also affect actual purchase behaviour rather than intended behaviour. Furthermore, qualitative studies should address underlying cognitive and affective motives related to pricing and purchase behaviour.

With respect to the fact that among fast food restaurant visitors we did not find any effects of pricing among the general population, some aspects are worth mentioning. First, it is uncertain to what extent participants have paid attention to or even noticed the prices and price proportions. As mentioned in the introduction, value size pricing is standard in most point-of-purchase settings. Furthermore, as our environment is complex and food decisions have to be made swiftly (people make around 200 food decisions every day[28]), consumers are likely to have limited cognitive and computational resources available for these decisions. This could induce consumers to base their size choices on heuristics.[29] Therefore, it is conceivable that participants, expecting value size pricing,[11] were not inclined to calculate the price per gram and did not notice the proportional prices. In a comparable study on the impact of proportional pricing on size choices, no effects were found.[17] Based on the study from Harnack and colleagues and the findings from our study, it seems that when implementing pricing strategies, attention should be given to putting emphasis on the altered price proportions. Otherwise, there is a risk that consumers continue assuming that large sizes are advantageous from an economic point of view. Multiple exposures to or explicit communication of proportional prices (for instance by communicating the prices per gram) might be necessary for drawing attention to pricing strategies related to portion sizes.

One of the strengths of the studies reported in this article was that the sample comprised of a wide range of consumers, in all probability representative of general fast food restaurant and worksite cafeteria consumer populations. However, both samples had a lower overweight and obesity prevalence than that in the Dutch population, which might be explained by a tendency to underreport body weight.[30] Furthermore, the fast food restaurant sample was relatively young and BMI levels increase with age.[24] Another strength of this study was that the questionnaire that was used included relevant measures directed at explaining the study findings.

A limitation of these studies was that pricing strategies were manipulated through different versions of a questionnaire, and that actual choice behaviour was not assessed. This method was chosen as a means to overcome practical boundaries related to the inclusion of various food products and to facilitate the assessment of pricing strategies in different settings. Also, empirical research has shown that people's virtual choices correspond strongly with their actual purchase and consumption behaviour.[31] Nevertheless, additional experimental studies assessing the impact of pricing strategies on actual behaviour in realistic settings are recommended. We would also suggest future studies to address the impact of repeated exposures to pricing strategies and communicating pricing strategies clearly. With respect to applying pricing strategies to healthier foods such as fruits and vegetables, we have conducted some preliminary research on the effect of value size pricing of salads on the likelihood to select large portion sizes. Although we did not find any effects, this issue merits further study.

In conclusion, pricing strategies can help overweight and obese consumers selecting appropriate portion sizes of soft drink and high caloric snacks. It is therefore advised to put an effort into the policy development related to pricing strategies with respect to portion sizes of foods and drinks that contain many calories and few nutrients. A difficult issue that remains is how to translate the interaction effect that was found in the fast food restaurant study between overweight status and the response to pricing strategies, to policy development. It seems neither feasible nor desirable to implement pricing strategies in settings that cater uniquely to individuals that are overweight or obese. Furthermore, both the sizeable overweight prevalence and our study results indicating that pricing strategies did not have an adverse effect on people with a healthy weight should be considered. Therefore, a general implementation of pricing strategies seems more realistic and appropriate.

With respect to the implementation of pricing strategies, a study into the feasibility of—amongst others—pricing strategies aimed at portion size identified competition as an important barrier for point-of-purchase settings.[14] In this study, point-of-purchase setting representatives expressed their worries that customers would go to the competition if they did not feel they are getting value for money. It might be the case that portion size interventions should be implemented widely. However, making such agreements is currently prevented by existing competition laws (in order to prevent cartels). It is therefore important that policy makers explore the possibilities for drawing up new legislation to facilitate the implementation of pricing strategies related to portion size.

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Key points

- Proportional pricing of portion sizes of high caloric food could help people who are overweight or obese to select smaller portion sizes.
- More insight is necessary into the question why people who are overweight or obese might be more responsive to proportional pricing of fast food items than people with a healthy weight, and whether this is also the case when actual behaviour is measured.
- Multiple exposures to or explicit communication of proportional prices might enhance the effectiveness of pricing strategies.
- Public health policy makers should explore the possibilities to facilitate the implementation of pricing strategies.

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Social inequities in environmental risks associated with housing and residential location—a review of evidence

Matthias Braubach[1], Jon Fairburn[2]

Background: Housing conditions and environmental quality of residential areas are differentially distributed in the population. Less affluent population groups are more often affected by inadequate housing conditions and higher environmental burden in their residential neighbourhoods. A synthesis of the dispersed evidence on health-related housing characteristics and social status is needed to provide support for housing policies addressing social inequities. **Methods:** The literature on social inequities and environmental risks related to housing and residential location was searched in health, environmental and geographical databases and reviewed to summarize the evidence. Household-level socio-economic status and income were considered as indicators of social status. The review was limited to European evidence. **Results:** Adequate studies were only available for few countries. Most studies identified the less affluent population groups as most exposed to environmental risks in the place of residence. Inequities were reported for risks experienced within the dwelling (such as exposure to dampness, chemical contamination, noise, temperature problems and poor sanitation) and related to residential location (neighbourhood quality, traffic-related pollution, proximity to pollution sites). Increased exposure to environmental risks within more affluent population groups was rarely identified. **Conclusions:** The review indicates that social status and especially low income are strongly associated with increased exposure to environmental risks in the private home or related to residential location. However, due to the methodological variety of the available studies and the lack of data for many countries, it is not possible to provide a general assessment of the magnitude of inequity in Europe at the present time.

Keywords: environmental inequities, health inequities, housing, neighbourhood, social determinants

Introduction

Housing is a fundamental human right and has been identified as one of the determinants for health and quality of life. Different housing conditions lead to different levels of exposure and therefore different levels of environmental risk. Health effects of housing and residential conditions can for example be triggered by lack of thermal comfort, dampness, indoor air pollution, lack of sanitary equipment, noise and environmental pollution in the neighbourhood.[1–4] The strength of the identified associations between housing conditions and health outcomes varies significantly. Many studies find a strong link between housing characteristics and health, while the evidence for links between residential location and health is much more difficult to establish and at this time tends to be mostly indicative.

Housing—including its spatial context which is referred to as 'residential location' in this review—is a good offered in the free market. With varying quality, the price for housing differs and consequently the quality of housing and residential location is directly and indirectly associated with income and socio-economic status (SES).[1,5,6] Similar concerns exist for social housing which often is of lower quality and clustered in deprived neighbourhoods.[7]

Studies from many countries show that it is often the most vulnerable or disadvantaged part of the population that is located in housing with poorer environmental quality.[8–12] However; there is no review available that describes the link between the exposure to housing-related health risks and the social status on a disaggregated level such as dwellings or households. This paper therefore aims at compiling the available evidence on the impact of social inequities on environmental risks related to housing and residential conditions. It includes associations between social status and (i) housing conditions or housing-related exposure conditions directly affected by social status (such as fuel poverty or passive smoke exposure) and (ii) independent housing risks such as exposure to pollution. Only exposure variables that have been confirmed as risk factors for health were considered. However, as this review did focus on the exposure differentials, studies presenting evidence on the housing-related health outcomes were not included. Due to the large international variation of housing parameters and social factors, the review was limited to evidence from European countries.

The results of the review could support the development of housing policies as a means to reduce inequities in health between social groups,[13] and help improving the daily living conditions as a major strategy to tackle social inequities as recently proposed by the World Health Organization (WHO) Commission on Social Determinants of Health.[14]

Methods

Evidence on income and SES-related inequities in environmental risks related to housing and residential location has been searched. In parallel, reports of national and international organizations were identified to gather

[1] WHO Regional Office for Europe, ECEH Bonn Office, Bonn, Germany
[2] Department of Geography, Staffordshire University, Stoke on Trent, UK
Correspondence: Matthias Braubach, WHO Regional Office for Europe, European Centre for Environment and Health, Hermann-Ehlers-Str. 10, 53113 Bonn, Germany, tel: +49-228-8150417, fax: +49-228-8150440, e-mail: mbr@ecehbonn.euro.who.int

Table 1 Examples of search terms and identified publications in PubMed

Combination of search terms	Total publications identified	Publications matching criteria
'inequalities'	225 196	Not assessed
'inequities'	1159	Not assessed
'environmental', 'inequalities'	26 510	Not assessed
'environmental inequalities'	7	1
'environmental', 'inequities'	162	5
'environmental inequities'	12	1
'housing', 'inequalities'	3984	Not assessed
'housing inequalities'	0	–
'housing', 'inequalities', 'social'	1971	Not assessed
'housing', 'social inequalities'	32	7
'housing', 'inequities', 'social'	22	0
'housing', 'social inequities'	0	–
'neighbourhood', 'social inequalities'	58	9
'neighbourhood', 'social inequities'	3	0
'residential', 'social inequalities'	13	1
'residential', 'social inequities'	0	–

Note: The search was restricted to articles on 'humans' only.

evidence beyond scientifically published articles. The review was limited to European evidence.

