APPENDIX AVAILABLE ON REQUEST

Research Report 139

Effects of Long-Term Exposure to Traffic-Related Air Pollution on Respiratory and Cardiovascular Mortality in the Netherlands: The NLCS-AIR Study

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Appendix E. Motivation of Selection of Ecological Covariates

Note: Appendices Available on the Web appear in a different order than in the original Investigators' Report. HEI has not changed these documents. Appendices were relettered as follows:

Appendix C was originally Appendix 1
Appendix D was originally Appendix 2
Appendix E was originally Appendix 3
Appendix F was originally Appendix 4

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Appendix 3: Motivation of selection of ecological covariates

Proposed ecologic covariates in the HEI reanalysis were classified in 3 categories: demographic and social environment, climate and physical environment, and health services. Finally, in the reanalysis 20 ecologic covariates were used from a longer list of 30 potential ecologic covariates (Table 3). A more detailed description of the ecologic covariates that were included in the reanalysis can be found on page 178 of the reanalysis report.(Krewski, Burnett et al. 2000) Briefly, eight measures of the social environment were considered: population change, percentage of white residents, percentage of black residents, mean income of residents in 1979, poverty level in 1979, income disparity as measured by the Gini coefficient, unemployment in 1979, and percentage of residents age 25 or older who had completed high school. In terms of the physical environment, altitude, water hardness, and climate (average maximum temperature, average monthly variation in maximum temperature, average daily relative humidity, and average monthly variation in daily relative humidity). Four gaseous copollutants were also used in the reanalysis: CO, NO_2, O_3, and SO_2. Two measures of the provision of health care services were used: number of physicians per 100,000 residents and number of hospital beds per 100,000 residents. However, it was not possible to obtain data on certain ecologic covariates for some of the cities included in the ACS study.(Krewski, Burnett et al. 2000)

Reasons for not including some proposed ecologic covariates ranged from no data available (barometric pressure) and no reliable data available (crime rate and other airborne toxic substances) to that the data do not necessarily represent a useful group-level variable (race, serum iron levels, and air conditioning). A full description of the proposed ecologic covariates that are not used is given in Appendix E of the HEI reanalysis report.(Krewski, Burnett et al. 2000)

Table 3: Proposed ecologic covariates in the HEI reanalysis

Demographic and socioeconomic environment	
Used in the reanalysis	*Not used in the reanalysis*
Income	Crime rate
Education	Race
Income disparity	Serum iron levels
Population change	
Poverty	
Unemployment	

Percent whites	
Percent blacks	
Climate and physical environment	
Used in the reanalysis	*Not used in the reanalysis*
Temperature	Barometric pressure
Temperature variation	Air conditioning
Relative humidity	Geographic position: latitude and longitude
Relative humidity variation	Other airborne toxic substances
Altitude	Radon gas
Water hardness	
Gaseous copollutants:	
CO, NO_2, O_3, SO_2	
Health services	
Used in the reanalysis	
Number of physicians	
Number of hospital beds	

Relevance of the proposed ecologic covariates in the HEI reanalysis for the NLCS-AIR study

The demographic variables that were considered in the HEI reanalysis may all be relevant. Of the climate variables none are relevant for the NLCS-AIR study. For example, temperature (and temperature variation), humidity (and humidity variation), altitude, and barometric pressure are fairly similar over the Netherlands, because the Netherlands has a much smaller spatial scale (~300 * 150 km) compared with the United States, and there are no altitude differences of any meaning. Water hardness is possibly a relevant ecologic covariate for our study. Gaseous copollutants are certainly relevant, but were treated as exposures instead of ecologic covariates. Geographic position will not be used as an ecologic covariate, but was used when account was taken for spatial autocorrelation of exposure data.

It is thus clear that not all proposed ecologic covariates that were used in the HEI reanalysis of the ACS study are relevant in the NLCS-AIR study. It has to be evaluated which of the proposed ecologic covariates in the HEI reanalysis of the ACS study are relevant for the NLCS-AIR study. Furthermore, the HEI reanalysis used ecologic covariates on a metropolitan scale. This is probably not the most relevant scale. ‘Neighborhood’ or ‘postal code areas’ are probably better as the spatial scales for ecologic covariates in the NLCS-AIR study, since large differences in demographic variables exist in urban areas.

