THE NEW ZEALAND
MEDICAL JOURNAL
Vol 118 No 1208 ISSN 1175 8716

Bias measuring mortality gradients by occupational class in New Zealand

Tony Blakely, Jackie Fawcett

Abstract

Background Socioeconomic differences in mortality in New Zealand have traditionally been measured using occupational class from mortality data (based on *usual* or *last* occupation) as the numerator, and class from census data (*current* occupation on census night) as the denominator. Such analyses are prone to numerator-denominator bias. Record linkage of census and mortality data in the New Zealand Census-Mortality Study (NZCMS) allows analyses of 'linked' data that will avoid numerator-denominator bias, but may be prone to other biases.

Objectives To determine differences in the assignment of occupational class between census and mortality data; to investigate biases in the observed association of class with mortality using linked census-mortality data; and to compare the class-mortality association using unlinked versus linked census-mortality data.

Methods Census records for males aged 25–64 years on census night 1991 were anonymously and probabilistically linked to 5,844 out of 8,145 eligible deaths occurring in the second and third years following census night.

Results (by objective) Only 47% of linked deaths had an occupation recorded on census data, compared to 84% on mortality data—a census to mortality ratio of 0.56. Relatively fewer deaths were identified as class 4 on census data (census to mortality ratio of 0.45) compared to other classes (ratios 0.55 to 0.64). *Linkage bias*: A lower likelihood of 25-44 year old deaths (but not 45-64 year olds) from lower socioeconomic classes being successfully linked to a census record meant that analyses using linked census-mortality data underestimated the class-mortality association. *Bias due to exclusion of economically inactive:* Analyses on linked-census data (using *current* occupational class) considerably underestimated the estimated association of *usual* occupational class with mortality. The strength of the association of class with mortality according to linked census-mortality data (and adjusted for the above two biases) and unlinked data were roughly comparable.

Conclusion Differences in the recording of occupational class on census and mortality data in New Zealand mean measuring mortality differences by class is thwart with difficulty. If one assumes that biases for any particular method of analysis are similar over time, or one carefully adjusts where possible for bias, using occupational class to monitor trends in socioeconomic mortality gradients may be valid.

Mortality differences by occupational class have been the mainstay for monitoring changes over time, and differences between countries, in social inequalities in health—both in New Zealand[1–5] and internationally, particularly Europe.[6–13] However, there are numerous biases that may arise in such comparisons due to the

© NZMA

collection of occupation and the use of either 'unlinked' (cross-sectional) or 'linked' (cohort) analyses of census and mortality data.

Unlinked analyses involve determining the number of deaths in each occupational class from mortality data (the numerator) and the number of people in each occupational class from census data (the denominator). Mortality rates are then calculated by dividing the former by the latter within each occupational class. Examples of unlinked studies include the Decennial Supplement series in England and Wales[6,14] and those by Pearce and colleagues in New Zealand for 1974–1978, 1985–87, and 1995–97.[1–5,15,16] These latter New Zealand analyses have found a two-fold difference in mortality for the lower occupational classes compared to the higher occupational classes[1,2,5,15,16], and possibly increasing mortality gradients by occupational class from 1975–1977 to 1995–1997.[3]

Linked analyses involve record linkage of census and mortality data, thereby creating cohort studies of census populations followed-up for mortality. Occupational class is assigned using the census data, negating the need to use occupation codes on mortality data. Examples of linked studies include the UK OPCS Longitudinal Study[17] and the Scandinavian record linkage studies.[18–22]

Unlinked analyses are prone to numerator-denominator bias because of differences in the way that occupation is recorded between mortality and census data. For example, census and mortality data may differ with regard to: who provides the occupation (self-identified or next of kin); coding rules; and whether current, usual or last occupation is recorded. The direction and magnitude of numerator-denominator biases that consequently arise vary between countries. In the UK, it is thought to be modest.[23,24]

Linked analyses using current occupation to calculate occupational class mortality gradients can underestimate the gradient due to differential health selection out of the labour force.[25–27] This differential arises because unwell people in lower occupational classes (e.g. labourers) are more likely to exit the active labour force than people with the same level of poor health in higher occupational classes (e.g. lawyers). As those not in the labour force are excluded from occupational class analyses, differential health selection will bias the association of occupational class with mortality. However, there are methods to adjust for this health selection bias.[10,28]

Mortality and census records have been anonymously and probabilistically linked in the New Zealand Census-Mortality Study (NZCMS).[26,29] This linkage provides the opportunity to measure mortality gradients by occupational class using linked census-mortality data. However, such linked analyses may be biased by differential health selection as occupation on the New Zealand census is *current* occupation rather than last or usual occupation. Conversely, the previous unlinked analyses that utilise usual or last occupation on death certificates may be biased by numerator-denominator bias.

