Childhood housing conditions and later mortality in the Boyd Orr cohort

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Abstract

***Study objectives*—To examine associations between five measures of housing conditions during childhood and subsequent mortality from all causes, coronary heart disease, stroke, and cancer.**

***Design*—Historical cohort study.**

***Setting*—Data on housing conditions were collected from survey centres in 16 areas of England and Scotland.**

***Participants*—Children of families participating in the Carnegie Survey of Family Diet and Health in pre-war Britain (1937–1939). Analyses are based on a subset of 4168 people who were traced and alive on 1 January 1948.**

***Main results*—Poorer housing conditions were generally associated with increased adult mortality. After adjustment for childhood and adult socioeconomic factors, statistically significant associations were only found between lack of private indoor tapped water supply and increased mortality from coronary heart disease (hazard ratio 1.73, (95% CI 1.13, 2.64); and between poor ventilation and overall mortality (hazard ratio for people from households with poorest ventilation relative to best ventilation 1.30, 95% CI 0.97, 1.74).**

***Conclusions*—This study provides evidence that associations between housing conditions in childhood and mortality from common diseases in adulthood are not strong, but are in some respects distinguishable from those of social deprivation.**

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In recent years there has been a growing appreciation that adult chronic diseases may be influenced by exposures acting before birth,[1] during childhood,[2–4] as well as in adult life. Taken together these data suggest that accumulation of adverse exposures over the whole lifecourse underlies susceptibility to a range of adult diseases.[5] Recent analyses have examined the relative influence of exposures at different periods in the lifecourse (including childhood housing conditions[6]), on adult health outcomes.[7] Investigations of the effects of early life factors often rely on indirect anthropometric measures of adversity, such as birth weight[1] or childhood height,[4] rather than direct measures of the exposures themselves, such as diet or childhood infections.

The household environment is an important determinant of risk for the acquisition of a number of infections, and for exposure to pollutants such as combustion products, allergens such as dust mite faeces, and fungal spores.[8] Such exposures, when encountered during childhood, may have long term consequences for adult health, yet these can be difficult to study because of the long time period between exposure and manifestation of disease. One study of the mortality experience of subjects whose housing conditions had been recorded in 1936 found that adult mortality patterns were adversely influenced by both household overcrowding (persons per bedroom) and lack of fixed hot water supply. These effects were only seen among subjects who were children (aged up to 12 years) at the time of the housing survey.[9] Crowding in childhood has been linked to *Helicobacter pylori* seropositivity in adult life,[10–12] and an ecological association has been demonstrated between childhood crowding and rates of stomach cancer in adulthood.[13] Overcrowding in the childhood home has also been associated with reduced adult height—itself a predictor of mortality from coronary heart disease and other chronic illnesses.[14]

We examined overall and cause specific mortality in a cohort of people whose household circumstances during childhood were recorded as part of a wider survey of family diet and health carried out in 1937–39.[15] Housing conditions are related to socioeconomic position, which itself is associated with adult mortality patterns,[2 16] and indeed poor housing may be one way in which socioeconomic influences on health operate. It is therefore important to assess the effect of controlling for such influences in any analysis of the long term impact of housing conditions on health. Continuity of socieconomic circumstances from childhood into adulthood means that children of poor families (living in poor quality housing) are more likely to be poor as adults, and be less healthy. We used an ecological measure of socioeconomic deprivation in adulthood to control for this.

Methods

THE BOYD ORR COHORT

The methods used to establish the Boyd Orr cohort have been described previously.[17] Briefly, the cohort consists of the children of 1343 households who participated in the Carnegie survey of family diet and health carried out in 16 centres in England and Scotland between 1937 and 1939. Of 4973 children whose families participated in the original survey it has so far been possible to trace 4301 (86%) people through the NHS Central Register.