Possible ecologic covariates identified in the literature

Similar to the search for possible ecologic covariates in the reanalysis of the ACS study, we also made use of 3 categories (i.e. demographic and socioeconomic environment, climate and physical environment, and health services) to search for possible ecologic covariates. Both a Medline search and reference-tracking was conducted to identify possible relevant ecologic covariates. The possible ecologic covariates found in the literature are shown in Table 4. It is however not sure whether all these data are available on an area level or whether these data are available on the preferred area level and for the preferred time period in the Netherlands. It has also to be evaluated which of the identified possible ecologic covariates may be relevant for the NLCS-AIR study. Furthermore, while some of these ecologic covariates were identified from studies investigating the effects on mortality, other ecologic covariates were identified from studies which investigated the effects on health. It has to be evaluated whether ecologic covariates which have an effect on health are also relevant for the NLCS-AIR study, in which the effects on mortality and lung cancer incidence are studied.

Table 4: Possible ecologic confounders identified in the literature

Demographic and socioeconomic environment
Income
Income inequality
Proportion households with income below minimum
Housing values
Ratio between owner-occupied houses and rented houses
Unemployment rate
Proportion of people who depend on benefits
Proportion people with severe financial problems
Proportion of single mothers
Infrastructure deprivation
Residential stability/population change
Urbanization
Region/province
Climate and physical environment
Water hardness
Health services
Availability and accessibility of health services
General practitioner deprivation score

Discussion

It is important to conceptualize the causal pathways by which ecologic covariates can affect mortality.(Pickett and Pearl 2001) Differences in mortality between areas may be caused by two mechanisms:

1. Socioeconomic differences or differences in area-bound factors such as for example pollution differences between areas;
2. Selective migration of “healthy” people out of “non-healthy” areas (for example cities).(Lucht and Verkleij 2001)

For ecologic covariates, both the average and the spread of ecologic covariates may be worthy of examination (Pickett and Pearl 2001), for example mean income versus income range in a neighborhood. Ecologic covariates may also be inter-correlated and therefore the correlation between different ecology covariates has to be evaluated.

Most of the possible ecologic covariates found in the literature are social economic status (SES) related covariates. To investigate the effect of these ecologic SES covariates, individual level SES covariates have to be accounted for. Furthermore, different alternative measures of SES may be considered jointly because each measure may represent different aspects of social status and may be associated with different intermediate risk factors in the relation between SES and mortality.(Backlund, Sorlie et al. 1999) Therefore, in the analyses, account was taken for individual level SES covariates and different alternative area level measures of SES.
However, results from studies indicate that the choice of area level variables may be less critical than ensuring correct control for individual level social economic status. (Fiscella and Franks 1997; Lucht and Verkleij 2001; Pickett and Pearl 2001; Osler, Prescott et al. 2002; Steenland, Henley et al. 2004) For example, the results of a study with analysis of pooled data from two cohort studies (13,710 women and 12,018 men) indicated that area based income inequality did not affect all cause mortality after adjustment for individual income and other risk factors. The authors concluded that Denmark's welfare system, that is based on a Nordic model, may even out the effect of area inequality.(Osler, Prescott et al. 2002) In addition, a study by Fiscella and Franks had almost the same conclusion, i.e. family income, but not community income inequality independently predicted mortality. This study was a longitudinal study in the US where 14,407 people (aged 25-74 years) were followed from 1971-5 until 1987.(Fiscella and Franks 1997) A longitudinal study in Canada where 2,116 people (age 18-75 years) were followed from 1990 through December 1999, found that neighborhood socioeconomic characteristics (neighborhood income, educational level, unemployment rate) were not significantly associated with mortality. However, within advantaged neighborhoods, the importance of individual socio-economic characteristics for mortality is increased relative to disadvantaged neighborhoods. This has also been demonstrated in the US and thus also, although less pronounced, in Canada, in a setting with universal access to basic health and social services.(Veugelers, Yip et al. 2001) A recent cohort study by Steenland *et al.* on individual- and area-level socioeconomic status variables as predictors of mortality with 179,383 study participants suggested that the predictive value of area-level socioeconomic status variables varies by cause of death but is less important than individual-level socioeconomic status variables.(Steenland, Henley et al. 2004)
Studies in the Netherlands also showed that after correction for more individual level SES factors smaller health differences between neighborhoods were found.(Lucht and Verkleij 2001) However, the findings of a longitudinal study (GLOBE-study) in the Netherlands (baseline: 1991, with a follow-up time of 6 years) in 8,506 men and women aged 15-74 years, indicated that particular indicators of neighborhood SES were related to all cause mortality of men and women

in an urban setting. After the stringent control for individual SES, the neighborhood percentage of unemployed or disabled persons, and the percentage who reported severe financial problems continued to affect mortality risks. The educational and occupational indicators of neighborhood SES were also related to mortality, but less strongly, and their effects were no longer statistically significant after control for individual-level socioeconomic indicators.(Bosma, van de Mheen et al. 2001)

Although ecologic covariates may be less important than individual-level variables, both individual and ecologic variables were evaluated as potential confounders in our study.