The identification of relevant publications used a systematic approach to search in a variety of databases (PubMed, Web of Science, SWETSWISE, Annual Reviews, Google Scholar). Key words used in varying combinations were 'housing', 'home', 'indoor' and 'residential' to describe the spatial component, and 'income', 'socio(-)economic status', 'inequality/ies', 'inequity/ies', 'environmental' and 'risk' to describe the social gradient. However, the combination of keywords to focus on housing or residential location together with terms such as inequalities/inequities quickly reduced the number of matching studies (see table 1).

The most frequent reasons for not including studies in the review were: (i) the evidence was based on non-European data; (ii) the study only referred to 'deprived' housing and did not indicate specific housing or residential risk factors; (iii) the study did not report on the distributions of risk by income or SES categories.

It is likely that this review fails to cover some of the existing evidence. Some papers known to the authors and used in this review were actually not identified during the literature search at all as they were not primarily published as inequity-driven papers. The same accounts for reports by governments or international organizations which provide a significant share of the evidence, but are not accessible through literature search programmes.

Results

The review showed that many studies dealing with social inequities related to housing and residential conditions focus on ecological level analysis of neighbourhoods by social deprivation level and often fail to deeper investigate environmental inequities—especially those related to the dwelling. For each environmental risk factor related to housing and residential location, only few studies or reports were identified that provided insight into the social gradient of risk exposure. Such evidence is available only for few countries, with Germany and UK being the main contributors. In parallel, there is a scarcity of evidence on specific environmental risks such as, e.g., sanitation (no peer-reviewed publication matching the criteria was identified), while for home safety and injuries no data were actually identified at all.

Housing and indoor environments

The European Foundation for the Improvement of Living and Working Conditions[15] states that there is an association between household income and inadequate housing, which is stronger in the new EU member states than in the EU15. WHO data based on eight European cities further confirms that inadequate housing conditions are associated with risk factors such as mould, crowding, indoor pollution and noise especially for low-income households.[1,16]

Fuel poverty and thermal comfort

Excess winter deaths are responsible for premature deaths of ten thousands of EU citizens each year.[17] Healy[18] examined excess winter deaths in 14 EU countries and demonstrated that countries with the poorest housing in terms of thermal efficiency showed the highest level of excess winter mortality (Portugal: 33% mortality increase; Spain: 21%, Ireland: 21%, UK: 19%). In-depth research undertaken in the UK showed that excess winter mortality is stronger expressed in residents of cold homes than warm homes,[19] linking excess winter deaths to fuel poverty and thereby the less affluent population groups.

The European Quality of Life Survey[20] shows that for the affordability of heating, large income-related inequities exist: in 9 out of 31 countries—old and new EU members—this problem is twice as often reported by households in relative poverty (defined as below 60% of national median income) (figure 1).

In general terms, affordability of heating is a major problem in Eastern European cities, affecting >40% of all low-SES households.[1] Buzar[21] describes the frequent problems of fuel poverty in the Czech Republic (4–11% of population affected) and the Former Yugoslav Republic of Macedonia (up to 60%), noting that income-poor households are also the most energy-poor. Similarly, a report by the United Nations Development Programme (UNDP)[22] on energy, environment and poverty in Serbia and Montenegro indicated that the burden of cold is disproportionally affecting the low-income households, 27% of which are limiting the heating use to only a reduced number of rooms.

Thermal risks also arise from heat waves when houses accumulate the heat and cannot cool down during night. Data from the 2003 heat wave in Paris showed that the highest heat exposure categories were found in the most deprived areas while similar results were not found for the rest of the country due to less heterogeneity in

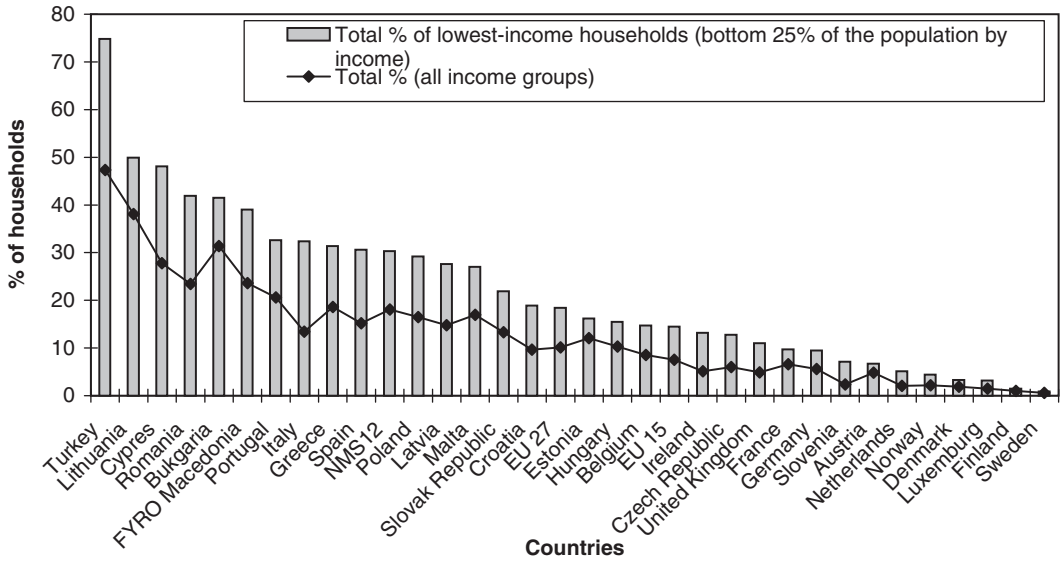

Figure 1 Households that cannot afford to keep their homes adequately warm (2007). Source: European Foundation for the improvement of living and working conditions

deprivation.[23] Further studies indicate that elderly residents of low-quality housing were most vulnerable and that building age (before 1975), location of dwelling under the roof and low insulation quality doubled the risk of heat-related mortality.[24]

Indoor environmental exposures and crowding

Studies from various European countries identified significant social inequities for environmental tobacco smoke (ETS) exposure,[11,25–28] with children in low-income households being exposed about twice as much[11] (higher exposure rates are even found for low education status of parents[25]).

In the EU15, 18% of households in the lowest income quartile have damp or leaks compared with 9% in the highest quartile; in the 12 new member states, the figures are 29% in the lowest quartile and 8% in the highest quartile.[15] Low-income households are more often exposed in all countries except Sweden, Norway and Finland and the biggest problems of dampness are faced by low-income households in Poland (57% reporting dampness or leaks) and Romania (45%). For Serbia and Montenegro,[22] the problem of dampness is strongly related to affordability of heating: 48% of households using coal and wood for heating-reported dampness problems versus 14% of households benefitting from district heating systems. Poortinga *et al.*[29] in Wales found that lower socio-economic households were more exposed to heavy condensation, damp, cold or mould.

German data[11] indicate inequities for benzene exposure in indoor air of children's bedrooms, and for child blood lead levels. However, a number of exposures were more frequently found in well-off households, such as polychlorinated biphenyl in children's blood, terpene concentrations in indoor air and dichlor-diphenyl-trichlorethylene (DDT) levels in house dust samples. Household chemicals which pose potential health threats (e.g. disinfectants, indoor sprays, detergents, etc.) are more often and more frequently used by households with low social status.[30] However, chemical compounds for pest control (moths, ants, etc.) are more often applied by households with high social status.

A rising concern is the use of solid fuels for heating and cooking, which is especially frequent in the Eastern countries and also is an alternative energy source for low-income households in more developed countries.[31] The UNDP[22] report on energy use in Serbia and Montenegro identified the use of lignite coal—known as a serious risk factor for indoor air pollution—as more common in the housing stock inhabited by less affluent population groups. In homes heated with coal and wood, increased exposure to carbon monoxide, benzene, particulate matter and formaldehyde were identified.

Problems with crowding were more than three times more frequent for households in relative poverty in Bavaria.[32] According to data from the European Quality of Life Survey[33], 21.7% of the EU15 households in the lowest income quartile report problems with shortage of space in their dwelling, while this is only reported by 12.2% of the highest income households. In the new EU member states, the problem of shortage of space is found even more frequently (22% in high-income and 28% in lowest income households).

Water and sanitation

Water and sanitation are key requirements for healthy housing, but for European countries there is little information available on inequities in water supply. Therefore, data were almost exclusively found in relation to international databases and monitoring programmes. The lack of a flush toilet for the private use of the household is still an issue for the lowest income population groups in the EU (figure 2).[33] The biggest problems are faced by Romania, where already 11.2% of the highest income group reports such a problem, and 68.8% of the lowest income group is affected. However, for the EU15, the problem rate for the lowest income groups can also go as high as 3.9% (UK), 4% (the Netherlands) and 5.3% (Greece) and thereby reach unexpected levels for highly developed countries as well.