The objectives of this paper are:

- To determine differences in the assignment of occupational class between census and mortality data,
- To investigate biases in the observed association of class with mortality using linked census-mortality data due to (a) differential linkage of mortality data back to census data by socioeconomic position (i.e. linkage bias), and (b) the use of

© NZMA

‘current’ occupation on census data (i.e. bias due to exclusion of the economically active), and

- To compare the class-mortality association using unlinked versus linked census-mortality data.

Methods

Census data—For this paper, analyses were limited to 25 to 64-year-old males. Occupational class was assigned to census data using the New Zealand Socioeconomic Index (NZSEI).[30,31] The NZSEI ranks occupations by socioeconomic position on a scale of 10 to 90. We used cut-points of 30, 40, 50, 60, and 70 to form six occupational classes.[30] We also created a separate class for farmers.

Record linkage and mortality data—Mortality records were anonymously and probabilistically linked to the 1991 census using Automatch®[32] as described elsewhere.[33,34] Briefly, 5,844 of 8,145 (71.7%) eligible male decedents who were aged 25–64 years on 1991-census night and died in the second and third years following census night (5 March 1991) were successfully linked to a census record using these matching variables. Greater than 95% of linked census and mortality records were estimated to be correct linkages.[35] Census records linked to a mortality record where death occurred in the first year of follow-up were discarded to militate against health selection biases, and due to inaccurate recording of occupational codes on mortality data during 1991.

Cross-tabulating census and mortality data occupational class (Objective 1)—To investigate for numerator-denominator bias, we cross-tabulated the mortality data occupational class (usual occupation) by census data occupational class (current occupation on the census night preceding death) among the subset of linked census-mortality records.

Analyses of the association of occupational class with mortality—We used logistic regression to measure occupational class mortality gradients. As death is uncommon among 25–64 year olds over a 2-year period, the odds ratios were close approximations of the risk ratio. Analyses were conducted separately for 25–44 and 45–64 year olds. For the ‘linked’ analyses, we simply used census data occupational class (where non-missing) as the independent variable. The ‘unlinked’ analyses also used the linked data, but with the occupational class from the mortality data as the independent variable.

We also calculated relative indices of inequality (RIIs), details of which are available elsewhere.[36] The RII is a summary relative risk measure that is derived by fitting a regression line to the rates of death (or in our paper the odds ratios of death) for each occupational class on the midpoints on a cumulative rank distribution for each occupational class. For example, if 10% of the population are in occupational class 1 then this class is assigned an x-value of 0.05 (i.e. the midpoint of the range 0 to 0.1).

If occupational class 2 comprised 30% of the populations ion this example, its assigned x-value would be 0.25 (0.1 [for class 1] plus half of 0.3). The slope of this regression line is the difference in the estimated mortality rate (or odds ratio unit in out paper) for the hypothetical person of lowest occupational class compared to highest occupational class. The RII is then calculated as the [slope + intercept] / [intercept]. The regression was weighted by the inverse of the variance of the class rate.

Adjusting linked analyses for possible linkage bias (Objective 2)—Not all eligible mortality records could be linked to a census record, and it was therefore possible that the odds ratios by occupational class could be biased if the linkage success varied by occupational class. We quantified this possible linkage bias by comparing the proportion of mortality records linked to a census record across occupational classes (usual occupational class according to mortality data), using log-link regression.[26,34] The relative risks from these regressions were then used to adjust the odds ratios in the cohort analyses for linkage bias.

For example, if the relative risk of linkage for class 6 decedents compared to class 1 decedents was 0.95, and the observed odds ratio of death in the cohort analysis was 1.60, then the linkage bias adjusted odds ratio was 1.6/0.95 = 1.68.