Relevant spatial scale for ecologic covariates

A recent study by Reijneveld et al. (Reijneveld, Verheij et al. 2000) in the Netherlands examined the impact of geographical classification on the clustering of poor health (as measured by 4 indicators in a interview: self rated health, physical symptoms, mental symptoms, and long term physical limitations) per area and on the size of the differences in health by area deprivation. Three classifications were used:

1. *Neighborhoods* are areas with a similar type of buildings, often delineated by natural boundaries. Because of this, they are socioculturally rather homogenous and therefore relate to "real" communities, but their population size varies a great deal.
2. *Postcode sectors* have a logistic origin, adequate post delivery, and were designed at a national level. They had to comprise similar numbers of addresses and therefore, their average population size varies less. Postcode sectors do not further have a (emotional) meaning to most of their residents.
3. *Boroughs* concern aggregates of socioeconomically comparable neighborhoods; they mostly exist in urban areas. In some of the bigger cities of the Netherlands they have their own public administration.

Regarding homogeneity, ecologic, area-bound factors may have a greater impact on health if an area relates to a socioculturally homogeneous, "real", community. Therefore, the independent area effect on the clustering of poor health was largest for neighborhoods. A large part of these area effects can be explained by differences between areas in the socioeconomic composition of their population.

However and more importantly, the choice of the geographical classification had hardly any impact on the size of the health differences by area deprivation in this study.(Reijneveld, Verheij et al. 2000)

Because this study has been conducted in Amsterdam, the conclusions cannot automatically be applied to other cities/towns.

Van der Lucht and Verkleij (Lucht and Verkleij 2001) found mortality differences between neighborhoods in cities are greater than mortality differences between cities and non-urban areas. But mortality differences between neighborhoods do not only exist in cities, but can also been found between neighborhoods in non-urban areas. It has been estimated that all cause mortality in the “poorest” neighborhoods is 13 percent higher compared with all cause mortality in the “wealthiest” neighborhoods. However, mortality differences between neighborhoods are especially great among men and women younger than 65 years. At older ages, these mortality differences between neighborhoods are small, especially among women.(Lucht and Verkleij 2001)

The exact geographical classification of areas is thus possibly of less importance for studying mortality differences between areas, and besides, at older ages mortality differences between areas may be small, especially among women. Furthermore, the relevant spatial scale can differ for covariates.

Available and to be used ecologic covariates

In the previous sections it has been described which ecologic covariates may be relevant for the current study, and which spatial scale may be relevant. However, what is possible also depends on the information that is available. In this section an overview is given which GIS-data are available from the RIVM. Using the geographical coordinates of the 1986 home addresses of the study participants for each study participant a value for an ecologic covariate can be generated. In table 5 an overview is shown which potential ecologic covariates, and at which scale and for which year(s), are available at RIVM. All these covariates were evaluated as potential ecologic covariates.

Table 5: Available potential ecologic covariates.

GIS coverage	***Potential predictor variable***	***Scale***	***Year***
Wijk en buurt	Average income per inhabitant	District/quarter/borough Neighbourhood (‘wijk’)	1995
	Percentage persons with income < fl. 26,245		
	Percentage persons with income > fl. 42,106		
	Percentage persons who depend on benefits		

In a study by Reijneveld general practitioner deprivation score was used as an area-level confounder. The general practitioner deprivation score was computed as the sum of the standardized scores of a neighbourhood regarding degree of urbanization, proportion of ethnic minorities, average income and percentage persons who depend on benefits.(Reijneveld 2002) It has to be evaluated whether we will use the general practitioner deprivation score, also because the proportion of ethnic minorities is not available at the neighbourhood scale but only on the 4-digit postal code area scale.
Not all information was available to compute general deprivation score.

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