Outdoor environments and residential location

The strongest link found in terms of residential location is between deprivation and ambient air quality (see review by Deguen and Zmirou-Navier in this issue). However, studies from various countries have looked at the link between

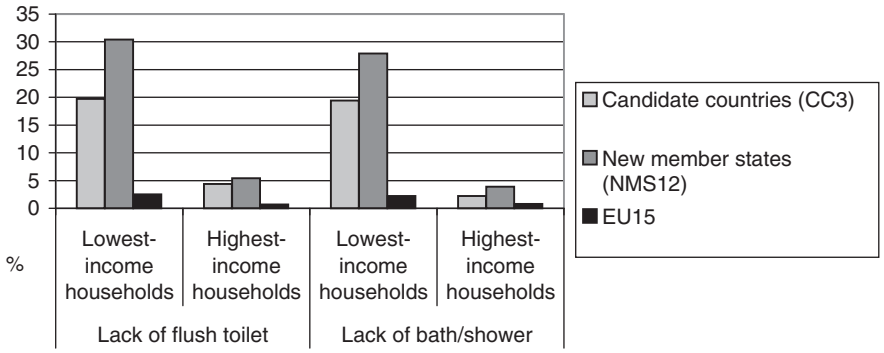

Figure 2 Lack of sanitary equipment by household income in the EU (2007). Source: European Foundation for the improvement of living and working conditions. The lowest/highest income is defined as bottom/top 25% of the households by income

social status and residential location for other environmental factors. Whilst the number of such studies is small, their results presented below provide evidence that quite stark inequities exist in the countries that have been studied so far.

Neighbourhood deprivation, safety and physical activity

Studies from England, Scotland and Wales found that those from a lower socioeconomic background were more likely to report litter and poor neighbourhood quality and found a clear association between neighbourhood deprivation and exposure to poor environments.[29,34,35]

A housing survey undertaken in eight European cities showed that the level and frequency of physical activity in the residing population were affected by perceived safety in deprived neighbourhoods (associated with litter, graffiti, etc.)[36] as well as by a lack of greenery.[37] Although respondents in more deprived areas in the UK may live closer to green spaces, they still report poorer perceived accessibility, poorer safety and less frequent use of these areas which may also relate with the quality of the green spaces.[38] Finally, lower levels of public green areas have been found for low-income neighbourhoods in the Rijnmond region in the Netherlands (five times less than for highest income groups)[39] and for low-income households in Bavaria in Germany.[32]

Noise

German studies examined perceived exposure to noise pollution amongst a range of different social characteristics and found increased exposure to traffic-related noise particularly for low socio-economic groups.[32,40] This result confirmed earlier work which found that people with lower socio-economic status often lived nearer to main roads with high traffic noise.[41] Similar results are obtained for Switzerland,[31] stating that noise exposure is highest in lower social classes and regularly exceeds the Swiss limit value of 65 dB(A). In addition, Swiss data show that 65% of the households with lowest SES live in areas with industrial activities where background noise levels are around 7 dB(A) higher than in residential areas. A Dutch case study reported that lower levels of income reduced the chance of noise exposure levels < 50 dB(A) in the Dutch Rijnmond region[9] but an exception was found for aircraft noise for which high income was associated with increased exposure.[39] Brainard *et al.*[42] studying Birmingham, England, found that night time noise was significantly elevated in deprived communities and Poortinga *et al.*[29] found for Wales that persons with lower socioeconomic status were more likely to report noise exposure.

Industrial pollution and environmental deprivation

The siting of Integrated Pollution Control (IPC) sites has been examined for England[10,43] using the national Index of Multiple Deprivation 2000 at ward level. The results indicate a strong inequity as 20.1% of the population living in the most deprived wards were living within 500 m distance to an IPC site versus 3.8% of the population in the least deprived wards.

From 1991 to 2001, there were five times as many authorizations in the most deprived decile wards, compared to the least deprived. Furthermore, IPC sites in deprived areas on average produced greater numbers of emissions and presented a greater potential pollution hazard, as indicated by the Agency in authorization scores. Levels of particulate matter (PM_{10}) emissions from IPC sites were disproportionately high in more deprived wards and to a lesser extent also emissions of nitrogen dioxide (NO_2), the latter also being confirmed for the Netherlands when looking at low-income groups.[39] In 2007, the Environment Agency[44] carried out a more detailed analysis, confirming that such sites were concentrated in the most deprived areas with the exception of landfills.

In Scotland, Fairburn *et al.*[45] found a strong social gradient in the siting of IPC sites as well, while Laurian[46] found that towns in France with high proportions of immigrants were more likely to host hazardous sites even after controlling for size and income. In the Dutch Rijnmond region, waste sites were more frequently built in neighbourhoods populated by low-income groups.[9,39] Specific concern has been voiced for Eastern European countries where thousands of abandoned and in-use landfills—and many more illegal and unlocated dump sites—cannot be sufficiently monitored by the responsible agencies and toxic leakages may occur.[47]

Fairburn *et al.*[45] reported on Scotland using individual household location classified according to the Scottish Index of Multiple Deprivation covering ambient air quality, industrial pollution, derelict land, river water quality, landfill sites, quarry and open cast sites and woodlands. For industrial pollution, derelict land and low river water quality, there was a strong relationship with socio-economic deprivation indicating increased exposure in more deprived datazones (~1500 residents per datazone) (see table 2).

Table 2 Scottish population living close to derelict land, IPC sites and polluted rivers

Decile	Total Population	Population within 600 m of derelict land	Percentage	Population within 500 m of IPC sites	Percentage	Population within 600 m of rivers classified as C or D	Percentage
1 (most deprived)	505 775	340 045	67.2	422 564	83.5	129 752	25.7
2	506 808	267 125	52.7	387 929	76.5	88 247	17.4
3	506 064	219 564	43.4	336 369	66.5	83 760	16.6
4	506 082	170 656	33.7	277 154	54.8	79 393	15.7
5	506 596	155 380	30.7	251 672	49.7	70 623	13.9
6	505 966	144 472	28.6	218 421	43.2	67 010	13.2
7	505 930	135 568	26.8	208 505	41.2	61 453	12.1
8	506 157	125 781	24.9	219 250	43.3	57 022	11.3
9	506 485	93 659	18.5	200 501	39.6	61 778	12.2
10 (least deprived)	506 148	70 180	13.9	150 251	29.7	67 799	13.4
Scotland	5062 011	1722 431	34.0	2672 615	52.8	766 839	15.1

Source: Fairburn *et al.*[45]

Discussion

A large part of the identified studies focused on data analysis on aggregated (mostly neighbourhood) level and did not enable the identification of specific risks or a social gradient in exposure. This review therefore relied on studies that provided data on specific housing and residential risks, and the distribution of these risks by income or SES. Drawing from published evidence, the review confirmed the existence of a social gradient in exposure to housing and residential risks. The environmental disadvantages are—with very few exceptions—faced by the less affluent population subgroups. Examples are housing and housing-related exposure conditions directly associated with social status such as fuel poverty, lack of sanitary amenities, damp buildings and ETS exposure and independent risk factors such as noise exposure, lack of green spaces and distance to polluted or polluting sites in the residential environment. In contrast, no evidence for social gradients was found for safety threats although injuries are widely considered a major housing-related health outcome.

A major caveat to the presented results is that the evidence is based on studies from few countries with only fragmented contributions from other countries. International data covering several countries are almost exclusively available from international agencies, the United Nations network, or the European Commission and its bodies (Eurostat, Eurofound). Due to the lack of data for many countries, it is not possible to provide a general assessment of the magnitude of housing-related inequity in a European context at the present time.

There is an obvious lack of indicators of multiple environmental risks as studies tend to look at various exposures separately. A few studies only offer evidence on risk indices compiling several risk factors,[9,16,48] all indicating that less affluent population groups are often facing accumulated environmental disadvantages. However, based on the marginal evidence, no assessment is possible on the social distribution of multiple risk.

Key challenges for further work on environmental quality in the field of living conditions will be to (i) develop consistent methodologies to allow comparison of data on international scale (especially regarding use and definition of social determinants such as age, gender, income, employment, ethnicity, etc.), (ii) better integrate social determinants into data collection systems such as national or EU-based surveys and monitoring projects, (iii) make available spatial or geographical data allowing application of Geographic Information Systems, (iv) develop and apply multiple exposure indices to assess inequities more holistically and (v) promote health and environmental inequities as a major working field for health, social and environmental actors.

The results of this review support the recommendation of the WHO Commission on the Social Determinants of Health[14] to improve daily living conditions and address the unfair distribution of resources and power. This position advocates not only that poverty and social gradients need to be tackled but it also very clearly identifies the need to disconnect the current association between being poor and being disadvantaged in terms of environmental conditions.

To address the housing risks directly related to social status and building quality, rehabilitation of the existing housing stock and neighbourhood renewal will be a main target for action by public actors, but increases in supply of public housing need to be considered as well as healthy standards for new construction. However, a major challenge will be to offer quality housing affordable for low-income population groups.

For independent risks, mostly related to pollution and residential quality, greater use needs to be made of spatial planning to avoid the build up of multiple exposures to poor environments and ghettoization of neighbourhoods. This would be accompanied by integrated regional planning to consider the impacts of new facilities and infrastructural developments on inequities. Publication of multiple impact maps should be used to stimulate discussion amongst the general public particularly around the issue of local unwanted land uses (LULUs).

