How much does health care contribute to health gain and to health inequality? Trends in amenable mortality in New Zealand 1981-2004

Abstract

Objective: To estimate the contribution of health care to health gain, and to ethnic and socio-economic health inequalities, in New Zealand over the past quarter century.
Method: Amenable and all-cause mortality rates by ethnicity and equivalised household income tertile from 1981-84 to 2001-04 were estimated from linked census-mortality datasets (the New Zealand Census-Mortality Study). Amenable mortality (deaths under age 75 from conditions responsive to health care) was defined using a classification recently developed for use in Australia and New Zealand. The contribution of health care to the observed improvement in population health status was estimated by the ratio of the difference in amenable to the difference in all-cause mortality over the observation period.
Results: Trends in amenable causes of death were estimated to account for approximately one-third of the fall in mortality over the past quarter century, for the population as a whole and for all income and ethnic groups except Pacific peoples, for whom there was no reduction in amenable mortality. In 2001-04, amenable causes accounted for approximately one quarter of the mortality gap between all ethnic groups compared to the European/Other reference.
Discussion: Our finding provides one indicator of the social impact of health care over this period. More importantly, that Pacific peoples seem to have benefited less than other ethnic groups calls for urgent explanation. Also, our finding that amenable causes account for about one quarter of current mortality disparities, clearly indicates that improvement in access to and quality of health care for disadvantaged groups could substantively reduce health inequalities.

Key words: amenable mortality, trends, New Zealand

Aust N Z Public Health. 2009; 33:70-8
doi: 10.1111/j.1753-6405.2009.00342.x

Martin Tobias and Li-Chia Yeh

Health and Disability Intelligence, New Zealand Ministry of Health

Health expenditure has risen steeply over the past two or three decades in most of the established market economies, both in absolute terms and as a proportion of gross domestic product (GDP).[1] This has generated concern about health system efficiency and motivated efforts to reform national health systems so as to raise productivity.[2]

Efficiency measures the extent to which the resources used by a national health system achieve the goals of that system.[3] There is general agreement that attainment of the highest possible level of health, and a fair distribution of health across the population, are among the goals of any national health system.[3] In New Zealand, these goals are reflected in the New Zealand Health Strategy.[4]

If improvement in the level and distribution of population health is accepted as a goal for the health system, then the challenge arises of how to attribute population health outcomes to health care. One approach is to identify deaths that should not have occurred given available health care services – 'unnecessary untimely deaths' or 'amenable mortality'.[5] Then the contribution of health care to improvement in population health status can be estimated by the ratio of the difference in amenable mortality to the difference in all-cause mortality over the observation period. And similarly, the contribution of health care to health inequality can be estimated by the ratio of the (standardised) mortality rate differences ($SRD_{amenable}$ / $SRD_{all\text{-}cause}$) between the population subgroups of interest (at one point in time).

Amenable mortality is a subset of the broader construct of avoidable mortality, which includes deaths from causes that can be prevented (incidence reduction) as well as those that can be treated (case fatality reduction). Avoidable mortality therefore reflects influences from well beyond the boundaries of the health care system as conventionally defined. By contrast, amenable mortality provides a more specific and focused indicator of health care performance.

The list of amenable causes of death has recently been updated by one of us (Tobias)[6] with assistance of an international expert panel (regular updating is necessary to incorporate advances in health care technology). Updating involved identifying conditions (causes of death) for which effective clinical interventions exist. That is, premature mortality from these conditions should not occur, given available personal health care services. The age limit below which deaths are considered to be premature (a necessary precondition for amenability) has been extended from the conventional cut-off of 65 years to 75 years (reflecting recent gains in life expectancy in developed countries), in line with our earlier work.[7] Where a condition is both preventable and treatable, priority is given to the former (so injury deaths, for example, are not considered amenable despite the known effectiveness of trauma care). For three conditions – coronary heart disease, stroke and type 2 diabetes – prevention and treatment are about equally effective (as demonstrated, for instance, in

Submitted: April 2008 **Revision requested:** August 2008 **Accepted:** September 2008

Correspondence to:
Martin Tobias, Ministry of Health, PO Box 5013, Wellington, New Zealand.
Fax: 64 4 816 2340; e-mail: martin_tobias@moh.govt.nz

the MONICA studies), so only half of these deaths are classified as amenable, following Nolte and McKee.[8] Full justification for inclusion and exclusion of each cause of death as 'amenable' is provided elsewhere.[6] The updated list of amenable conditions together with their ICD codes is reproduced here for ease of reference (see appendix). Full justification for inclusion of each condition on this list is provided in the *Australian and New Zealand Atlas of Avoidable Mortality*, available from www.publichealth.gov.au or www.moh.govt.nz.[6]

The objectives of this study are therefore to estimate:

1. The contribution of health care to the gain in health achieved over the past quarter century in New Zealand (by the total population and ethnic or socio-economic subpopulations).
2. The contribution of health care to ethnic and socio-economic inequalities in health in New Zealand as measured by the ratio of amenable to all-cause mortality rate differences between time periods or groups of interest, adjusted for important confounders.