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Table 1 Characteristics of 1343 childhood households according to social class of head of household (1931 classification)

Household characteristic	Social class						Missing observations number (%)	p Value for trend*
	I/II	III	IV	V	Unemployed	Unknown		
Number of households	124	268	299	194	343	115	—	
Mean number of residents (SD)	4.13 (2.43)	5.08 (2.41)	5.56 (2.04)	6.18 (2.56)	6.36 (2.41)	4.81 (2.62)	0 (0.0)	<0.001
Mean crowding index (SD)	1.18 (0.77)	1.65 (0.92)	1.84 (0.84)	2.18 (1.05)	2.56 (1.33)	1.86 (0.84)	174 (13.0)	<0.001
Proportion with in house running water	81.4	81.4	64.8	76.0	79.6	76.6	354 (26.4)	0.001
Proportion with in house flush toilet (not shared)	59.2	55.4	25.6	37.8	35.8	36.7	382 (28.4)	<0.001
Proportion with very good ventilation	89.4	81.7	76.3	72.5	56.9	77.6	117 (8.7)	<0.001
Proportion of households with "poor" cleanliness	44.8	54.3	62.6	64.3	66.7	69.3	104 (7.7)	<0.001

*Test for linear trend using linear regression for comparison of means, and χ^2 test for comparison of proportions. The category of unknown social class was omitted for trend tests.

HOUSING CONDITIONS

Housing conditions were documented by members of the dietary survey team during visits to each household. Some of the information collected—the number of rooms, domestic water and toilet facilities—was relatively objective, while that on the the adequacy of through ventilation and the general state of cleanliness of the home required a more subjective judgement by a member of the survey staff. These details were recorded in free text in the diaries completed for each household, and for the purpose of this analysis, were reclassified into a smaller number of categories considered a priori to reflect differing degrees of exposure to risk of infection or to poor living conditions in general. Information was also collected on type of house (for example, detached house, council house, flat) and neighbourhood (for example, fair, poor, mining area, rural), but in most cases this information was too ambiguous for meaningful classification, therefore these items were excluded from the analysis. The housing variables analysed were:

(1) *crowding (four categories)*: a four level crowding index was defined, based on the number of persons normally resident divided by the number of rooms in regular use: <1.5; 1.5–<2.5; 2.5–<3.5; 3.5 or more persons/room.
(2) *water supply (two categories)*: (a) private tapped domestic water supply; (b) other arrangements (for example, communal or shared tap/well/pump/rainwater cistern).
(3) *toilet facilities (three categories)*: (a) flush toilet inside and not shared; (b) flush toilet outside and/or shared; (c) no flush toilet.
(4) *adequacy of ventilation (three categories)*: (a) good/very good/excellent; (b) fair/moderate; (c) poor/very poor
(5) *"cleanliness" of the household (three categories)*: (a) very good/excellent; (b) fair/moderate/good; (c) poor/very poor.

SOCIOECONOMIC CIRCUMSTANCES

Childhood social class was determined on the basis of the occupation of the male head of household at the time of the original survey, classified according to the Registrar General's Decennial Supplement for 1931. Information was also collected on household per capita food expenditure: six groups were originally defined, but for this analysis the top and bottom two groups were combined to give four groups of comparable size, defined by cut points of 5, 7, and 9 shillings per person per week. Similarly, for household per capita income, six groups were originally defined but in this case the three highest income groups were combined to give four groups defined by cut points of 10, 15, and 20 shillings per person per week. The Townsend deprivation score for the FHSA of current residence, or residence at the time of death (based on the 1991 census) was used as a marker of socioeconomic status in adulthood.

CAUSE OF DEATH

Underlying cause of death was classified according to International Classification of Diseases, ninth revision (ICD9) and mortality from the following causes were examined: all causes; coronary heart disease (CHD: ICD 410–414); stroke (ICD 430–438); cancer (ICD 140–209); cancers not thought to be related to smoking (ICD 142, 151–156, 158–159, 164–

Table 2 Cause specific mortality hazard ratios according to level of crowding in the childhood home