There need to be much stronger links between local municipalities and the health service providers to tackle residential conditions together. National governments may want to consider switching resources from health service providers to local municipalities to provide more of a focus on preventative as opposed to curative policy measures. In that context, municipal services could be developed to further support housing and local neighbourhoods especially for low-income families and elderly.

Overall, national policies should consider housing as a determinant of health as well as social stability, and thus an asset to the society.

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Key points

- This is the first published review of European evidence on the impact of social inequities on health-related housing and residential risks that specifically addresses the disaggregated level of households or dwellings.
- The review confirms that strong social inequities exist in both quality of housing and the residential location. Largest inequities have been found for less affluent population groups and are most often related to risks due to material deprivation.
- Evidence and national data broken down by social categories is rare, especially on household or person-level. Almost no information is available on the parallel exposure to multiple risks.
- Public health work needs to further address the dimension of health and environmental inequity as a major policy focus.

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Children's physical activity, TV watching and obesity in Cyprus: the CYKIDS study

Chrystalleni Lazarou[1], Elpidoforos S. Soteriades[2,3]

Background: Even though there is a severe obesity problem in Cyprus, information about the contribution of predisposing lifestyle factors is limited. Our aim was to investigate the relationship between physical activity (PA), sedentary behaviour and various obesity indices [i.e. body mass index (BMI), waist circumference (WC), percentage of body fat (BF%) and 'total & abdominal obesity' (TAO)]. **Methods:** A national cross-sectional study of 1140 children (mean age = 10.7 ± 0.98 years) selected by multistage sampling in Cyprus was conducted during 2004–05. Children completed a 32-item, semi-quantitative PA questionnaire, which assessed organized and free-time PA and sedentary behaviours. Weight, height and WC were collected from a random sub-sample of 622 children and obesity was defined by IOTF criteria. Body fat percentage was calculated, and TAO status was computed based on obesity status and WC [i.e. (i) both BMI/WC, (ii) either BMI/WC abnormal and (iii) both BMI/WC abnormal]. Linear and logistic regression analyses with obesity indices as dependent variables were applied after adjusting for several potential confounders. **Results:** Only variables describing sedentary behaviours were retained in the final regression models in both boys and girls. Girls who spent ≥4 h/day on TV and DVD watching were almost three times more likely to be overweight or obese [OR = 2.84 (95% CI 1.08–7.47)], three times more likely to have WC ≥75th percentile [OR = 3.25 (95% CI 1.06–9.98)] and 3.5 times more likely to have ≥30% body fat [OR = 3.63 (95% CI 1.01–12.98)], while in boys, even though the same variable was retained in almost all final models, it did not reach statistical significance. **Conclusion:** Sedentary behaviours such as TV watching may be more important predictors of children's various obesity indices than PA behaviours. Interventions targeting sedentary behaviours, such as TV watching, may help in the prevention and treatment of obesity among Cypriot children.

Keywords: BMI, Cyprus, obesity, physical activity, sedentary behaviour, television.

Introduction

Childhood obesity constitutes an ever growing global epidemic, which not only affects children's current health, but also jeopardizes their future health. It has been reconfirmed by a recent review[1] that overweight or obese youth have increased risk to become overweight or obese in adulthood. Also, it has been estimated that about 70% of obese children aged between 10 and 13 years, are at risk of remaining obese during their adult life.[2] On the other hand, children's physical activity (PA) levels seem to be decreasing, while the time spent on television viewing, computers and video games has increased.[3–6] The problems of childhood obesity and sedentary lifestyle are interrelated leading to a vicious cycle, which is exacerbated by unhealthy dietary behaviours and a built environment that discourages PA.[7]

Lifestyle recommendations for prevention and management of childhood obesity emphasize maintenance of daily moderate to vigorous PA for at least 60 min[8] and highlight exacerbating factors such as television viewing and other screen time, which should be limited to not more than 2 h per day.[9] Supporting evidence for the above guidelines, however, is not consistent. In particular, while the evidence on the benefits of obesity prevention and limiting television viewing is convincing, the available evidence on the role of PA in preventing obesity among children appears to have mixed results.[9–14] For example, Sallis *et al.*[15] reported in a review article that only 16 out of 31 studies and six out of 21 studies examined in children and adolescents, respectively, have shown a significant association between PA and obesity. Similar findings are reported in a relevant meta-analysis by Marshall *et al.*[16] and in another recently published review regarding PA and inactivity correlates by Van Der Horst *et al.*[3] Van Der Horst *et al.*[3] in particular report that in most studies, no significant association between body mass index (BMI) or skin folds and PA levels in children and adolescents was evident, whereas, evidence regarding the positive association of BMI/skin folds and sedentary behaviours (e.g. TV, DVD watching and time spent on playing electronic media) was more consistent.[3]

It is noteworthy that most of the research was conducted in the USA with few studies reported from other countries. Hence, there is a need for further investigation of the above relationship and an enhanced understanding of interrelated factors in order to develop targeted preventive programs tailored to regional and local populations.

Even though a severe obesity problem in the Cyprus population has been documented,[17,18] information about the contribution of predisposing lifestyle factors, such as PA and sedentary patterns, on the association between PA and obesity is limited. In particular, Savva *et al.*[18] reported in a cross-sectional nationwide study among 2457 children, 6–17 years of age from Cyprus, that no significant association between sedentary activities, as assessed via a parental questionnaire and obesity was seen.

We therefore sought to examine the association between PA and sedentary behaviour patterns to total and central obesity among Cypriot children, aged 9- to 13-years old. The findings of this work might inform the design of interventions for obesity prevention in Cypriot children, while additionally might be useful for other populations as well, who have similar socio-demographic characteristics.

1 Department of Nutrition and Dietetics, Harokopio University, Athens, Greece
2 Department of Environmental Health, Environmental and Occupational Medicine and Epidemiology (EOME), Harvard School of Public Health, Boston, MA, USA
3 Department of Occupational and Environmental Medicine, Cyprus Institute of Biomedical Sciences, Nicosia, Cyprus
Correspondence: Chrystalleni Lazarou, BSc, MSc, 28 Kronos street, 2369 Ayios Dhometios, Nicosia, Cyprus, tel: +357 22771617; fax: +357 22770676; e-mail: stalolaz@logosnet.cy.net

Methods

Participants

A national survey was conducted in 2005, using a multistage stratified sample of 1140 children (533 boys and 607 girls), aged 9–13 years, attending the fourth, fifth and sixth grade of 24 elementary public schools from five districts of Cyprus. A total of 1589 children were identified for potential enrolment; 1140 agreed to participate (72% participation rate), representing 3.7% of the total population of children in Cyprus in the corresponding ages. The study was approved by the Ministry of Education and Culture of Cyprus, and consent forms for children's participation were obtained from parents and/or legal guardians. Further details have been reported elsewhere.[19,20]

Measurements

PA

The children completed a 32-item semi-quantitative, PA questionnaire during regular school hours. Internal reliability tested by Cronbach's-α was 0.713.[21] Test–retest reliability was assessed by giving the same questionnaire in 100 children of the sample, 1 month apart, and was found to be good [Spearman ρ correlation coefficient ranged from 0.200 to 0.890, with most items (30 of the 32) being >0.500 and only two items being <0.300]. Validation of the questionnaire was performed against counts of Yamax pedometer (DW-200, Yamax Corporation, Tokyo, Japan) in a sample of 80 children. Specifically, the Spearman ρ correlation coefficient regarding the levels of PA (mean hours per day) as compared with the mean value of counts in all 4 days (three weekdays and one weekend day) that pedometers were worn was 0.305. These values are similar to what others have reported.

Information was collected on the frequency and duration of everyday physical and sedentary activities on weekdays, weekends and on the day prior to the completion of the questionnaire, using an eight-level scale ranging from '0' to '>8 h' per day or week. Time spent on individual PAs was assessed based on a four-level scale ranging from '0 times per week' to '>6 times per week'.

Principal component analysis (PCA) (varimax rotation) was employed to extract the main factors out of 21 variables from the above-described questionnaire, assessing children's frequency and duration of physical activity.[21]

A physical activity index (PAI) was calculated based on two variables that measured frequency of all running and walking activities per week. We decided to keep the PAI in the regression models, instead of the factors obtained from PCAs, because it is simpler and much easier to be interpreted in the logistic regression models. The PAI has four categories, representing the frequency with which students are committed to the several PAs: (i) 0 times/week, (ii) 1–2 times/week, (iii) 3–5 times/week and (iv) 6–7 times/week. PAI has been validated against pedometer counts (DW-200, Yamax Corporation) in a sample of 80 children. Results show that Spearman's correlation coefficients range between 0.280 for PA levels during weekdays to 0.352 for PA levels during weekends. For the same reason—simplicity—we used a categorical variable to quantify the hours children were watching TV, video and DVD every day, which was computed on the basis of the variables that constructed the relevant factor from PCA and was categorized in the three following categories: (i) up to 2 h per day, (ii) >2 h and up to 4 h per day and (iii) >4 h per day.

