ORIGINAL ARTICLES

Socio-economic factors and mortality among 25-64 year olds followed from 1991 to 1994: the New Zealand Census-Mortality Study

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Abstract

Aim. To measure the association of income, education, occupational class, small area socio-economic deprivation, car access and labour force status with mortality among 25-64 year old males and females using the 1991 census-cohort of the New Zealand Census-Mortality Study.

Methods. Mortality records for 1991-94 were anonymously and probabilistically linked to 1991 census records, thereby creating a cohort study of all New Zealand census respondents. Odds ratios of mortality comparing categories of each socio-economic factor were calculated using logistic regression. For income, education and deprivation (NZDep91) a modified relative index of inequality ($RII_{10:90}$) was calculated. The $RII_{10:90}$ estimates the relative risk of mortality for low socio-economic people (10th percentile rank) compared to high socio-economic people (90th percentile rank) allowing direct comparisons across socio-economic factors.

Results. The relative risk of all-cause mortality for 25-64 year old males with an equivalised household income less than $20 000, compared to greater than $50 000, was 2.16 (95% confidence interval 1.99 to 2.34). For females, this relative risk was 1.68 (1.52 to 1.86). Using the $RII_{10:90}$ all-cause mortality was 2.22, 1.94 and 1.58 times greater among low compared to high socio-economic males for income, NZDep91 and education, respectively. For females, these $RII_{10:90}$ estimates were 1.77, 1.69 and 1.57, respectively. By cause of death, the strongest gradients were observed for respiratory diseases, followed by lung cancer, cardiovascular disease and unintentional injury. For suicide deaths, unemployed males and females had 2.70 (1.84 to 3.95) and 2.86 (1.19 to 6.85) greater rates than the employed.

Conclusions. There are strong socio-economic gradients for all-cause mortality and most specific causes of mortality among both males and female adults in New Zealand, regardless of the choice of socio-economic factor. The gradients were strongest for income, followed by small area deprivation and education, and strongest for 'preventable' causes of death.

NZ Med J 2002; 115: 93-7

Two major bodies of research are available in New Zealand on the association of socio-economic factors with mortality. First, Pearce and colleagues documented the association of occupational class with 15-64 year old male mortality for 1974-78 and 1985-87 (1995-97 forthcoming).[1,2] This body of work found, among other things, an approximately two-fold difference in mortality for the lower occupational classes compared to the higher occupational classes and steeper gradients for deaths amenable to medical intervention. Second, the development of a small area measure of deprivation by Salmond, Crampton and Sutton (NZDep91 and NZDep96)[3] has allowed the measurement of socio-economic mortality gradients by age, sex and ethnic groups.[4,5]

The New Zealand Census-Mortality Study aims to measure socio-economic mortality gradients by linking census (1981, 1986, 1991 and 1996) and mortality records, thereby creating cohort studies of the entire New Zealand census population. The aim of this paper is to present the associations of all-cause and cause-specific mortality during 1991-94 with education, income, car access, small area deprivation, occupational class and labour force status, for premature mortality among males and females aged 25 to 64 years on census night 1991.

Methods

Socio-economic factors from census data. Highest qualification was specified as a four-level variable: tertiary qualification, trade and other qualifications, school qualification only, and no formal qualifications. Household income was equivalised for the number of adults and children in a household using the Jensen Index (Jensen J, Department of Social Welfare. Unpublished), thereby allowing for economies of scale and varying consumption requirements between adults and children. Car access (a marker of asset wealth and access to community resources)[6] was simply the number (nil, one, and two or more) of cars in each household. Labour force status was categorised as the employed, the unemployed (but seeking and available for work), and the non-labour force (eg students, permanently ill, retired). Small area deprivation was assigned on the basis of usual residence using NZDep91 (a New Zealand measure of socio-economic deprivation)[3] and was categorised in quintiles from the least to most deprived of small areas. Occupational class was assigned into six categories based on the New Zealand Socio-Economic Index,[7,8] with a modified cut-point between classes 1 and 2.[9]

Mortality outcome. In addition to all causes combined, deaths were categorised as: cancer (with sub-classifications for colorectal, lung, prostate and breast), cardiovascular (with ischaemic heart disease and cerebrovascular disease), infection and pneumonia, respiratory (with chronic obstructive pulmonary disease), unintentional injury (with whether the death was due to a road traffic crash), suicide, homicide, and remaining causes of death.[9]