Adjusting for exclusion of economically inactive (Objective 2)—We used a previously published method to adjust our linked current occupational class results to approximate what would have been observed had usual occupation been available on the census.[10,28] This method uses external survey data of the proportion of each (usual) occupational class in current employment and the relative risk of mortality for the non-employed compared to the employed. The New Zealand Household Labour Force

 © NZMA

Survey (HLFS; 1991 data) collects data on current occupation and, if no current occupation, the last occupation within five years.

Accordingly, we estimated that 2%, 2%, 5%, 11%, 12%, and 12% of males aged 25–44 years in classes 1 to 6 respectively had no current occupation, and likewise 10%, 13%, 15%, 21%, 25%, and 16% among 45–64 year old males. The relative risk of mortality in the NZCMS for the non-employed compared to employed were 2.77 and 2.35 for 25-44 and 45–64 year olds, respectively.

Comparing linked and unlinked analyses (Objective 3)—We conducted a close approximation of an unlinked analysis by using the census occupational class for all non-linked census records, but using the mortality data occupational class for the census records linked to a mortality record. As this method only allows analyses on the actually linked mortality records, we also adjusted these analyses for linkage bias using the same methods as above.

Results

How does occupational class recording on census data differ to that on mortality data?—Table 1 shows the cross-classification of occupational class for 25–64 year old male decedents according to census data (using current occupation on 1991 census night) and according to mortality data (usual or last occupation). Neither the mortality nor the census data can be considered the 'gold standard'. However, we have presented the data from the perspective of the mortality data 'usual or last' occupational class, and how census 'current' occupational class classification performs with respect to the mortality data.

Many of the possible cross-classification cells in Table 1 have been merged to meet privacy requirements of Statistics New Zealand that all tabular data be randomly rounded to a near multiple of three, and a minimum cell size of six.

The main points to note from Table 1 are, firstly, more of the 5844 decedents had an occupational class assigned on their mortality record (4,932 or 84%) than on their corresponding census record (2,754 or 47%). Second, the percentage of decedents on the mortality data with the same occupational class on census data *decreased* by class from 43% in class 1 to 24% in class 6. Third, decedents in lower occupational classes on the mortality data were less likely to have had a current occupational class recorded on census data (38% in class 6 compared to 62% in class 1). Fourth, and offsetting the previous point, it was more common among men with no usual occupation on mortality data to be assigned to census 'current' class 5 and 6 (8% and 6%, respectively) than to census class 1 and (1% and 3%, respectively).

Despite these considerable differences in occupational class assignment between the census and mortality data, the net result was that the ratio of the total census count to the total mortality count for each class is around 0.6 for most classes (final column of Table 1), although there was still some notable variation that is described further below.

What is the association of class with mortality using analyses of the linked census-mortality data?—Table 2 shows the distribution of census counts and linked census-mortality records by census 'current' NZSEI occupational class, separately for 25–44 and 45–64 year olds males. The linked deaths in Table 2 are equivalent to the deaths in the bottom row of Table 2—e.g. 240 deaths in census NZSEI class 1 from Table 1 equals 66 deaths among 25-44 year olds plus 174 deaths among 45–64 year olds as shown in Table 2. Odds ratios from a logistic regression adjusting for 5-year age groups and ethnicity are also shown in Table 2. There was a mostly monotonic gradient of increasing mortality odds moving from class 1 to 6, with the observed mortality odds in class 6 being nearly 50% greater than in class 1 for both 25–44 and 45–64 year olds. The relative indices of inequality (RIIs) for 25–44 and 45–64 year old males were 1.68 and 1.61 (Table 2). That is, the expected mortality rate for the males of lowest occupational class was 68% or 61% higher than the expected mortality rate of the males of highest occupational class.

What is the impact of adjusting linked analyses for linkage bias?—Figure 1 presents the association of mortality with occupational class for a range of analyses, for both 25–44 year olds and 45–64 year olds. RIIs for each type of analysis are placed just beneath the x-axis. The first sets of bars for each age group is the age and ethnicity adjusted odds ratios presented in Table 2. The second set adjusts the former results for linkage bias. This adjustment increases the strength of association of class with mortality by 34% for 25-44 year olds (i.e. [1.91–1.68] / [1.68–1]) and by 8% for 45–64 year olds. Therefore, there was notable linkage bias among 25–44 year olds, but relatively minor linkage bias among 45–64 year olds.