Assessment of other characteristics

Diet

We assessed children's adherence to the Mediterranean diet by applying the KIDMED index (Mediterranean Diet Quality Index for children and adolescents). The index[22] is derived from 16 components that summarize the principles of the Mediterranean diet prototype and provides an arithmetic score that ranges from 0 to 12. It has been positively and significantly correlated with intake of several macro- and micronutrients as they have been estimated by 24 h dietary recalls.[23]

Socio-demographic variables

Questions regarding socio-demographic characteristics such as age, gender, place of residence and family size were also documented. However, information on other demographic characteristics such as parents' educational level, income and parents' occupation were collected via the short questionnaire, which was completed by the parents. Family socio-economic status (SES) was defined by the University of Nicosia (previously known as InterCollege) Research Center, based on parents' profession and educational level; the highest level of profession, reported by either parent, was used as a proxy of the family's SES level, along with family income. A similar procedure for defining parental educational level has been used by Velde *et al.* (in Lazarou *et al.*[20]).

Anthropometry and obesity definition

Anthropometric data (i.e. weight, height and WC) were collected from a sub-sample of 622 children, according to a standard protocol described in Heymsfield *et al.*[24] Obesity was defined based on cut-off criteria from the International Obesity Task Force (IOTF) on age- and sex-specific BMI.[25] Percentage of body fat (BF%) was calculated by using the Deurenberg formula, based on BMI for children's populations.[26] Furthermore, based on children's BMI status and WC level, a new variable called 'total and abdominal obesity' (TAO) was computed, comprising the following three levels: (i) obesity status = (normal weight) NW and WC < 75th percentile; (ii) either condition, obesity status = overweight (OW)/obese (OB) or WC ≥ 75th percentile; and (iii) both conditions apply obesity status = OW/OB and WC ≥ 75th percentile.

Data analyses

Descriptive characteristics were stratified by gender. Associations between normally distributed variables were tested by Student's *t*-test, and Mann–Whitney U-test was used for non-normally distributed continuous variables. Associations between categorical variables were evaluated by contingency tables and chi-square test without Yate's continuity in 2 × 2 tables. Normality of variables' distribution was tested by Shapiro Wilks' test and by examination of Q–Q plots.

The eight extracted factors of PA and sedentary behaviours were regressed on BMI and WC using multiple linear regression analyses (backward method). Regression analyses were adjusted for age, gender, socio-economic status, place of residence and quality of diet as assessed by the KIDMED score.[22] Finally, logistic regression analyses (backward method) were used to compare and complement the results of our linear regression analyses and provided estimates of effects based on odds ratios. A dichotomous BMI variable based on the obesity status (normal weight vs. overweight/obese) and a dichotomous WC variable based on 75th percentile cut-off point

Table 1 Descriptive characteristics of the sample from the nation-wide CYKIDS study (2004-2005)

	Boys	Girls	*P*-value
Age (mean ± SD)	10.68 (0.96)	10.67 (0.99)	0.827
Place of residence [frequency (%)]			0.602
Urban	291 (54.8)	342 (56.3)	
Rural	240 (45.2)	265 (43.7)	
Socio-economic status [frequency (%)]			0.772
High	87 (21.2)	111 (21.9)	
Average	171 (41.7)	219 (43.3)	
Low	152 (37.1)	176 (34.8)	
Ethnicity [frequency (%)]			0.667
Greek	377 (88.7)	461 (88.5)	
Foreigners	14 (3.3)	13 (2.5)	
Mixed	34 (8)	47 (9)	
Number of inhabitants in home [frequency (%)]			0.518
≤3–4	191 (42.2)	227 (41.1)	
5–6	218 (48.1)	281 (50.9)	
≥7	44 (9.7)	44 (4.4)	
Physical activity factors (from PCA)			
Factor 1: physical activity and sports after school	0.34 (1.21)	−0.31 (0.85)	<0.001
Factor 2: video, electronic games and computers	0.14 (1.10)	−0.15 (0.84)	0.003
Factor 3: watching TV, video and DVD	−0.01 (1)	0.05 (0.96)	0.225
Factor 4: homework and private lessons	−0.24 (0.91)	−0.19 (0.84)	0.049
Factor 5: home chores and outside home chores, aerobics, gymnastics, sports	−0.17 (1.08)	−0.06 (0.90)	0.119
Factor 6: theater cinema, use of mobile phone	−0.18 (1)	0.03 (0.97)	0.045
Factor 7: afternoon sleep, less private lessons	−0.05 (1.03)	−0.06 (0.93)	0.936
Factor 8: Sports for all, after school activities (except sports)	0.050 (0.84)	0.025 (0.83)	0.434
Mean hours engaged in physical activity after school the day before	1.50 (1.74)	1.17 (1.35)	0.001
Mean hours engaged in sports after school the day before	1.32 (1.58)	0.66 (1.06)	<0.0001
Mean hours engaged in aerobics/week	5.75 (11.36)	4.99 (8.68)	<0.0001
Mean hours watched TV-video the day before	2.42 (2.06)	2.32 (1.96)	0.317
Mean hours played with electronic games, computer the day before	1.15 (1.73)	0.64 (1.16)	<0.0001
Mean hours engaged in outside home chores/week	2.31 (6.05)	1.90 (4.31)	0.219
Mean hours engaged in home chores/week	2.79 (6.52)	5.69 (8.37)	<0.0001
PAI [frequency (%)]			0.037
None, 0 times/week	31 (6.4)	25 (4.4)	
Some, 1–2 times/week	149 (30.5)	193 (34.3)	
Much, 3–5 times/week	177 (36.3)	228 (40.6)	
Every day, 6–7 times/week	131 (26.8)	116 (20.6)	
TV viewing time [frequency (%)]			0.872
Up to 2 h/day	146 (30.4)	174 (31.3)	
2+ up to 4 h/day	225 (46.9)	263 (47.3)	
>4 h/day	109 (22.7)	119 (21.4)	
Quality of diet (as assessed by KIDMED score) [frequency (%)]			0.097
Poor quality diet: score 0–3	138 (44.8)	170 (55.2)	
Average quality diet: score 4–7	189 (40.9)	273 (59.1)	
Good quality diet: score 8–12	31 (55.4)	25 (44.6)	
Obesity status of children: Frequency (%)			0.144
Normal weight (NW)	177 (67.3)	231 (72.9)	
Overweight/Obese (OW/OB)	86 (32.7)	86 (27.1)	
WC of children [frequency (%)]			0.004
<75th percentile (i.e. <76 cm)	187 (71.6)	259 (81.7)	
≥75th percentile (i.e. ≥77 cm)	74 (28.4)	58 (18.3)	
TAO status of children [frequency (%)]			0.177
Normal weight (NW) and <75th percentile (i.e. <76 cm)	169 (64.8)	222 (70)	
Either overweight/obese (OW/OB) and/or ≥75th percentile (i.e. ≥77 cm)	92 (35.2)	95 (30)	
Body fat percentage of children [frequency (%)]			0.024
<30%	246 (93.5)	279 (88)	
≥30%	17 (6.5)	38 (12)	

were used as dependent variables.[5] All *P*-values were based on two-sided tests and compared with a significance level of 0.05. All statistical analyses were performed using SPSS 13.0 software (Statistical Package for Social Sciences, Chicago, IL, USA).

Results

Demographic and lifestyle characteristics of the participants

In table 1, we present selected descriptive characteristics of the population sample by gender. The mean age was similar in boys and girls (10.68 ± 0.96 vs. 10.67 ± 0.99, $P = 0.827$), age range 9–13 years old. Boys reported higher levels of PA and more time spent daily on electronic games, while girls reported more time spent in private lessons and studying homework. Obesity levels, as examined by four different indices, showed significant gender-specific differences on WC and obesity status as determined by percentage of body fat, while no significant differences were detected with respect to obesity status as evaluated by BMI and the TAO status. Specifically, a higher percentage of boys were classified as either overweight or obese based on BMI, TAO and WC. However, the difference was statistically significant only by the WC criterion. However,

when the criterion of body fat percentage (BF%) was taken into consideration, the direction of this difference was reversed, i.e. significantly higher percentage of girls was classified as either overweight or obese. Detailed results are presented in table 1.

Multivariable analyses

In table 2, we delineate the results of the backward multiple linear regression analysis regarding the most important factors associated with various obesity indices in both boys and girls. 'TV and DVD watching' in girls was positively associated with all obesity indices, while in boys, the above relationship was significantly associated only with abnormal WC. On the other hand, the most consistent factor inversely associated with obesity status in boys was having more afternoon sleep and fewer private lessons.

Results of the backward logistic regression analyses are reported in table 3. We found that children's TV viewing time was, on an average, three times more likely to be associated with obesity in four different regression models in both genders [e.g. OR = 2.84 (1.08–7.47) for the association between TV viewing time and BMI in girls]. TV viewing time was the most significant factor that was retained in all final obesity models in both genders.

Discussion

We present the results from a national survey among pre-adolescent Cypriot children examining the relationship between selected PAs, sedentary behaviours and various proxy measures of body composition. Our findings provide evidence that television viewing and sedentary activities in a sample of Cypriot pre-adolescent children (~2% of the reference population) are the most important factors examined, that are consistently associated with various obesity indices in both boys and girls. Only one of the PA factors, namely 'Sports For All' programs, appeared to be significantly and inversely related with obesity status but only in girls. We also found that obesity was inversely related to having more afternoon sleep.