Mortality records were anonymously and probabilistically linked to 1991 census records.[10,11] Briefly, of 19 128 eligible decedents who were aged 25-64 years on 1991-census night and died in the six month to three year period following census night, 14 322 (74.9%) were successfully linked to a census record. This linkage success varied by age and ethnicity. However, within age by ethnicity strata there was relatively little difference by occupational class and small area deprivation in linkage success.[11]

Analyses. The 1991-census cohort was restricted to 25-64 year olds with complete data for highest qualification, household income, car access and labour force status. Additionally, deaths in the first six months after census night were excluded due to possible bias from health selection effects. The association of each socio-economic factor with all-cause and cause-specific mortality was determined by logistic regression, with age and ethnicity controlled as covariates. Detailed tabular results of the logistic regression

analyses (similar to that presented in Table 1 for income but with 95% confidence intervals) are available elsewhere,[9] from the NZCMS website,[12] or from the authors.

$RII_{10:90}$. To summarise the association of income, education and NZDep91 with all-cause and cause-specific mortality, we used a variant of the relative index of inequality (RII).[13] Briefly, the RII is a form of relative risk comparing the mortality risk for the most socio-economically *disadvantaged* person compared to the most socio-economically *advantaged*. The RII assumes a linear association of mortality risk with *rank* of the socio-economic factor. A linear regression line was fitted to the odds ratios by midpoint on the cumulative proportion distribution for each ranked socio-economic factor. For example, the intercept of a regression equation for income is the estimated mortality risk at the zero percentile of income (in this case the 'hypothetical' poorest person), the slope is the difference in mortality between the zero and 100th percentile (richest person), and the RII is equal to [intercept] / [intercept + slope]. (As the mortality risk usually decreases with increasing income, the slope is usually negative, and thus the RII is greater than 1.0). The RII becomes unstable if the mortality risk among the most socio-economically advantaged is much less than among the disadvantaged, and is inappropriate if the relationship is non-linear (particularly at the extremes). For these reasons, and also for greater policy relevance, in this paper we present the RII for the 10th compared to 90th percentile based on the same regression line (the $RII_{10:90}$), but both the RII and $RII_{10:90}$ are presented in the Archive Tables on the NZCMS web-site.[12]

Occupational class. Analyses by occupational class were problematic, and are reported on in detail elsewhere.[9,12] For the purposes of this paper, we present only summary results for all males aged 25-64 years with a current occupation on the 1991 census, discarding deaths in the first year of follow-up.

Results

Household income. There was a strong monotonic association of household income with all-cause mortality among both males and females, and for both 25-44 and 45-64 year olds (Figure 1). Comparing the lowest (<$10 000) and highest (>$70 000) household income categories, the relative risks were 2.25 and 2.05 for 25-44 and 45-64 year old males, respectively, and 1.59 and 1.58 for 25-44 and 45-64 year old females, respectively.

Table 1 shows the odds ratios of all-cause and cause-specific mortality for 25-64 year olds by aggregated income categories. The odds ratios of all-cause mortality for 25-64 year old males with an equivalised household income less than $20 000, compared to greater than $50 000, was 2.16 (95% confidence interval 1.99 to 2.34). For females, this odds ratio was 1.68 (1.52 to 1.86). The majority of causes of death were strongly associated with income, with higher mortality among those with lower income. The exceptions to this generalisation were colorectal cancer, infection and pneumonia, homicide, female suicide and female non-road traffic crash injury deaths. However, the lack of association for these latter four causes of death may be due to the small number of deaths. Particularly strong gradients were apparent for respiratory causes of death (including lung cancer), with approximately five-fold greater respiratory mortality among the lowest income groups compared to the highest income group and two and a half times the mortality risk for lung cancer.