What is the impact of adjusting linked analyses (i.e. current occupation) for exclusion of the economically inactive?—The third set of columns for each age-group show the impact on the linked analyses of adjusting for economic inactivity (Figure 1). The mortality gradient increases (in excess terms over and above a null RII of 1.0) among 45 to 64 year olds by 42% from an RII of 1.66 to 1.94, and among 25 to 44 year olds by 58% from an RII of 1.91 to 2.44. Therefore, it appears that there is notable underestimation of occupational class mortality gradients using census (current occupation) data if one is trying to estimate the gradient according to usual occupation.

Are linked and unlinked analyses similar?—The final sets of columns show the results for the unlinked analyses (i.e. closely approximating just using the mortality data as numerators and census data as the denominators). Among 45–64 year olds, the unlinked analysis produced a gradient similar to that for linked analyses adjusted for both linkage bias and economic inactivity. Note the higher odds ratio for class 4 in the unlinked compared to linked analyses—this is predicted by the lower census to mortality ratio for class 4 in Table 1. (The 45–64 year olds dominate the cross-classifications in Table 1.) The lower relative risk for class six compared to class five in the unlinked analysis is also consistent with the varying census to mortality ratios of 0.55 and 0.64 for these two classes as shown in Table 1.

Among 25–44 year olds, a visual inspection of the unlinked analysis is distorted by a (probably spurious) higher mortality rate than might be expected in class 1—the referent group. Replotting the histograms using class 6 as the referent group, the visual impression is of similarity between the unlinked analysis and both the adjusted linked analyses. The RIIs (that do not rely on treating one category as the reference group) also confirm this interpretation, with a RII for the unlinked analysis of 2.03 being between the RIIs of 1.91 and 2.44 for the adjusted linked analyses.

© NZMA

Table 1. Cross-classification of mortality by census NZSEI occupational class for 5,844 male 25-64 year old deaths during the second and third year of follow-up

Mortality (usual) occupational class	Census (current) occupational class: Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Farmer†	No Occ	Total	Census to mortality ratio *
Class 1	168 (43%)	72 (19%)					-	147 (38%)	**387**	0.62
Class 2	24 (5%)	150 (32%)	96 (21%)				-	189 (41%)	**462**	0.65
Class 3	75 (9%)		276 (32%)	135 (16%)			-	369 (43%)	**861**	0.58
Class 4	93 (8%)			333 (28%)	78 (7%)		-	672 (57%)	**1182**	0.45
Class 5	111 (10%)				372 (33%)	36 (3%)	-	609 (54%)	**1137**	0.55
Class 6	57 (15%)					93 (24%)	-	243 (62%)	**393**	0.64
Farmers	57 (11%)						261 (51%)	189 (37%)	**507**	0.60
No occupation	6 (1%)	24 (3%)	33 (4%)	36 (4%)	72 (8%)	51 (6%)	12 (1%)	678 (74%)	**912**	3.39
Total	**240 (4%)**	**300 (5%)**	**498 (9%)**	**531 (9%)**	**627 (11%)**	**252 (4%)**	**306 (5%)**	**3090 (53%)**	5844	

*** The census to mortality ratio is the ratios of the total number of decedents identified within each occupational class (and farmers and no class) according to census data compared to mortality dat**
For example, the ratio of 0.62 = 240/387.