Cause of death (number of deaths)			Crowding index range (number of individuals in category)				p Value for trend
			<1.5 (623)	1.5–<2.5: reference (1447)	2.5–<3.5 (810)	⩾3.5 (511)	
All cause	(761)	unadjusted*	0.65 (0.51, 0.84)	1.0	1.02 (0.84, 1.24)	0.99 (0.79, 1.24)	0.02
		adjusted†	0.76 (0.57, 1.01)	1.0	0.99 (0.81, 1.20)	0.92 (0.73, 1.16)	0.56
CHD	(222)	unadjusted*	0.72 (0.48, 1.09)	1.0	1.12 (0.77, 1.64)	1.11 (0.69, 1.78)	0.11
		adjusted†	0.74 (0.47, 1.14)	1.0	1.13 (0.77, 1.66)	1.17 (0.71, 1.91)	0.15
Stroke	(107)	unadjusted*	0.40 (0.16, 1.01)	1.0	0.59 (0.29, 1.18)	0.99 (0.44, 2.25)	0.53
		adjusted†	0.38 (0.14, 1.04)	1.0	0.63 (0.31, 1.28)	1.07 (0.47, 2.43)	0.50
Cancer	(237)	unadjusted*	0.79 (0.53, 1.20)	1.0	1.08 (0.77, 1.51)	0.87 (0.56, 1.34)	0.67
		adjusted†	1.08 (0.70, 1.68)	1.0	0.99 (0.71, 1.38)	0.73 (0.46, 1.16)	0.21
Cancers not related to smoking	(110)	unadjusted*	0.75 (0.43, 1.29)	1.0	0.89 (0.54, 1.46)	0.73 (0.38, 1.39)	0.84
		adjusted†	1.13 (0.62, 2.08)	1.0	0.80 (0.48, 1.31)	0.60 (0.30, 1.20)	0.10
Lung cancer	(72)	unadjusted*	0.53 (0.23, 1.21)	1.0	1.21 (0.69, 2.10)	1.06 (0.55, 2.02)	0.20
		adjusted†	0.59 (0.25, 1.40)	1.0	1.05 (0.60, 1.86)	0.93 (0.47, 1.81)	0.61

*All models were stratified by sex and district, and robust standard errors calculated to account for clustering within families. †Adjusted for year of birth, income, food expenditure, childhood social class, and adult Townsend score.

Table 3 Cause specific mortality hazard ratios according to availability of tapped water supply in the childhood home

Cause of death (number of deaths)			Indoor private tapped water supply? (number of individuals in category)		
			Yes: reference (2217)	No (627)	p Value for difference between groups
All cause	(621)	unadjusted*	1.0	1.29 (1.01, 1.64)	0.04
		adjusted†	1.0	1.25 (0.98, 1.61)	0.07
CHD	(184)	unadjusted*	1.0	1.57 (1.03, 2.41)	0.03
		adjusted†	1.0	1.73 (1.13, 2.64)	0.01
Stroke	(50)	unadjusted*	1.0	0.73 (0.31, 1.75)	0.53
		adjusted†	1.0	0.83 (0.36, 1.89)	0.71
Cancer	(197)	unadjusted*	1.0	1.00 (0.64, 1.56)	1.00
		adjusted†	1.0	0.93 (0.60, 1.44)	0.73
Cancers not related to smoking	(89)	unadjusted*	1.0	1.31 (0.68, 2.54)	0.40
		adjusted†	1.0	1.20 (0.63, 2.27)	0.58
Lung cancer	(62)	unadjusted*	1.0	1.02 (0.54, 1.93)	0.96
		adjusted†	1.0	0.96 (0.50, 1.84)	0.91

*All models were stratified by sex and district, and robust standard errors calculated to account for clustering within families. †Adjusted for year of birth, income, food expenditure, childhood social class, and adult Townsend score.

187, 189–195, 200–208); lung cancer (ICD 162). No information was available on the smoking habits of the cohort members during adulthood, therefore associations with lung cancer were examined to see whether smoking during adulthood might explain any observed associations between housing conditions and other causes of death.

STATISTICAL ANALYSIS

Associations between household social class and housing variables were examined by tests of trend.