Highest qualification and small area deprivation. For those living in the most socio-economically deprived quintile of small areas compared to the least deprived the odds ratios were 2.05 (95% confidence interval 1.88 to 2.23) and 1.73 (1.56 to 1.92) for males and females, respectively. Similarly, the all-cause mortality odds ratios for those with nil

Table 1. Numbers of deaths during 1991-94, odds ratios of death by category of household income, and $RII_{10:90}$ estimates (for household income, highest qualification (education) and small area socio-economic deprivation (NZDep91)) among 1.5 million 25-64 year olds.*

	Deaths	OR by cat of income ($000s)				$RII_{10:90}$ by:		
		≥$50	$30-$49	$20-$29	<$20	Income	Education	NZDep91
Males								
Cancer	2019	1.00	1.33	1.46	1.65	1.69	1.37	1.45
Colorectal	378	1.00	1.22	1.18	1.18	1.19	0.98	1.10
Lung†	456	1.00	1.53	1.80	2.60	2.64	2.46	2.78
Prostate†	108	1.00	1.56	1.47	2.32	2.19	2.12	1.09
Cardiovascular disease	2319	1.00	1.45	1.80	2.31	2.40	1.65	2.13
IHD	1728	1.00	1.45	1.81	2.26	2.36	1.71	2.10
Cerebrovascular	240	1.00	1.77	1.93	2.76	2.77	1.88	2.60
Infection and pneumonia	111	1.00	1.10	0.89	1.11	1.01	0.78	2.66
Respiratory†	198	1.00	1.50	2.58	4.38	4.60	2.05	4.32
COPD†	153	1.00	2.08	3.94	5.59	7.45	2.23	4.96
Unintentional injury	357	1.00	1.65	2.10	2.30	2.52	1.95	1.72
Road traffic crash	183	1.00	1.61	1.89	1.99	2.15	1.64	1.77
Other unintentional	180	1.00	1.69	2.35	2.67	3.00	2.37	1.70
Suicide	282	1.00	1.29	1.50	2.25	2.22	1.74	1.85
Homicide, intentional injury	27	1.00	1.08	0.84	3.21	(na)	(na)	(na)
Other	438	1.00	1.69	2.76	4.06	4.62	1.89	3.28
All causes	**5766**	**1.00**	**1.40**	**1.70**	**2.16**	**2.22**	**1.58**	**1.94**
Females								
Cancer	1947	1.00	1.06	1.16	1.17	1.20	1.24	1.29
Colorectal	303	1.00	0.66	0.80	0.82	0.87	0.86	0.87
Lung†	255	1.00	1.60	1.92	2.47	2.59	4.61	3.53
Breast	477	1.00	0.93	1.22	0.93	1.00	1.34	0.97
Cardiovascular disease	915	1.00	1.45	2.14	2.65	2.92	2.27	2.43
IHD	498	1.00	1.60	2.56	3.66	4.15	3.36	2.59
Cerebrovascular	228	1.00	1.20	1.35	1.40	1.44	1.46	2.13
Infection and pneumonia	54	1.00	1.79	1.57	1.41	1.48	0.84	1.10
Respiratory†	180	1.00	1.51	3.00	4.89	5.88	2.92	3.24
COPD†	135	1.00	1.71	3.14	5.61	6.86	3.60	2.88
Unintentional injury	129	1.00	1.45	1.74	2.60	2.71	1.46	1.69
Road traffic crash	84	1.00	0.87	1.49	1.85	2.22	1.84	2.05
Other unintentional	42	1.00	5.76	3.53	8.22	5.40	0.94	1.21
Suicide	90	1.00	1.26	0.98	2.00	1.83	0.91	1.95
Homicide, intentional injury	15	1.00	2.52	2.61	8.43	(na)	(na)`	(na)
Other	369	1.00	1.31	2.17	2.31	2.66	3.11	2.13
All causes	**3702**	**1.00**	**1.18**	**1.46**	**1.68**	**1.77**	**1.57**	**1.69**

*The odds ratios are from a logistic regression model with age in ten-year age groups and ethnicity dichotomised as Maori and Pacific Island, and non-Maori non-Pacific. Numbers of deaths are random rounded to the nearest multiple of three as per SNZ protocol, but odds ratios are calculated with exact data. Odds ratios and 95% confidence intervals for household income (although with the <$20 000 group as the reference group as it contained the most deaths), highest qualification and small area deprivation may be found in Archive Table 1, Archive Table 2 and Archive Table 3 on the NZCMS web-site (http://www.wnmeds.ac.nz/nzcms-info.htm) or directly from the authors. † Only age-group 45-64 included in analysis.

qualifications compared to those with tertiary qualifications were 1.64 (1.52 to 1.77) and 1.49 (1.37 to 1.62) for males and females, respectively (Detailed results available elsewhere).[9,12]