Methods

New Zealand Census Mortality Study

The NZCMS is a record linkage study in which mortality records for persons who died aged 1-74 years within three years of the 1981, 1986, 1991, 1996 or 2001 Census are anonymously and probabilistically linked to their corresponding censal record (using Automatch and Validity software). The matching variables were domicile (the blocking variable, geocoded at meshblock [approximately 100 people] level); socio-economic position; country of birth; and day, month and year of birth. Depending on the cohort, from 71.0% to 79.6% of eligible mortality records were linked (of which over 96% are estimated to be true positives). Linkage weights were calculated for strata based on age, sex, ethnicity and small area deprivation. All mortality rates reported were adjusted using these weights, which have been shown to satisfactorily adjust for linkage bias.[9]

The NZCMS thus yields five short-duration population-based cohort studies of identical design, allowing analysis of trends over the 23 year observation period (March 1981 – March 2004). Each cohort study provides unit record data free of numerator-denominator bias (particularly important in relation to analysis of ethnic mortality inequalities), involving millions of person-years of observation (Tables 1 and 2), and enabling use of the rich socio-demographic data collected in the census.

The measure of socio-economic position used in this report is equivalised household income. Equivalisation for household size and composition was carried out using the modified Jensen index.[10] Incomes were then inflation adjusted using the consumer price index (base year 1996), such that groupings over time used the same inflation adjusted cut-points. Approximately 15% of individuals could not be assigned a household income (usually due to one adult being away from the dwelling on census night) and these person-years have been excluded from the analysis. Ethnicity was measured using the total response concept (i.e. pesons identifying with more than one ethnic group were counted in each of these ethnic groups). Full details of methods used in the NZCMS have been published elsewhere.[18-20]

Estimation of amenable and total mortality rates, nationally and for subgroups

Amenable causes of mortality were identified using the cause list shown in the appendix for the 2001 dataset, and an earlier version of this list for the 1981-1996 datasets. This earlier code list differs only slightly from the current list, reflecting in part changes from ICD-9 to ICD-10 coding. Amenable and all-cause mortality rates by sex, ethnicity (standardised for age) and equivalised household income tertile (standardised for age and ethnicity) were estimated from the linked datasets. Ethnicity was classified as Māori, Pacific, Asian and European/Other (the latter category is equivalent to non-Māori non-Pacific non-Asian and is non-overlapping, while the former three categories all overlap). Methods for household income equivalisation and thresholds

Table 1: Person-years and deaths available for analysis.

Cohort	Total person-years		Total deaths[a]	
	Male	Female	Male	Female
1981-84	4,191,299	4,299,565	23,424	14,154
1986-89	4,282,082	4,344,705	22,749	13,857
1991-94	4,389,754	4,489,748	21,114	13,032
1996-99	4,585,546	4,726,314	20,070	12,651
2001-04	4,559,230	4,752,266	18,081	12,054

Notes: (a) Weighted for linkage bias, then random rounded to near multiple of three.

Table 2: Person-years available for analysis by ethnic group.

	Cohort	Maori	Pacific	Asian	European/Other	Missing ethnicity
Males	1981-84	520,088 (12.4%)	147,216 (3.5%)	56,198 (1.3%)	3,441,135 (82.1%)	36,563 (0.9%)
	1986-89	537,716 (12.6%)	179,613 (4.2%)	73,347 (1.7%)	3,474,086 (81.1%)	40,614 (0.9%)
	1991-94	565,277 (12.9%)	224,226 (5.1%)	136,498 (3.1%)	3,458,987 (78.8%)	31,601 (0.7%)
	1996-99	700,021 (15.3%)	278,736 (6.1%)	234,359 (5.1%)	3,382,260 (73.8%)	48,007 (1.0%)
	2001-04	671,440 (14.7%)	302,760 (6.6%)	303,631 (6.7%)	3,282,283 (72.0%)	50,711 (1.1%)
Females	1981-84	533,532 (12.6%)	146,203 (3.5%)	53,740 (1.3%)	3,460,700 (81.8%)	45,011 (1.1%)
	1986-89	554,314 (12.8%)	180,515 (4.2%)	74,939 (1.7%)	3,513,766 (80.9%)	44,591 (1.0%)
	1991-94	597,793 (13.3%)	233,779 (5.2%)	139,891 (3.1%)	3,514,862 (78.3%)	30,962 (0.7%)
	1996-99	736,216 (15.6%)	289,093 (6.1%)	255,834 (5.4%)	3,458,371 (73.2%)	45,491 (1.0%)
	2001-04	715,532 (15.1%)	315,869 (6.6%)	339,156 (7.1%)	3,390,384 (71.3%)	43,635 (0.9%)