Mortality analysis was based on deaths occurring between 1 January 1948 and 31 July 1998. Associations between childhood household conditions and later mortality were examined using Cox's proportional hazards models. Unadjusted models and models adjusting for the possible confounding effects of childhood and adult socioeconomic circumstances were examined in the same individuals. Age was the main timescale, with year of birth entered in the models to control for possible birth cohort effects. All models were stratified by sex and survey district. Interaction terms were entered in the fully adjusted models to assess whether the effect of housing variables was modified by gender, or by age at time of survey (<8 years, 8 years and over). Reference groups for categorical variables were chosen to contain the largest number of individuals. Robust standard errors were estimated to account for clustering of individuals within families. Analyses were performed using Stata.[18]

Results

BASELINE DATA

Table 1 shows the characteristics of 1343 households according to social class of the head of household. Higher social class was associated with less crowding and smaller household size, increased availability of indoor flush toilet and private indoor water supply, and better ventilation and cleanliness. Children from higher social class households were on average slightly older than children from lower social class households (mean age 9.1 years for social class I, compared with 7.6 years for social class V, p <0.001 for trend).

TRACING

Traced study members were broadly similar to untraced individuals in terms of social class (proportions in classes I–III versus classes IV–V, p=0.75), crowding index (p=0.57), toilet facilities (p=0.47) and ventilation (p=0.31). Statistically significant differences between traced and untraced members were noted for water supply (78% of traced and 71% of untraced members had private indoor tapped water, p=0.001), and cleanliness (29% of traced and 31% of untraced members were from households with poor cleanliness, p=0.024).

MORTALITY

On 1 January 1948, the start of the period for which mortality was assessed, there were 4168 traced individuals eligible for inclusion of whom 929 died and 192 emigrated by the end

Table 4 Cause specific mortality hazard ratios according to type of toilet facility in the childhood home

Cause of death (number of deaths)			Type of toilet facility (number of individuals in category)			
			Flush inside not shared (1084)	Flush outside/shared: reference (1356)	No flush (355)	p Value for difference between groups
All cause	(621)	unadjusted*	0.83 (0.69, 1.00)	1.0	0.87 (0.54, 1.38)	0.13
		adjusted†	0.88 (0.73, 1.06)	1.0	0.88 (0.54, 1.43)	0.41
CHD	(179)	unadjusted*	0.72 (0.51, 1.04)	1.0	0.66 (0.34, 1.26)	0.13
		adjusted†	0.72 (0.50, 1.02)	1.0	0.69 (0.36, 1.35)	0.14
Stroke	(47)	unadjusted*	1.34 (0.73, 2.47)	1.0	1.02 (0.27, 3.85)	0.67
		adjusted†	1.34 (0.75, 2.40)	1.0	1.03 (0.25, 4.33)	0.42
Cancer	(203)	unadjusted*	0.85 (0.62, 1.16)	1.0	0.92 (0.46, 1.82)	0.60
		adjusted†	0.96 (0.70, 1.31)	1.0	0.91 (0.44, 1.89)	0.94
Cancers not related to smoking	(93)	unadjusted*	0.99 (0.64, 1.54)	1.0	1.06 (0.44, 2.53)	0.99
		adjusted†	1.13 (0.71, 1.79)	1.0	1.05 (0.44, 2.50)	0.89
Lung cancer	(61)	unadjusted*	0.70 (0.40, 1.20)	1.0	1.04 (0.35, 3.15)	0.45
		adjusted†	0.76 (0.43, 1.33)	1.0	1.26 (0.42, 3.78)	0.23

*All models were stratified by sex and district, and robust standard errors calculated to account for clustering within families. †Adjusted for year of birth, income, food expenditure, childhood social class, and adult Townsend score.