Income, education and deprivation compared by $RII_{10:90}$. The $RII_{10:90}$ estimates of the all-cause and cause-specific mortality gradients by household income, highest qualification and small area socio-economic deprivation (NZDep91) are shown in Table 1, and plotted in Figure 2. For all-cause mortality by income, the $RII_{10:90}$ were 2.22 and 1.77 for males and females, respectively. That is, using the odds ratios in Table 1 and the proportions of the 25 to 64 year-old cohort in each income-group, we estimated that a woman with a low household income (10th percentile rank) had 1.77 times the mortality risk of a woman with a high income (90th percentile rank). For both males and females, the $RII_{10:90}$ estimates of the all-cause mortality gradients were strongest for income, intermediary for NZDep91, and weakest for education.

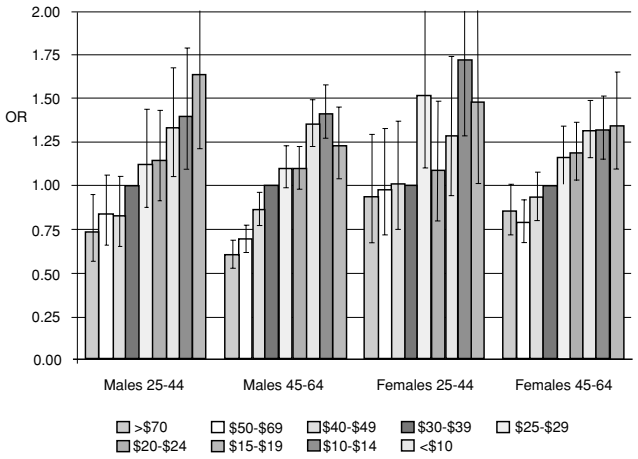

Figure 1. Age and ethnicity adjusted odds ratios of all-cause mortality by equivalised household income (in $1000s) for 25-44 and 45-64 year olds, males and females. Bars are 95% confidence intervals. The reference category for the odds ratios is $30-39 999.

For cause-specific mortality, several patterns are evident from Figure 2. First, as with all-cause mortality, there was tendency for income gradients to be strongest, followed by NZDep91 then education. Second, the gradients (regardless of socio-economic factor) were strongest for respiratory diseases, followed by lung cancer, cardiovascular diseases, and unintentional injury. Third, the patterns were similar between males and females. For example, among both sexes all three socio-economic factors were strongly associated with respiratory mortality but not colorectal cancer mortality. (Note that for more uncommon causes of death among 25-64 year olds eg prostate cancer, and those with large socio-economic mortality gradients eg, chronic obstructive pulmonary disease, the $RII_{10:90}$ may be unstable as represented by the scatter in Figure 2).

Occupational class. The $RII_{10:90}$ for male all-cause mortality was 1.48, and by cause of death was 1.36 for cancer, 1.56 for cardiovascular disease, 1.60 for injury and 1.75 for suicide.

Car access (measure of asset wealth and access to community resources). Compared to males living in households with access to two or more cars, males without car access had an odds ratio of all-cause mortality of 2.23 (2.03 to 2.46) and males with access to one car had an odds ratio of 1.35 (1.28 to 1.43). For females, the odds ratios were 1.67 (1.49 to 1.87) and 1.30 (1.21 to 1.39), respectively.