The observation of a positive association between TV viewing and all four obesity indices was statistically significant only in girls, while in boys, it reached statistical significance only in one of the four obesity indices, that of abnormal WC. The above gender-specific difference has also been reported by others.[27,28] Crespo *et al.*[27] have investigated a sample of 4069 children aged between 8 and 16 years in the NHANES (National Health and Nutritional Examination Survey) study showing that increased television watching is associated with a higher prevalence of obesity among girls. Similarly, in a European study among 12.538 children of 11 years old, te Velde *et al.*[29] observed that, in contrast to boys, girls' sedentary behaviours seemed more important than physical exercise with respect to overweight status. Hancox *et al.*[30] in a prospective study examining 3–15 years among 1.037 individuals, reported that, while BMI and prevalence of overweight at all ages were significantly associated with mean hours of television viewing, these associations were stronger in girls than boys.

Furthermore, it is notable, that, as shown in table 1, there is no significant difference in the percentage of boys and girls regarding the mean time spent in everyday TV viewing. This observation is in agreement with data reported from a previous study conducted during 1998–99 among 1337 Cypriot children (11–12 years), in which it was estimated that there was no difference in the percentage of boys (67.4%) and girls (68.3%) who watched TV on an average of >2 h/day.[5] Thus, a possible explanation of the observation of the positive relationship of TV viewing in girls with all obesity indices were examined, while this relationship was weaker in boys, even with similar mean TV viewing time, may be attributed to the fact that boys seem to be more physically active than girls (table 1). Therefore, provided that mean TV viewing time is about the same in both genders, the higher PA levels reported by boys might be one potential mechanism contributing to a better energy balance in boys. According to a recent review by Jordan and Robinson,[31] possible mechanisms, which might explain the positive association of TV watching and obesity in children, include the displacement of PA by TV watching, the reduction of resting energy expenditure because of the lower metabolic rate and the increase in energy intake because of increased consumption of energy dense foods.

Regarding the first proposed mechanism of PA and displacement, it should be noted that PA includes the so called NEAT (non-exercise activity thermogenesis) PA, which seems to be a potentially important factor in the link with obesity.[32] It has been argued that watching TV reduces participation in moderate or low-intensity household, lifestyle and recreational activity, or NEAT.[32] Examination of the association of TV watching and PA levels in our sample did not show any such significant relationship. This is in agreement with several other studies among children, which suggest that the effect of TV viewing on obesity status is independent of PA levels.[33,34]

With regard to the third proposed mechanism, i.e. the positive association of the intake of energy dense foods and TV viewing time, the literature has shown that this might be attributed to the increased consumption of high fat snacks and sugar-sweetened beverages, the influence of TV food advertisements and the infrequent consumption of fruits and vegetables.[35] Further, examination of the correlation between TV viewing and children's diet quality (as assessed by the KIDMED score) revealed a statistically significant inverse relationship, which, however, was of low effect size ($\rho = -0.100$, $P = 0.05$).

Another finding that bears attention is the observed inverse association between factor behaviour type 7 of more afternoon sleep and fewer private lessons and obesity status in boys (table 2). This finding is in agreement with the reported consistent positive association between short sleep duration and obesity in a recent meta-analysis among 30 000 children from all over the world.[36] Additionally, increased participation in afternoon private lessons might be a contributing factor to increased stress levels among children, which have been associated with increased obesity levels.[37] It may also be noted that children who sleep more may watch less TV.

Overall, the above reported results of positive association between TV viewing time and obesity status in children, and particularly among girls, call for specific measures to target TV viewing and further investigate additional correlates as well as clustering of risk factors with particular behaviours and other lifestyle patterns.

In particular, public health professionals, educators and parents should prioritize on actions that will motivate children to reduce sedentary habits, such as television watching or other screen time. Several randomized controlled trials demonstrated that reducing television and other screen media use result in decreased BMI, WC and weight loss among overweight children.[34,38] The study of Epstein *et al.*[39] suggest that reducing sedentary behaviours may be a more effective strategy to reduce obesity than increasing PA. Interventional approaches that were applied in the above trials may provide model schemes for interventional programs targeting the young population. Moreover, research suggests that certain time periods of the day are linked to increased

Table 2 Results from multiple linear regression (backward method), showing the standard coefficients b and associated *P*-values, that evaluated the association between obesity status (dependent) and factors of physical activity and TV viewing (independent variables)

Variables included in the final model	Model for obesity as assessed by BMI[a]		Model for obesity as assessed by BF percentage[b]		Model for abnormal waist[c]		Model for total and abdominal obesity[d]	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Physical activity factors (from PCA)								
Factor 3: watching TV, video and DVD	NS	0.217**	NS	0.232**	0.210**	0.156**	NS	0.267***
Factor 7: afternoon sleep, less private lessons	−0.192**	NS	−0.195**	NS	−0.208**	NS	−0.160*	NS
Factor 8: sports for all, after school activities (except sports)	NS	NS	NS	NS	NS	−0.178**	NS	NS
Quality of diet (as assessed by KIDMED score)	NS	0.176**	NS	0.182**	NS	NS	−0.167*	0.134*
Place of living (urban/rural)	NS	NS	NS	NS	0.162*	0.152*	NS	NS
Socio-economic level (high, medium and low)	NS	−0.143*	NS	−0.138*	NS	−0.177**	NS	NS
Adjusted R^2 explained by the variables retained in the final model	0.03	0.09	0.03	0.08	0.08	0.06	0.04	0.07

Variables presented in the table are only those retained in the final model (after application of backward multiple linear regression method), showing the standard coefficients *b* and associated *P*-values, that evaluate the association between four obesity indices and factors of PA and TV viewing (independent variables), by gender

Variables entered on Step 1: place of residence (categorical), age (per 6 months), socio-economic status (categorical), PA factors (from PCA) [Factor 1: physical activity and sports after school; Factor 2: video, electronic games and computers; Factor 3: watching TV, video and DVD; Factor 4: homework and private lessons; Factor 5: home chores and outside home chores, aerobics, gymnastics, sports; Factor 6: theater cinema, use of mobile phone; Factor 7: afternoon sleep, less private lessons; and Factor 8: sports for all, after school activities (except sports)], quality of diet as assessed by KIDMED score (continuous)

a: dependent variable overweight or obesity vs normal weight status

b: dependent variable BF% $\geq$ 30 vs BF% < 30

c: dependent variable WC $\geq$ 75th vs < 75th percentile

d: dependent variable overweight or obese and WC $\geq 75^{th}$ percentile vs normal weight and WC $<75^{th}$ percentile, respectively

*$P < 0.10$; **$P < 0.05$; ***$P < 0.001$

NS = non-significant association

Table 3 Results from multiple logistic regression* (backward method), that evaluated the association between obesity status (dependent) and factors of physical activity and TV viewing (independents), from the nation-wide CYKIDS study (2004–05)

Variables included in the final model	Model for obesity as assessed by BMI[a]		Models for obesity as assessed by %BF[b]		Models for abnormal waist[c]		Models for total and abdominal obesity[d]	
	OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
TV viewing time								
Up to 2 h/day	–	1	1	1	1	1	1	1
2+ up to 4 h/day	–	1.96 (0.85–4.54)	0.34 (0.05–2.12)	1.79 (0.55–5.90)	0.85 (0.33–2.17)	1.70 (0.62–4.64)	0.83 (0.34–2.02)	1.72 (0.78–3.77)
>4 h/day	–	2.84 (1.08–7.47)	1.33 (0.25–7.13)	3.63 (1.01–12.98)	2.15 (0.76–6.11)	3.25 (1.06–9.98)	2.26 (0.80–6.40)	2.23 (0.88–5.65)
Quality of diet (as assessed by KIDMED score)								
Poor quality diet: score 0–3	–	–	–	–	–	–	1	–
Average quality diet: score 4–7	–	–	–	–	–	–	0.42 (0.20–0.92)	–
Good quality diet: score 8–12	–	–	–	–	–	–	0.43 (0.12–1.55)	–
Age (Per 6 months)	0.46 (0.25–0.85)	–	–	–	–	–		–

a: dependent variable overweight or obesity vs normal-weight status. Total cases: 622 (2% of the reference population)
b: dependent variable BF% $\geq$ 30 vs. BF% < 30. Total cases: 622 (2% of the reference population)
c: dependent variable WC $\geq$ 75th vs < 75th percentile. Total cases: 622 (2% of the reference population)
d: dependent variable overweight or obese and WC $\geq$ 75th percentile vs normal weight and WC < 75th percentile, respectively. Total cases: 622 (2% of the reference population)
*Variables entered on Step 1: place of residence (categorical), age (per 6 months), socio-economic status (categorical), PA index (categorical), TV viewing time (categorical), quality of diet as assessed by KIDMED score (categorical)

sedentary or PA pursuits. In the study of Hager,[40] it has been shown that increased TV viewing after school correlated with decreased PA. Therefore, further investigation of the relationship between specific day time periods associated with sedentary behaviour and PA patterns may provide further helpful insights into the understanding of such behaviours, which might in turn inform public health programs.