© NZMA

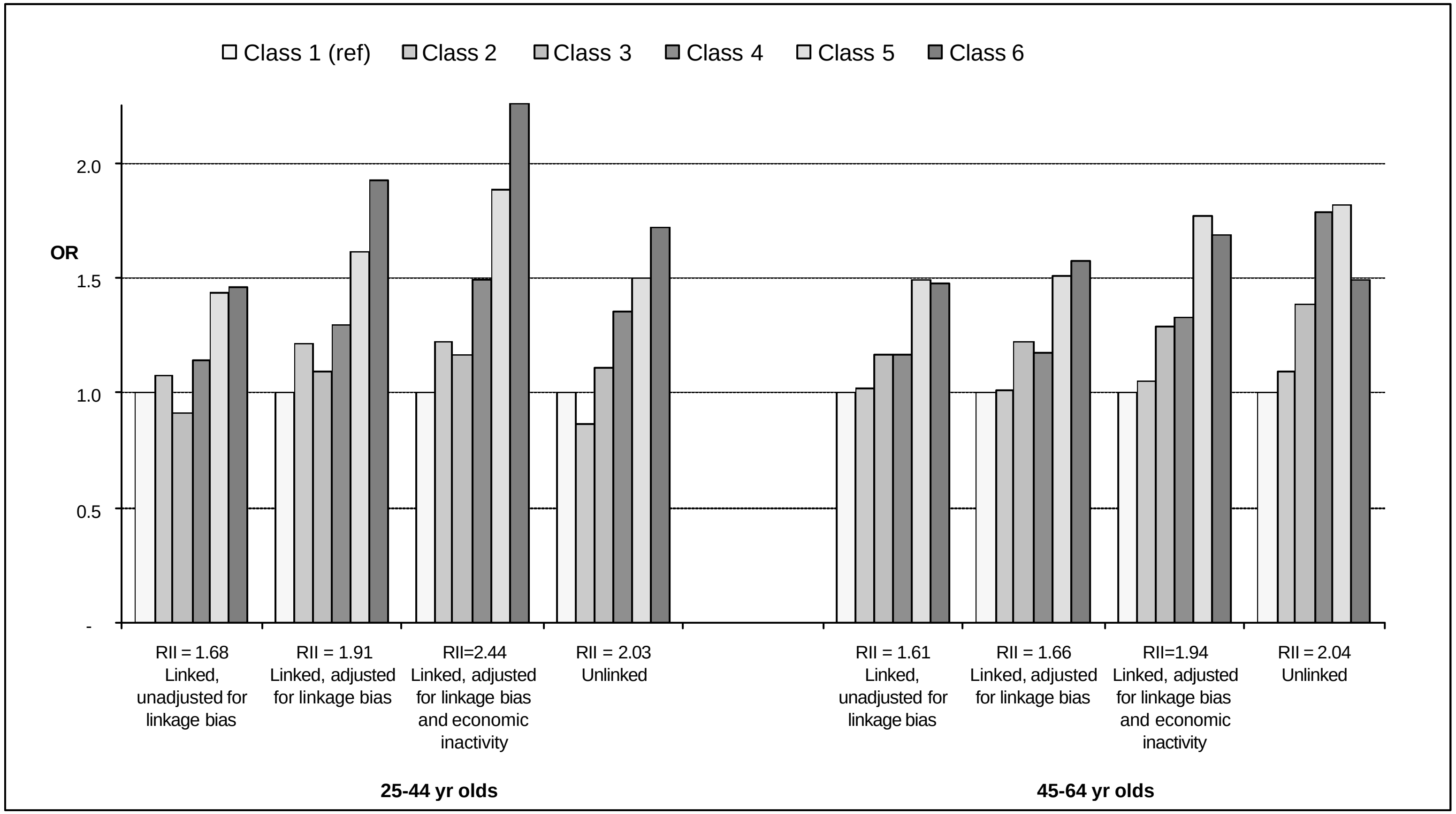
Table 2. Distribution, odds ratios (95% CI) and relative indices of inequality (RII) of all-cause male mortality by NZSEI occupational class

NZSEI occup class	Census number	Linked deaths	Age and ethnicity adjusted odds ratios (95% confidence intervals)
25-44 yrs			
1	42,435	66	1
2	50,619	90	1.08 (0.78-1.48)
3	87,087	123	0.91 (0.68-1.23)
4	86,682	147	1.14 (0.85-1.53)
5	74,835	171	1.44 (1.08-1.92)
6	27,801	63	1.47 (1.03-2.08)
Farmers	40,809	69	1.11 (0.79-1.56)
Subtotal	**410,268**	**729**	
No occup	96,114	330	
RII			1.68
45-64 yrs			
1	22,557	174	1
2	28,305	213	1.02 (0.83-1.25)
3	44,001	375	1.17 (0.98-1.40)
4	41,829	381	1.17 (0.97-1.40)
5	36,855	456	1.49 (1.25-1.78)
6	14,526	192	1.48 (1.20-1.83)
Farmers	27,924	234	0.96 (0.79-1.17)
Subtotal	**215,997**	**2,025**	
No occup	95,388	2,763	
RII			1.61

The odds ratios are from a logistic regression model with age in five-year age groups and ethnicity trichotomised as Maori, 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.