Table 5 Cause specific mortality hazard ratios according to adequacy of ventilation in the childhood home

Cause of death (number of deaths)			Adequacy of ventilation (number of individuals in category)			p Value for trend
			Very good: reference (2386)	Fair (869)	Poor (272)	
All cause	(774)	unadjusted*	1.0	1.19 (1.00, 1.42)	1.38 (1.02, 1.87)	<0.01
		adjusted†	1.0	1.13 (0.94, 1.35)	1.30 (0.97, 1.74)	0.03
CHD	(228)	unadjusted*	1.0	1.10 (0.79, 1.55)	1.44 (0.86, 2.39)	0.14
		adjusted†	1.0	1.06 (0.75, 1.51)	1.38 (0.84, 2.28)	0.24
Stroke	(64)	unadjusted*	1.0	1.72 (0.99, 2.99)	1.71 (0.66, 4.40)	0.08
		adjusted†	1.0	1.72 (0.99, 2.98)	1.85 (0.70, 4.86)	0.07
Cancer	(245)	unadjusted*	1.0	1.06 (0.78, 1.44)	1.42 (0.89, 2.29)	0.17
		adjusted†	1.0	0.97 (0.71, 1.32)	1.29 (0.81, 2.06)	0.46
Cancers not related to smoking	(115)	unadjusted*	1.0	1.35 (0.91, 1.20)	1.29 (0.64, 2.59)	0.21
		adjusted†	1.0	1.21 (0.81, 1.81)	1.17 (0.60, 2.30)	0.44
Lung cancer	(72)	unadjusted*	1.0	0.94 (0.53, 1.67)	2.36 (1.26, 4.40)	0.07
		adjusted†	1.0	0.83 (0.45, 1.54)	2.05 (1.08, 3.88)	0.18

*All models were stratified by sex and district, and robust standard errors calculated to account for clustering within families.
†Adjusted for year of birth, income, food expenditure, childhood social class, and adult Townsend score.

of follow up on 30 July 1998. There were 271 (29%) deaths from coronary heart disease (CHD), and 79 from stroke (8%), 289 (31%) from cancer of which 84 were lung cancer and 158 were from cancers unrelated to smoking.

After excluding participants for whom information on possible confounders was missing, data on 3817 (92%) individuals and 852 deaths (91%) were available for mortality analysis. Tables 2 to 6 show the hazard ratios for mortality from different causes, according to housing conditions in childhood. Because of differences in completeness of housing variables, these tables are based on differing numbers of subjects. Test of statistical interaction provided no evidence to suggest that the effect of housing conditions was significantly different for males and females, or for children aged less than or more than 8 years at the time of the survey, therefore results are presented for both sexes and all ages combined.

CROWDING

With the exception of cancer, mortality was lowest among children living in the least crowded conditions (table 2). After adjustment for childhood and adult socioeconomic factors there was a suggestion of a trend of increasing CHD mortality with increased crowding but this was not statisticallly significant (p=0.15). For cancer, and more specifically cancers unrelated to smoking, mortality risk appeared to decrease with increasing crowding, but again this was not statistically significant (p=0.10). No association was seen with lung cancer.

WATER SOURCE

Table 3 shows that CHD mortality was higher in individuals whose childhood home did not have a private indoor tapped water supply (adjusted hazard ratio 1.73, 95% CI 1.13 to 2.64). Lack of indoor tapped water was also associated with increased all cause mortality, but this association was no longer statistically significant at conventional levels in the fully adjusted model. There was no association with lung cancer mortality.

TOILET FACILITIES

The type of toilet facilities in the childhood home did not seem to influence adult mortality (table 4). In general the highest mortality was seen in the group with access to outdoor and/or shared flush toilets (the reference group).

VENTILATION

In general, mortality risk was highest among participants whose childhood home was poorly ventilated (table 5). An association between overall mortality and poorer ventilation was attenuated slightly after adjustment for confounding factors but remained statistically significant (p=0.03). A stronger trend in the same direction was also seen for stroke mortality, but this was not statistically significant, perhaps because of the smaller numbers of events (p=0.07). Poor ventilation was associated with an increased risk of lung cancer mortality in the unadjusted model (p=0.07), and adjustment for socioeconomic circumstances reduced the

Table 6 Cause specific mortality hazard ratios according to level of cleanliness in the childhood home