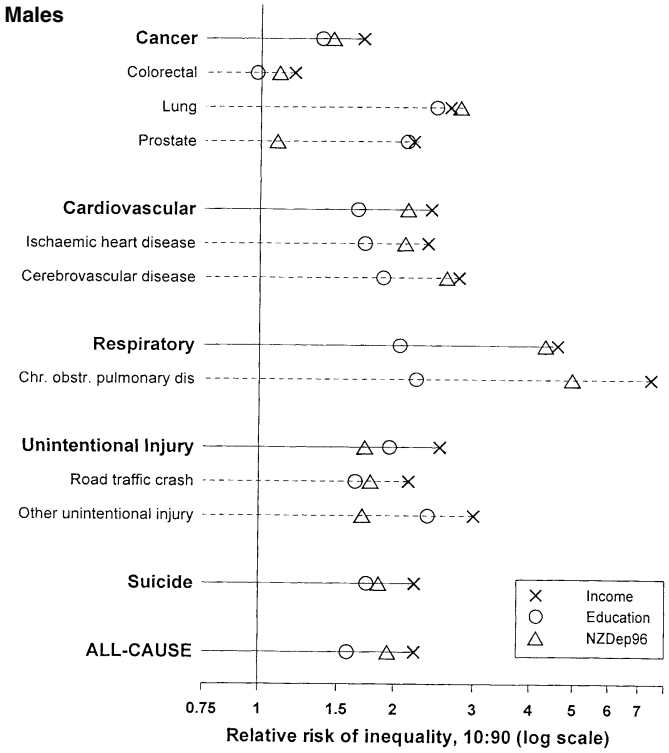

Figure 2a. Cause-specific relative indices of inequality (10:90) by income, education and small area socio-economic deprivation in the 1991 NZCMS cohort among 25-64 year olds. Lines are not error bars. $R11_{10:90}$ values are presented in Table 1.

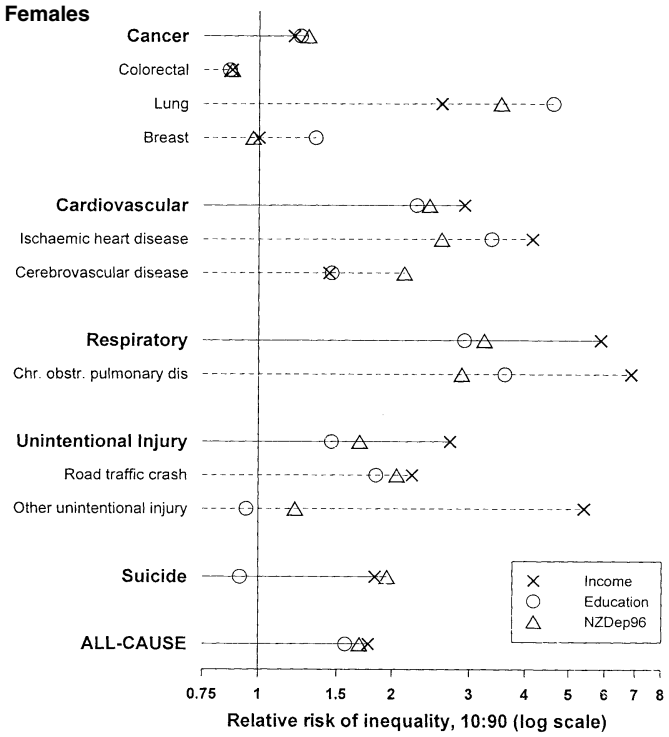

Figure 2b. Cause-specific relative indices of inequality (10:90) by income, education and small area socio-economic deprivation in the 1991 NZCMS cohort among 25-64 year olds. Lines are not error bars. $R11_{10:90}$ values are presented in Table 1.

Labour force status. Those in the *non-active labour* force had the most elevated risks of mortality compared to the employed (Table 2). This was expected for cancer and cardiovascular disease (and possibly suicide) as people in poor health are more likely to be in the non-active labour force. The association of

Table 2. All- and cause-specific mortality odds ratios (95% CI) by labour force status in the 1991 NZCMS cohort among 25-64 year olds, adjusted for age and ethnicity.*

	Employed		Unemployed		Non-active labour force	
Cohort size (males; females)	(519,195; 406,107)		(39,312; 29,760)		(90,243; 231,315)	
	OR	Death	OR (95% CI)	Deaths	OR (95% CI)	Deaths
Males						
Cancer	1.00	1059	1.24 (0.99-1.56)	81	2.01 (1.82-2.23)	882
CVD	1.00	1092	1.42 (1.15-1.74)	99	2.45 (2.23-2.68)	1125
Unintent. Injury	1.00	264	1.25 (0.84-1.85)	27	1.42 (1.06-1.91)	66
Suicide	1.00	168	2.70 (1.84-3.95)	33	3.29 (2.45-4.43)	81
All causes	**1.00**	**2850**	**1.40 (1.24-1.59)**	**270**	**2.56 (2.41-2.72)**	**2646**
Females						
Cancer	1.00	789	0.88 (0.63-1.22)	36	1.52 (1.37-1.68)	1119
CVD	1.00	228	1.16 (0.70-1.93)	15	2.68 (2.28-3.15)	675
Unintent. Injury	1.00	60	0.62 (0.19-2.00)	6	1.73 (1.19-2.53)	66
Suicide	1.00	33	2.86 (1.19-6.85)	6	2.77 (1.74-4.43)	51
All causes	**1.00**	**1227**	**1.15 (0.92-1.43)**	**84**	**2.07 (1.92-2.23)**	**2388**