 © NZMA

Figure 1. Odds ratios (age and ethnicity adjusted) of male mortality by NZSEI occupational class: cohort analysis of linked data; unlinked analysis; and cohort analysis of linked data, adjusted for the economically inactive



The first (linked) and third (linked adjusted for economically inactive) analyses include adjustment for linkage bias. HLFS = Household Labour Force Survey.

© NZMA

Discussion

Only 47% of linked deaths had an occupation recorded on census data, compared to 84% on mortality data. Whilst a basic point, the missing data on occupational class from either mortality or census data (but especially the latter) opens the door to substantial potential bias in measuring differences in mortality by occupational class. The higher 84% availability of class data on mortality data does not remove the potential for bias in unlinked analyses, as numerator-denominator biases are likely. For example, our cross-classification of class by census and mortality data demonstrated that relatively fewer deaths were identified as class 4 on census data (census to mortality ratio of 0.45) compared to other classes (ratios 0.55 to 0.64).

On the other hand, our linked analyses that used current occupational class according to census data (i.e. occupational class only available for 47% of those census respondents that were linked to a mortality record) were also prone to bias. First, among 25–44 year olds, the class-mortality association was underestimated due to linkage bias. This linkage bias was easily overcome by adjustment.

Further, the recent development of weights on NZCMS data to adjust for linkage bias [37] (not used in this paper) means that linkage bias can be easily addressed in future analyses on the linked data using occupational class or any other socioeconomic factor. More problematic though, and more specific to occupational class, was the bias due to excluding the economically inactive when using census occupational class. *If* we are trying to estimate the association of usual or last occupational class with mortality, our linked analyses appear to be substantially underestimated. (Our results for the association of current occupational class with mortality remain valid—but most researchers would prefer the association of usual or last occupational class to avoid health selection biases.[25,27])

We used data from the HLFS on the last occupational class within 5 years among those with no current occupation to adjust our unlinked analyses. However, this method is far from perfect. First, the HLFS did not provide us with an occupational class for those people with an occupation prior to five years ago—but no occupation in the last 5 years. Second, the HLFS is a survey with its own imprecision when it comes to point estimates in small cells—a situation that arises in the adjustment methodology.

Nevertheless, it seems highly probable that the use of current occupation on census data in the linked analysis has resulted in differential health selection bias whereby unwell people from lower classes are less likely to be able to stay at work compared to unwell people from higher classes.[25,26]

At first inspection, it is reassuring that the unlinked analyses roughly agree with the linked analyses adjust for both linkage bias and bias due to excluding the economically inactive (Figure 1). However, a closer inspection of Table 1 suggests that both analyses may be underestimating the 'true' association of occupational class with mortality.

Why? Because whether one starts from census or mortality data, deaths from lower classes (e.g. 5 and 6) are more likely to have missing occupation on the other data-set. The flip-side of this is that deaths with missing occupation on one data-set are more likely to have a low occupational class than a high occupational class on the other

 © NZMA

data-set. This may be the result of greater rates of entry and exit into the employment among lower socioeconomic groups (i.e. greater churning) or greater amounts of misclassification biases. Regardless, this pattern points to a relative under-enumeration of lower class deaths on both census and mortality data. If this under-enumeration of deaths is not matched by similar under-enumeration of all people (i.e. denominators), then the strength of association of occupational class with mortality will be underestimated regardless of the method of analysis.

From an international perspective, our findings may provide some guidance to researchers undertaking similar analyses. Our findings also provide some indirect support for the method of Kunst et al[10] to adjust for differential health selection. From a New Zealand perspective, our findings suggest that linked analyses (with no adjustment for differential health selection) are biased. But perhaps more importantly, it is difficult to escape the conclusion that differences in the recording of occupational class on census and mortality data in New Zealand make measuring mortality differences by class thwart with difficulty and potential bias.

If one assumes that biases for any particular method of analysis are constant (or at least similar) over time, and one carefully adjusts where possible for bias, using occupational class to monitor trends in socioeconomic mortality gradients may be valid.

Author information: Tony Blakely, Senior Research Fellow; Jackie Fawcett, Research Fellow, Department of Public Health, Wellington School of Medicine and Health Sciences, University of Otago, Wellington

Acknowledgments: The NZCMS is conducted in collaboration with Statistics New Zealand, and the assistance of many members of staff. The NZCMS is funded by the Health Research Council of New Zealand, with co-funding from the Ministry of Health. June Atkinson assisted with the preparation of tables in this paper. Peter Davis and Neil Pearce provided comments on early drafts of this paper. Andrew Sporle provided comments on final drafts of the paper. Alistair Woodward and Neil Pearce supervised TB's PhD where many of the analyses presented in this paper were initiated.