Cause of death (number of deaths)			Level of cleanliness (number of individuals in category)			p Value for trend
			Very good (326)	Fair: reference (2198)	Poor (1036)	
All cause	(795)	unadjusted*	1.20 (0.91, 1.58)	1.0	0.97 (0.82, 1.16)	0.21
		adjusted†	1.15 (0.88, 1.50)	1.0	1.05 (0.88, 1.25)	0.82
CHD	(233)	unadjusted*	1.31 (0.80, 2.14)	1.0	1.32 (0.97, 1.81)	0.37
		adjusted†	1.32 (0.81, 2.14)	1.0	1.42 (1.03, 1.97)	0.21
Stroke	(68)	unadjusted*	1.05 (0.49, 2.23)	1.0	0.52 (0.28, 0.95)	0.07
		adjusted†	1.18 (0.53, 2.62)	1.0	0.56 (0.30, 1.05)	0.08
Cancer	(247)	unadjusted*	0.97 (0.60, 1.57)	1.0	0.91 (0.68, 1.22)	0.66
		adjusted†	0.91 (0.56, 1.46)	1.0	1.02 (0.75, 1.38)	0.71
Cancers not related to smoking	(116)	unadjusted*	1.15 (0.62, 2.12)	1.0	0.95 (0.63, 1.43)	0.62
		adjusted†	1.08 (0.59, 1.97)	1.0	1.07 (0.70, 1.64)	0.90
Lung cancer	(71)	unadjusted*	1.22 (0.62, 2.41)	1.0	0.91 (0.54, 1.55)	0.53
		adjusted†	1.13 (0.55, 2.31)	1.0	1.01 (0.58, 1.74)	0.85

*All models were stratified by sex and district, and robust standard errors calculated to account for clustering within families.
†Adjusted for year of birth, income, food expenditure, childhood social class, and adult Townsend score.

significance (p=0.18), but did not substantially reduce the strength of the association.

CLEANLINESS

There was evidence of a trend towards decreased stroke mortality associated with poorer cleanliness ratings for the household (table 6) but again this was not statistically significant (p=0.08). Cleanliness was unrelated to other causes of death, including lung cancer.

Discussion

We have examined associations between five measures of individuals' housing conditions in childhood, and mortality risk in adulthood, while controlling for the potentially confounding effect of socioeconomic circumstances, both in childhood and in adulthood. With the available data it was not possible to examine the cumulative influence of housing conditions across the lifecourse on adult health, but more detailed information is being collected from a subset of surviving members of this cohort, and it will be interesting in the future to examine the relative contributions of childhood and adult factors to mortality and morbidity risk in later life. Several earlier studies of childhood housing conditions have examined possible associations with stomach cancer[9 13] or *H pylori* infection.[10–12] In our study there were only 16 deaths from stomach cancer—too few to obtain reliable estimates of relative mortality.

Our analysis shows that subjects living in better quality housing generally experienced lower overall mortality rates. For all cause mortality these effects only reached conventional levels of statistical significance in relation to the adequacy of ventilation. We also found an increased risk of CHD mortality associated with a lack of an indoor tapped water supply. Also unlike previous analyses of this issue,[9] we found that the age of the subjects at the time when housing data was collected had no effect on the strength of associations between housing conditions and mortality. Our main findings are discussed in more detail below.

STRENGTHS AND WEAKNESSES OF THE STUDY

One strength of this analysis is that we used details of childhood housing conditions recorded in childhood, rather than relying on the recall of past living conditions. Numerous studies have demonstrated associations between socioeconomic deprivation in childhood and later morbidity and mortality.[2 16 19 20] In contrast with several other studies of the effects of childhood housing conditions on health,[9–13] we had detailed information on indicators of socioecomic circumstances collected comtemporaneously with the housing data, and an indicator of material deprivation during adulthood, and were able to examine whether controlling for such factors altered the strength of the associations.