• The odds ratios are from a logistic regression model with age in ten-year age groups and ethnicity dichotomised as Maori and Pacific Island, and non-Maori non-Pacific. Numbers of deaths are random rounded to the nearest multiple of three as per SNZ protocol, but odds ratios are calculated with exact data.

suicide death with *unemployment* was particularly strong, with odds ratios compared to the employed of 2.70 (1.84 to 3.95) and 2.86 (1.19 to 6.85) for males and females, respectively. (There was also a notable excess risk of suicide death among the non-active labour force). Thus, much of the elevated all-cause mortality among the unemployed (odds ratios of 1.40 (1.24 to 1.59) and 1.15 (0.92 to 1.43) for males and females, respectively) was due to suicide.

Discussion

Our results demonstrate strong socio-economic mortality gradients among adults for a range of socio-economic factors and a range of causes of death. Gradients were steepest for more preventable causes of death (Figure 2, eg lung cancer). There was little evidence of a threshold effect, rather each step up the socio-economic ladder was associated with an incremental reduction in mortality risk. Extensive sensitivity analyses reported elsewhere suggest that the results in this paper may be modestly underestimated due to bias in the record linkage but little affected by selection bias.[9] The census variables are crude measures of socio-economic factors.[9] For example, the household income variable is calculated from tick-box categories on the census, will be prone to errors based on incorrect recall of the previous years income, and was not a measure of 'usual' income. Accordingly, we would expect *all* the associations of the individual-level socio-economic factors with mortality presented in this paper to be underestimated due to misclassification bias. Thus, there is an indisputably strong *crude* association of socio-economic factors with mortality in New Zealand. However, causal inference based on the analyses presented in this paper requires a careful consideration of confounding, causal pathways and health selection – issues discussed below.

In addition to the generalised and strong socio-economic mortality gradient there was a particularly strong association of unemployment with suicide (Table 2). Similar elevated risks of suicide among the unemployed have been shown internationally[14-16] and in New Zealand for self inflicted harm.[17] Given that to be classified as unemployed on the 1991 census required being both available for work and seeking work, we do not believe that this elevated suicide rate for the unemployed is a function of people in poor mental health (and at higher risk of suicide) drifting out of employment into unemployment, since such people would tend to move completely out of the workforce into the non-labour force group. Further, multivariate analyses (reported elsewhere) suggest little confounding of the association of unemployment with suicide by other socio-economic factors – a quite different pattern to that observed for cancer, cardiovascular and injury deaths.[9] Thus, our results are consistent with a causal association of unemployment with suicide death. However, Beautrais et al found that after controlling for childhood, family and educational factors there was no statistically significant association of unemployment with suicide *attempt* in the Canterbury Suicide Project, a case-control study of 302 individuals who made a serious suicide attempt and 1028 randomly selected controls.[18] It is possible that the association of unemployment with suicide attempt is different from that with suicide death, or that this study was insufficiently powerful to detect a statistically significant association.

The associations of household income with all-cause mortality were stronger among males than females, and this difference was due mainly to a stronger association of household income with cancer death among males (Table 1). Such a finding suggests the possibility of health selection whereby poor health prior to death causes one's income to decrease (as is common with cancer) thereby spuriously strengthening the association of income with cancer death. As males among this cohort can be assumed to be the major contributors (on average) to household income, the pattern of a stronger association of income with cancer death among males is further suggestive of such health selection bias. Extensive sensitivity analyses to test this possibility in the NZCMS were inconclusive.[9] On balance, some of the observed association of income with cancer (and probably cardiovascular deaths) in the NZCMS was due to health selection, but not all of it.