Correspondence: Dr Tony Blakely, Department of Public Health, Wellington School of Medicine and Health Sciences, University of Otago, PO Box 7343, Wellington. Fax (04) 389-5319; email tblakely@wnmeds.ac.nz

Summary Statistics New Zealand Security Statement: (The full security statement is in a technical report to be published by the Wellington School of Medicine in hardcopy and at http://www.wnmeds.ac.nz/nzcms-info.htm)

The (New Zealand Census Mortality Study) NZCMS is a study of the relationship between socioeconomic 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 datasets 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.

© NZMA

For further information about confidentiality matters in regard to this study please contact Statistics New Zealand.

References:

1. Pearce N, Marshall S, Borman B. Undiminished social class mortality differences in New Zealand men. N Z Med J. 1991;104:153–6.
2. Pearce N, Pomare E, Marshall S, Borman B. Mortality and social class in Maori and nonMaori New Zealand men: changes between 1975-7 and 1985-7. N Z Med J. 1993;106:193–6.
3. Pearce N, Davis P, Sporle A. Persistent social class mortality differences in New Zealand men aged 15-64: an analysis of mortality during 1995-97. Aust N Z J Public Health. 2002;26:17–22.
4. Sporle A, Pearce N, Davis P. Social class mortality differences in Maori and non-Maori men aged 15-64 during the last two decades. N Z Med J. 2002;115:127–31.
5. Kawachi I, Marshall S, Pearce N. Social class inequalities in the decline of coronary heart disease among New Zealand men, 1975-1977 to 1985-1987. Int J Epidemiol. 1991;20:393–8.
6. Drever F, Whitehead M, editors. Health Inequalities. London: Office for National Statistics; 1997.
7. Vagero D, Lundberg O. Health inequalities in Britain and Sweden. Lancet 1989;1:35–6.
8. Kunst A, Mackenbach J. International variation in the size of mortality differences associated with occupational status. Int J Epidemiol. 1994;23:742–50.
9. Kunst A. Cross-national comparisons of socio-economic differences in mortality [thesis]. Rotterdam: Erasmus University; 1997.
10. Kunst A, Groenhof F, Mackenbach J, The EU working group on socioeconomic inequalities in health. Mortality by occupational class among men 30-64 years in 11 European countries. Soc Sci Med. 1998;46:1459–76.
11. Kunst A, Groenhof F, Mackenbach J, the EU Working Group on Socioeconomic Inequalities in Health. Occupational class and cause specific mortality in middle-aged men in 11 European countries: comparison of population based studies. BMJ. 1998;316:1636–42.
12. Kunst A, Groenhof F, Anderson O, et al. Occupational class and ischaemic heart disease mortality in the United States and 11 European countries. Am J Public Health. 1999;89:47–53.
13. Mackenbach J, Kunst A, Cavelaars A, et al. Socioeconomic inequalities in morbidity and mortality in western Europe. Lancet. 1997;349:1655–9.
14. Registrar General. Decennial Supplement, England and Wales, 1921. Part II Occupational Mortality, Fertility and Infant Mortality. London: HMSO; 1927.
15. Pearce N, Davis P, Smith A, Foster F. Mortality and social class in New Zealand. I: overall male mortality. N Z Med J. 1983;96:281–5.
16. Marshall S, Kawachi I, Pearce N, Borman B. Social class differences in mortality from diseases amenable to medical intervention in New Zealand. Int J Epidemiol. 1993;22:255–61.
17. Fox A, Goldblatt P. Longitudinal Study 1971-1975: Socio-demographic mortality differences. London: Her Majesty's Stationary Office: Office of Population Censuses and Surveys; 1982.
18. Martikainen P, Valkonen T. Do education and income buffer the effects of death of spouse on mortality? Epidemiol. 1998;9:530–4.
19. Valkonen T. Problems in the measurement and international comparisons of socio-economic differences in mortality. Soc Sci Med. 1993;36:409–18.
20. Martikainen P. Unemployment and mortality among Finnish men, 1981-5. BMJ. 1990;301:407–11.