There are several limitations to this study. Firstly, we have examined a number of disease and exposure specific associations (multiple testing), thereby increasing the chance of a Type I error. We have made no adjustment for this in our analyses. Secondly, the housing data were collected for the purpose of describing the prevailing socioeconomic circumstances experienced by poorer sections of society in late 1930s Britain—no specific hypotheses about housing conditions were advanced at the time of the study, and no explicit coding frame was available for the housing variables, making coding of these data more difficult. Thirdly, the original survey sample was selected to include specifically poorer sections of the British population, but no formal sampling frame was used. While this makes it difficult to assess the representativeness of the sample, it is unlikely to produce biased estimates of association between housing conditions and later mortality. Fourthly, as data were collected at a single point in childhood, they imperfectly reflect the overall childhood exerience of housing conditions. However, such misclassification of the housing variables is likely to be non-differential and biases will therefore tend to be conservative. Lastly, our indicator of socioeconomic deprivation in adulthood (that is, Townsend score) is an area-based measure, resulting in misclassification of some individuals and, in this case, incomplete adjustment for a potentially important confounder.[21] Although individual level data would clearly be preferable, Townsend score of area of adult residence has previously been shown to be associated with all cause and CHD mortality in this cohort,[16] therefore its inclusion offered potential for at least partial control for adult socioeconomic circumstances.

KEY POINTS

- Children encounter a wide range of exposures in the household environment. These may have long term effects on health.
- Unlike previous studies, we controlled for socioeconomic conditions during childhood and adulthood, which may otherwise confound associations between housing and health.
- Our results suggest that childhood housing conditions in the 1930s are not a major determinant of mortality risk during adulthood.
- The effects of childhood housing conditions on health are distinguishable from the more general effects of socioeconomic deprivation.

WATER SUPPLY AND CHD MORTALITY

The observed increase in CHD mortality associated with lack of private tapped water supply is interesting. While chance cannot be ruled out, it is unlikely that it is attributable to confounding by socioeconomic position as inclusion of indicators of socioeconomic conditions in the models increased the hazard ratio. The absence of an association with lung cancer also reduces the likelihood that smoking confounds the observed association. One possible explanation for the observed association is that lack of indoor tapped water supply is a marker for increased risk of certain

infections that may increase CHD risk in later life. An association between chronic *C pneumoniae* infection and CHD has been demonstrated in cross sectional epidemiological studies,[22 23] and by detection of the pathogen in atheromatous tissues,[24 25] however we are not aware of any published data linking *C pneumoniae* infection with water supply or sanitary conditions. *H pylori* infection has been associated with childhood living conditions including domestic crowding, and absence of fixed hot water supply.[9 10 12] However, current evidence for an aetiological role for *H pylori* infection in CHD is less consistent,[25–28] and two recent studies suggest that any causal association is likely to be weak.[29] As water supply is itself a relatively weak proxy for acquisition of *H pylori* infection, it is unlikely that this can alone explain the observed association between water supply and CHD mortality.

VENTILATION AND ALL CAUSE MORTALITY

All cause mortality risk was increased in individuals from households with poorer ventilation. Ventilation may act here simply as a marker of more general socioeconomic deprivation, and the attenuation of the relative risk estimates seen after adjustment for socioeconomic factors suggests a degree of residual confounding may persist. On the other hand, poor ventilation is likely to increase the exposure to indoor air pollutants, leading to bronchial obstruction,[30] and other respiratory diseases in children,[31] and possibly to impaired lung function as adults with increased mortality from a variety of causes.[32]

The increased lung cancer mortality among individuals from households with poor ventilation may reflect increased exposure to tobacco smoke, fumes from cookers and fires or other types of pollutant.

Stroke mortality was also increased, though not significantly, in children from poorly ventilated housing, and this was consistent with other studies that have found that stroke mortality increases with poorer childhood living conditions.[2 16] In contrast the association between stroke and cleanliness, such that lower levels of cleanliness in the childhood home were associated with decreased stroke mortality, is in the opposite direction from what might be expected given the association between stroke mortality and childhood deprivation. We note that this trend was not significant at conventional levels, and conclude that it may be a chance finding.

CONCLUSION

This work suggests that childhood housing conditions can have measurable effects on mortality in adulthood, which are distinguishable from the more general effects of socioeconomic deprivation, although in keeping with a previous analysis of this issue, the effects are relatively weak.[4] Given the nature of the data, it is difficult to speculate on underlying mechanisms, but these associations should be borne in mind in studies that use housing conditions as markers for socioeconomic deprivation.

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