What is the policy importance of the findings in this paper? Would it really lower someone's mortality risk if his or her income suddenly increased by a large amount (or another socio-economic factor was substantially altered) and nothing else changed? For some people in difficult circumstances it may make a big difference (being able to move to safer, less crowded, housing for instance). But overall, changing individual incomes without making any other changes is likely to have only a modest impact on population health in the short term.[19] First, it takes time for social influences to affect health. An increase in income might improve diet and as a result, over years, lower the risk of ischaemic heart disease. (However, counter-examples are possible too. For respiratory disease improved housing

conditions may have an immediate beneficial effect.) Second, socio-economic resources of individuals are not randomly distributed. Having a high income is a function of many factors including one's education and previous life circumstances. These correlated factors will also be predictors of health and therefore confounders of the income-mortality association. A life-course perspective suggests that health is a function of cumulative events experienced throughout life, and even inter-generationally.[20] Third, the socio-economic factors used in this study may be viewed as a mixture of 'markers' of underlying socio-economic conditions (eg car ownership), component items that reflect one's structural position on the 'macro' socio-economic ladder (eg income and education), as well as mediating variables at the 'micro' level that are proximate to health (eg sufficient income to afford a healthy diet). Thus, net health gains from changing socio-economic resources of individuals (particularly 'marker' variables like car access), but not changing the associated structure of society, are likely to be modest. Indeed, without changing the structure of society (eg narrowing income distributions) lifting one person up the socio-economic ladder may be (necessarily) balanced by someone else falling down the ladder.

Reliance on 'downstream' public health interventions (eg health education) have historically improved health more rapidly for higher socio-economic groups, thereby *increasing* relative health inequalities. In addition to targeting these downstream interventions more effectively and equitably (eg smoking quit programmes in poorer communities), and 'upstream' structural change to society suggested above, health inequalities would also probably be reduced by 'mid-stream' population-based interventions that preferentially improve health among lower socio-economic groups. Examples of such mid-stream interventions include reduction in tobacco availability, injury prevention programmes in the workplace, increased access to primary health care services, and access to safe and affordable housing.

Acknowledgements. The NZCMS is conducted in collaboration with Statistics New Zealand and is funded by the Health Research Council of New Zealand and Ministry of Health. June Atkinson assisted with the preparation of tables in this paper.

Summary statistics New Zealand security statement. The (New Zealand Census-Mortality Study) NZCMS is a study of the relationship between socio-economic factors and mortality in New Zealand, based on the integration of anonymised population census data from Statistics New Zealand and mortality data from the New Zealand Health Information Service. The project was approved by Statistics New Zealand as a Data Laboratory project under the Microdata Access Protocols in 1997. The data sets created by the integration process are covered by the Statistics Act and can be used for statistical purposes only. Only approved researchers who have signed Statistics New Zealand's declaration of secrecy can access the integrated data in the Data Laboratory. A full security statement is published at the NZCMS web-site (http://www.wnmeds.ac.NewZealand/nzcms-info.htm). For further information about confidentiality matters in regard to this study please contact Statistics New Zealand.

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Asthma linked with high paracetamol use

The high use of paracetamol in Britain and other English-speaking countries may be directly responsible for the surge in asthma cases and other respiratory illnesses compared with the Mediterranean countries and in eastern Europe.

In the biggest study of asthma undertaken involving 140 000 people in 22 countries the link between the drug's sale and prevalence of asthma startled researchers because it showed that in some countries people were up to eight times more likely to contract allergic respiratory diseases than in other apparently similar places.

Christer Janson, associate professor at the department of medical science at Uppsala University in Sweden, said paracetamol sales were high in English-speaking countries, and were positively associated with asthma symptoms, eczema and allergic eye problems in children, and wheeze, asthma, eye and bronchial problems in adults.

A high prevalence was found in Australia, New Zealand, Britain and the United States, with low scores in Iceland, Greece, Norway, Italy and Spain.

The extraordinary finding after the 10-year research programme was one of a number of new leads for researchers into asthma, which has reached epidemic proportions in Britain, where it kills 1600 people a year and affects one of seven children.

The European Community respiratory health survey involving 14 experts is published in the European Respiratory Journal this month.

Professor Janson said the main conclusion was that it was not geographical differences, for example more sunshine or living in the country, that made people more likely to get asthma but environmental reasons, like dust mites, pet cats, cooking with gas, or dust at work. Factors such as different testing methods and skin types were studied to make sure the results were not distorted, and were discounted.

Paul Brown. Guardian Weekly 13-19 September, 2001.