Additionally, there is a need to explore novel ways of encouraging children, who prefer screen entertainment, to be active while they watch TV. For example, a recently published study suggested a novel walking media station, which enables normally seated screen activities, in children, to be conducted whilst walking.[41] Parallel efforts should also target the promotion of PA and improvement of children's healthy dietary habits, since clustering of unhealthy lifestyle behaviours could further exacerbate the obesity problem.[35]

Our study findings also suggest that girls may need to be particularly targeted with special intervention programs. Therefore, research should also address factors that may be associated with gender-specific differences regarding PA and sedentary activity patterns as well as obesity.

Strengths of our study include the fact that this is a novel study in Cyprus examining the relationship of obesity indices, PA and sedentary behaviours, and thus adds to the growing body of literature on child sedentary behaviours and obesity. The sample was nation-wide and thus provided information applicable in public health programs on a nation-wide level, and in countries with similar demographic profile, such as other Mediterranean countries. Furthermore, we report associations between TV viewing time and various obesity indices, besides BMI, which is the only index that is usually reported and thus additional useful insights are given on the type, magnitude and consistency of the reported relationship.

We would also like to acknowledge the limitations of our study, which should be taken into account when interpreting and generalizing the results. First, this was a cross-sectional study and therefore causation should be examined with caution. Secondly, PA and dietary data were based on self-reports. Although we made every effort to obtain accurate data, there is a possibility that misreporting has occurred, which might have influenced our findings. Even though this is a cross-sectional study and observed associations may be bi-directional, we believe that our findings are suggestive of causal relationships based on plausible biological associations. Further more, current BMI cut-offs have lower sensitivity and therefore may lead to potential misclassification.[24] Even though we also estimated body fat percentage, the estimation was not from direct measurement, but was based on anthropometry (BMI). Two main disadvantages of prediction formulas are that their validity is only proven in the population in which they were developed and they often underestimate BF% especially in individual level. However, it is generally acknowledged that prediction formulas give generally good estimates of BF% on a group level. Furthermore, the use of four obesity indices in this study could help overcome any misclassification problems of each obesity index and offer valid results with respect to group-level associations.

Conclusion

In summary, our findings show that TV viewing time is an important correlate consistently associated with obesity status in Cypriot children, particularly among girls. Our results call for the implementation of public health programs to prioritize on actions that will motivate children to reduce sedentary habits, such as television watching or other screen time. Future research should also address factors that may be associated with gender-specific differences regarding physical activity and sedentary activity patterns and obesity.

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Key points

- An inverse association between more afternoon sleep and fewer private lessons and obesity status was observed.
- Television watching and sedentary activities are the most important of the factors that are consistently associated with four obesity indexes in both boys and girls.
- Public health professionals, educators and parents should prioritize on actions that will motivate children to reduce sedentary habits, such as television watching or other screen time.

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What makes you work while you are sick? Evidence from a survey of workers

Petri Böckerman[1], Erkki Laukkanen[2]

Background: Sickness absenteeism has been a focus of the EU Labour Force Surveys since the early 1970s. In contrast, sickness presenteeism is a newcomer. Based on surveys, this concept emerged in the empirical literature as late as the 1990s. Knowledge of the determinants of sickness presenteeism is still relatively sparse. **Methods:** The article examines the prevalence of sickness presenteeism in comparison with sickness absenteeism, using survey data covering 725 Finnish union members in 2008. We estimate logit models. The predictor variables capture working-time arrangements and the rules at the workplace. We include control variables such as the sector of the economy and educational attainment. **Results:** Controlling for worker characteristics, we find that sickness presenteeism is much more sensitive to working-time arrangements than sickness absenteeism is. Permanent full-time work, mismatch between desired and actual working hours, shift or period work and overlong working weeks increase sickness presenteeism. We also find an interesting trade-off between sickness categories: regular overtime decreases sickness absenteeism, but increases sickness presenteeism. **Conclusions:** Two work-related sickness categories, absenteeism and presenteeism, are counterparts. However, the explanations for their prevalence point to different factors.

Keywords: absenteeism, presenteeism, sickness absence, working-time arrangements.

Decrease in sickness absenteeism reduces firms' costs, but it also contains a possibility for decreasing productivity through presenteeism ('present at work in spite of sickness').[1] Sickness presenteeism may contribute to workers' ill health and firms' costs in the long run,[2–4] and even to dysfunctional 'competitive presenteeism', which is an extreme example of competitive culture at workplaces.[5]

The question about the right management strategy concerning sickness absenteeism and presenteeism is very important for employers as well as for the healthcare sector. In absenteeism, productivity loss is 100%, since the workers' contribution during sickness absence is non-existent. Direct and indirect costs caused by presenteeism are more difficult to estimate.[6,7]

Before the evaluation of costs, knowledge of the determinants of sickness presenteeism is essential. It is reasonable to assume that sickness presenteeism is affected by the same factors as sickness absenteeism, i.e. attributes related to workers and workplaces.[8] According to the literature, special attention should be paid to working-time arrangements,[9] workers' replacement practices,[10] attendance-pressure factors[11] and personal attitudes.[12]

This article contributes to the literature by analysing the prevalence of sickness presenteeism in comparison with sickness absenteeism. Using survey data of Finnish union members from 2008, we provide fresh evidence of the prevalence of both work-related sickness categories. The Finnish case is interesting, because flexible working-time arrangements have increased rapidly during the past 10 years.

1 Labour Institute for Economic Research, Helsinki, Finland
2 The Central Organisation of Finnish Trade Unions, Helsinki, Finland
Correspondence: Petri Böckerman, Labour Institute for Economic Research. Address: Pitkänsillanranta 3A, 6th floor, FI-00530 Helsinki, Finland, tel: +358 9 25357330, fax: +358 9 25357332, e-mail: petri.bockerman@labour.fi

Methods

Sample

Our data set consists of 725 members in SAK-affiliated unions. SAK, the Central Organisation of Finnish Trade Unions, is the largest workers' confederation in Finland, and includes 26 unions. The members of these unions cover all sectors of the Finnish economy. However, most of them are blue-collar workers. The survey provides a broad picture of the labour market in Finland, because the union density (i.e. the share of trade union members among wage and salary earners) is 70%. A total of 1044 individuals were selected for a telephone interview by using random sampling among the SAK-affiliated union members that was conducted by Statistics Finland in February 2008. Out of this sample, 725 persons or roughly 70% participated in the interviews.

Empirical modelling

The outcome variables of the models, absenteeism and presenteeism, are constructed following the literature.[11] Those who have never been or have once been absent (present while sick) during the last 12 months are marked as zero, those who have been absent (present) several times as one. This gives a prevalence of 32% for absenteeism and 30% for presenteeism (table 1). For women, both averages are higher than for men. The association between absenteeism and presenteeism is strongly positive. Half of the workers who have been absent from work several times have also been present at work several times while sick.

The predictor variables include the sector of the economy, educational attainment, age groups, the presence of children, establishment size and workers' replaceability. In the literature, workers' replaceability and working-time arrangements have achieved the status of key theoretical variables.[12,13] Replaceability is particularly interesting from the economic point of view, because when replaceability is not possible a worker has to accomplish all those tasks that were not done during his or her absence from work after he or she returns to work. In this case, the indirect costs of being absent from work while sick are particularly high for a worker.

Table 1 Definitions and averages of the variables as percentages

Variable	Definition	All	Men	Women
Outcome variables				
Absenteeism	Person has been absent several times because of illness during the past 12 months = 1, otherwise = 0	32	30	34
Presenteeism	Person has been present several times while sick during the past 12 months = 1, otherwise = 0	30	27	35
Predictor variables				
Sex	Male = 1, female = 0	58	–	–
Sector				
The public sector	Employer is state or municipality = 1, otherwise = 0 (reference)	23	11	40
Processing industries	Employer is in the processing industries = 1, otherwise = 0	46	65	19
Private services	Employer is in the private service sector = 1, otherwise = 0	31	24	41
Education				
Primary level	Comprehensive education only = 1, otherwise = 0 (reference)	23	22	24
Secondary education	Upper secondary or vocational education = 1, otherwise = 0	65	69	59
Higher education	Polytechnic or university education = 1, otherwise = 0	13	9	17
Age				
<35 years	Less than 35 years = 1, otherwise = 0 (reference)	23	25	20
35–50 years	Age 35–50 = 1, otherwise = 0	45	46	44
>50 years	Age >50 years = 1, otherwise = 0	32	29	36
Children	Person has at least one child = 1, otherwise = 0	58	58	58
Establishment size				
<20 workers	Size of plant less than 20 workers = 1, otherwise = 0 (reference)	44	37	53
20–50 workers	Size of plant 20–50 workers = 1, otherwise = 0	20	20	21
>50 workers	Size of plant over 50 workers = 1, otherwise = 0	36	44	26
Replaceability				
No replacement	Replacement is not possible = 1, otherwise = 0 (reference)	11	14	8
Replacement by substitutes	Replacement is possible by substitutes = 1, otherwise = 0	33	27	43
Replacement by colleagues	Replacement is possible by colleagues = 1, otherwise = 0	55	60	49
Working-time arrangements				
Permanent full-time work	Permanent full-time work = 1, otherwise = 0 (fixed-term or part-time work)	88	92	82
Working hours match	Desired and actual weekly working hours match = 1, otherwise = 0	66	67	64
Shift or period work	Shift or period work = 1, otherwise = 0	41	40	43
Regular overtime	Regular paid and unpaid overtime = 1, occasional or none = 0	11	12	9
>48 h a week	Weekly working hours more than 48 = 1, otherwise = 0. (48 weekly hours are the maximum working time according to the EU working time directive from 1993.)	4	4	4
Rules				
Three days' rule	Three days' paid sickness absence possible without a sickness certificate, as defined in the collective labour agreements = 1, otherwise = 0	45	38	55
Efficiency rule	In tough situations, efficiency rules out everything else in firm, according to the survey respondent = 1, otherwise = 0	48	46	52
Total		725	424	301

Replaceability includes two possibilities: replacement by substitutes and replacement by colleagues.