© NZMA

21. Martikainen P, Valkonen T. Excess mortality of unemployed men and women during a period of rapidly increasing unemployment. Lancet. 1996;348:909–12.

22. Westerling R, Gullberg A, Rosen M. Socioeconomic differences in 'avoidable' mortality in Sweden 1986-1990. Int J Epidemiol. 1996;25:560–7.

23. Fox A, Goldblatt P, Jones D. Social class mortality differentials: artefact, selection or life circumstances? J Epidemiol Community Health. 1985;39:1–8.

24. Kunst A. Potential sources of bias in "unlinked" cross-sectional studies. In: Kunst A, Cavelaars A, Groenhof F, Geurts J, Mackenbach J, EU Working Group on Socioeconomic Inequalities in Health, editors. Socioeconomic Inequalities in Morbidity and Mortality in Europe: A Comparative Study. Rotterdam: Department of Public Health, Erasmus University; 1996:147-162.

25. Martikainen P, Valkonen T. Bias related to the exclusion of the economically inactive in studies on social class differences in mortality. Int J Epidemiol. 1999;28:899–904.

26. Blakely T. The New Zealand Census-Mortality Study: Socioeconomic inequalities and adult mortality 1991-94.. Wellington: Ministry of Health; 2002:258. Available online. URL: http://www.wnmeds.ac.nz/nzcms-info.html Accessed January 2005.

27. Kunst A, Groenhof F, Borgan J-K, et al. Socio-economic inequalities in mortality. Methodological problems illustrated with three examples from Europe. Rev Epidemiol Sante Publique. 1998;46:467–79.

28. Kunst A, Groenhof F. Mortality differences by educational level and occupational class: the effect of excluding economically inactive men. In: Kunst A, Cavelaars A, Groenhof F, Geurts J, Mackenbach J, EU Working Group on Socioeconomic Inequalities in Health, editors. Socioeconomic Inequalities in Morbidity and Mortality in Europe: A Comparative Study. Rotterdam: Department of Public Health, Erasmus University; 1996:99–146.

29. Blakely T, Salmond C, Woodward A. Anonymous record linkage of 1991 census records and 1991-94 mortality records: The New Zealand Census-Mortality Study. Wellington: Department of Public Health, Wellington School of Medicine, University of Otago; 1999. Available online. URL: http://www.wnmeds.ac.nz/academic/dph/research/nzcms/AnonymousLinkage.pdf Accessed January 2005.

30. Davis P, McLeod K, Ransom M, Ongley P. The New Zealand Socioeconomic Index of Occupational Status (NZSEI). Wellington: Statistics New Zealand; 1997.

31. Davis P, McLeod K, Ransom M, Ongley P, Pearce N, Howden-Chapman P. The New Zealand Socioeconomic Index: developing and validating an occupationally-derived indicator of socioeconomic status. Aust N Z J Public Health. 1999;23:27–33.

32. MatchWare Technologies I. Automatch Generalised Record Linkage System, Version 4.2: User's Manual. Kennebunk, Maine: MatchWare Technologies, Inc; 1998.

33. Blakely T, Salmond C, Woodward A. Anonymous linkage of New Zealand mortality and Census data. Aust N Z J Public Health. 2000;24:92–5.

34. Blakely T. Socio-economic factors and mortality among 25-64 year olds: The New Zealand Census-Mortality Study [Doctorate]. University of Otago; 2001. Available online. URL: http://www.wnmeds.ac.nz/academic/dph/research/nzcms/BlakelyThesisAsSubmitted.pdf Accessed January 2005.

35. Blakely T, Salmond C. Probabilistic record linkage and a method to calculate the positive predictive value. Int J Epidemiol. 2002;31:1246–52.

36. Mackenbach J, Kunst A. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc Sci Med. 1997;44:757–71.

37. Fawcett J, Blakely T, Atkinson J. Weighting the 81, 86, 91 & 96 census-mortality cohorts to adjust for linkage bias. NZCMS Technical Report No. 5. ISBN 0-473-09112-7. Wellington:

 © NZMA

Department of Public Health, Wellington School of Medicine and Health Sciences, University of Otago, 2002:92. Available online. URL: http://www.wnmeds.ac.nz/academic/dph/research/nzcms/NZCMSTechRptNo5JF.pdf Accessed January 2005

 © NZMA