Besides these, the models include several indicators for working-time arrangements: working hours match (between desired and actual weekly working hours), shift or period work, regular overtime, and overlong weekly working hours. The working-time match between the desired and the actual working hours is used as an indicator of working-time balance. We use a single indicator for shift or period work, because period work bears a similarity to shift work in the sense that the hours for 2 or 3 weeks are fixed, without the usual limitations for daily or weekly hours.

We include predictor variables that capture the rules at the workplace: the 3 days' rule (3 days' paid sickness absence without a sickness certificate), and the efficiency rule. The efficiency rule reflects the relative position of workers compared with employers. The respondents were asked to assess their work by means of the statement: 'In tough situations efficiency rules out everything else.' If the respondents agreed with the statement, as 48% did, the variable for the efficiency rule was set as one, otherwise as zero. This indicator very strongly correlates with other workplace quality measures that are available in the survey, like continuing rush (i.e. a situation in which the worker is engaged in tasks without appropriate breaks from work) and the opportunities to influence one's work. To avoid multicollinearity problems, we prefer to use one overall indicator instead of several.

We estimate logit models, because our outcome variables are dichotomous indicators that categorize the data into two groups. We use Stata v10.1 to estimate the models. The predictor variables are entered in a single block. To make it easier to read the estimates, we report the marginal effects. For binary variables, they are calculated as differences in the predicted probabilities.

Results

Presenteeism is much more sensitive to working-time arrangements than absenteeism (table 2). Some common factors exist, however. In both sickness categories, the public sector workers and those involved in shift or period work are overrepresented.

The first 10 predictor variables are control variables. When these factors are controlled for, it is possible to assess the impact of replaceability and other workplace characteristics that are firms' possible policy instruments. In the case of sickness absenteeism, there are two such instruments: shift or period work and regular overtime. Participation in shift or period work increases the prevalence of sickness absenteeism by 8% and the presence of regular overtime decreases absenteeism by 13%.

In the case of sickness presenteeism, participation in shift or period work has the same sign as for sickness absenteeism, i.e. participation in shift or period work increases sickness behaviour in both sickness categories. However, in the case of

Table 2 The determinants of sickness absenteeism and presenteeism

Outcome variables	Absenteeism		Presenteeism	
Controls	Marginal effect	*P*-value	Marginal effect	*P*-value
Sex	−0.068	0.104	−0.098	0.022
The public sector	Reference			
Processing industries	−0.126	0.018	−0.108	0.040
Private services	−0.144	0.003	−0.116	0.017
Primary level	Reference			
Secondary education	−0.016	0.729	0.086	0.060
Higher education	−0.121	0.052	0.061	0.355
<35 years	Reference			
35–50 years	−0.028	0.524	0.000	0.992
>50 years	−0.245	0.000	−0.058	0.230
Children	−0.105	0.004	−0.000	0.995
<20 workers	Reference			
20–50 workers	0.011	0.817	−0.016	0.731
>50 workers	0.064	0.132	−0.031	0.451
Policy variables				
No replacement	Reference			
Replacement by substitutes	−0.017	0.788	−0.110	0.059
Replacement by colleagues	0.018	0.749	−0.072	0.199
Permanent full-time work	0.073	0.132	0.109	0.019
Working hours match	−0.023	0.531	−0.077	0.041
Shift or period work	0.075	0.048	0.063	0.095
Regular overtime	−0.134	0.014	0.118	0.044
>48 h a week	−0.082	0.418	0.227	0.020
Three days' rule	−0.013	0.737	−0.075	0.057
Efficiency rule	0.052	0.147	0.076	0.030
McFadden's pseudo R^2	0.085		0.062	
Total	725		725	

Reported estimates are marginal effects from the logit models, evaluated at variable means.

sickness presenteeism, participation in regular overtime is associated with a positive effect (12%) that is contrary to sickness absenteeism. Therefore, there is a trade-off between two work-related sickness categories: regular overtime decreases sickness absenteeism, but increases sickness presenteeism. In addition, there is evidence that the possibility of replacement by substitutes decreases the prevalence of presenteeism by 11%.

Other working-time arrangements also have an influence on sickness presenteeism. Participation in permanent full-time work increases the prevalence of sickness presenteeism by 11%. If the desired and the actual working hours match, sickness presenteeism is reduced by 8% less compared with the case in which they do not match. Furthermore, if the regular weekly working hours exceed 48 h, sickness presenteeism is 23% higher, compared with those who work less.

The presence of the 3 days' rule at the workplace, i.e. 3 days' paid sickness absence without a sickness certificate, decreases sickness presenteeism by 8%. The presence of the efficiency rule at the workplace, i.e. 'in tough situations efficiency rules out everything else', increases the prevalence of sickness presenteeism by 8%. Therefore, focusing only on efficiency increases workers' sickness behaviour in the form of presenteeism. Intuitively, a reasonable amount of 'slack' is useful in organizations, if the aim is to minimize the prevalence of presenteeism. There is also unaccounted variation in absenteeism and presenteeism after taking into account the effects of the predictor variables. One reason for this is that we use cross-sectional data. Thus, we cannot control for individual characteristics that are constant over time, such as personality.

Discussion

Two work-related sickness categories, absenteeism and presenteeism, are counterparts. However, the explanations for their prevalence point to different factors. If one controls for worker characteristics, sickness presenteeism is much more sensitive to working-time arrangements than sickness absenteeism.

Participation in permanent full-time work, regular overtime and overlong working weeks increases the prevalence of sickness presenteeism. In contrast, the match between the desired and the actual working hours decreases it. These results are in accordance with the ones in the earlier studies,[12] except the finding for permanent full-time work. One explanation for the fact that participation in permanent full-time work increases sickness presenteeism is related to the degree of control.[11] Workers in permanent full-time work have a higher degree of control over their work, compared with workers in fixed-term and part-time work. Hence, they are less replaceable while sick. We also find an interesting trade-off between two sickness categories: regular overtime decreases sickness absenteeism, but increases sickness presenteeism. This pattern is related to the earlier Canadian results according to which there exist trade-offs between absenteeism and presenteeism.[14]

The rules matter. If workers are eligible for 3 days' paid sickness absence without a sickness certificate, they work less often while sick. Even more interesting is the fact that this rule does not lead to higher levels of sickness absence. This indicates that workers are not 'slacking' when they get the opportunity to take sick leave without a medical certificate. We also find that the presence of the efficiency rule increases sickness presenteeism.

As we are analysing a cross-sectional survey, we cannot explore the direction of causality. This would require an instrumental variables strategy, involving instruments that would predict the presence of working-time arrangements but not the prevalence of sickness presenteeism. Hence, it is possible that the estimates presented are subject to selection bias, at least to some degree, if the unobserved factors that

determine whether workers participate in certain aspects of working-time arrangements also influence their behaviour regarding working while sick. In particular, the fact that shift or period work increases both sickness absence and presence raises the possibility that those who have shift or period work are selected in such a way that they have more bad health on average. Furthermore, the use of panel data would allow us to include a 'personal history of sickness' as a determinant of absenteeism and presenteeism. Another limitation of our approach is that we used a survey of Finnish union members. Union members are not a fully representative sample of the total workforce, even in a country with high union density. Finally, we were not in a position to estimate duration models, because our data do not record how long the individual spells of absences and presenteeism are.

Conflicts of interest: None declared.

Key points

- Sickness presenteeism is a newcomer. The concept emerged in the empirical literature as late as the 1990s. Information about the determinants of sickness presenteeism is still relatively sparse.
- This article focuses on the prevalence of sickness presenteeism in comparison with sickness absenteeism. Using survey data of Finnish union members from 2008, we provide fresh evidence of the prevalence of both work-related sickness categories.
- Controlling for worker characteristics, we find that sickness presenteeism is much more sensitive to working-time arrangements than sickness absenteeism is. Permanent full-time work, mismatch between desired and actual working hours, shift or period work and overlong working weeks increase the prevalence of sickness presenteeism. We also find an interesting trade-off between two work-related sickness categories: regular overtime decreases sickness absenteeism, but increases sickness presenteeism.

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