Note: The sum of the row percentages is greater than 100% as total groupings are used for Maori, Pacific and Asian.

for income tertiles are provided elsewhere.[9] Standardisation was done by the direct method with the WHO world population[11] and the New Zealand 2001 Census providing the age and ethnic reference populations respectively. Ethnic mortality rates were not standardised for income, as socio-economic position is a mediator – not a confounder – of the ethnicity-mortality association.[21]

'Measures of inequality' calculated were the standardised rate difference (SRD) and – for income inequality only – the regression-based equivalent of this measure, the slope index of inequality (SII).[12] The latter makes use of all data, not just data from the extreme groups, and is sensitive to variation in the size of the groups over time, but can be estimated only for groups that can be hierarchically ordered.

'Health care contribution' was then estimated as the ratio of SRDs or (for income groups) SIIs for amenable to all-cause mortality. Ninety-five per cent confidence intervals for all ratios were estimated by simulation. The means of amenable and all-cause mortality SRDs or SIIs by gender and ethnicity were simulated through 1,000 iterations assuming a binomial distribution. The SRD or SII ratios were then calculated using these 1,000 estimates, and 95% CIs were obtained from the 2.5th and 97.5th percentiles of the ratios.

Results

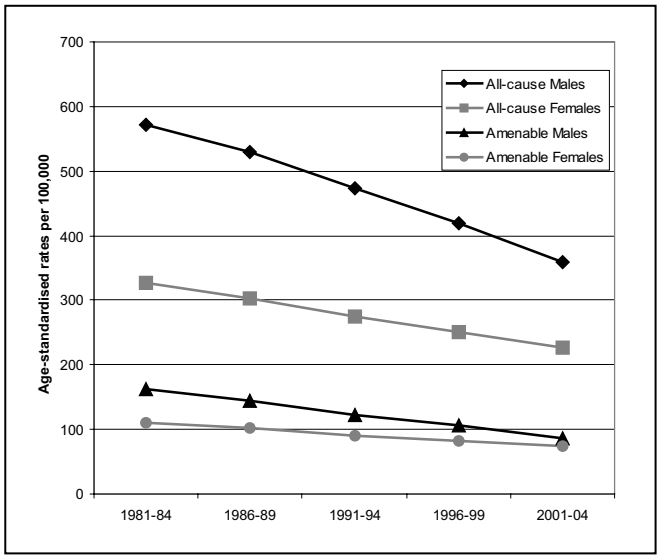
Contribution of health care to health gain

Total population

All-cause and amenable mortality rates, standardised for age, are shown in Figure 1. Figure 2 compares the first (1981-84) and last (2001-04) periods. A key is provided for Figure 2 and all similar figures.

In 1981-84 amenable causes accounted for 28.4% (95% CI 27.4%-29.5%) and 33.5% (32.0%-35.1%) of all mortality in the age range 1-74 years among males and females respectively. By 2001-04, these proportions had declined to 24.1% (22.9%-25.2%) and 32.3% (30.6%-34.2%), due to a greater relative decline in amenable than all-cause mortality. Consequently, the contribution of amenable to all-cause mortality fell by 15.1% for males and 3.6% for females over the 23 year observation period.

Figure 1: Standardised mortality rates, total population 1-74 years, 1981-84 to 2001-04.



Ethnic populations

Figures 3 reproduces Figure 2 for each ethnic group separately.

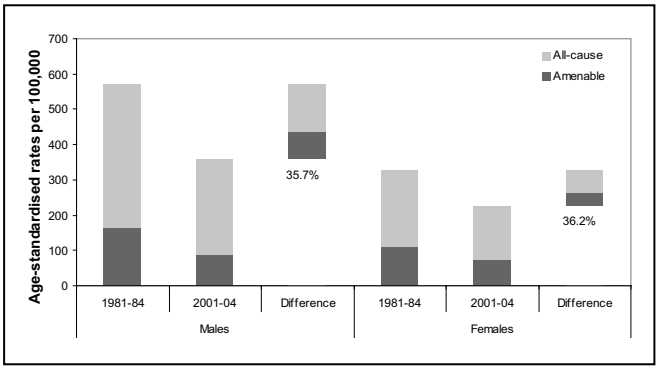
In 1981-84 amenable causes accounted for 25.2% (95% CI: 22.7%-27.9%) and 29.5% (25.9%-32.8%) of all mortality in the age range 1-74 years among Māori males and females respectively. Amenable mortality declined faster than all-cause mortality among Māori males and females, such that by 2001-04, amenable causes comprised 23.8% (21.6%-26.0%) and 28.9% (26.1%-31.7%) of all deaths in the age range 1-74 years respectively.

Decreases in amenable causes contributed almost one-third of the decline in all-cause mortality over the 23 year observation period in Māori (29.8 % [25.1%-34.9%] in males and 31.6% [25.6%-38.1%] in females).

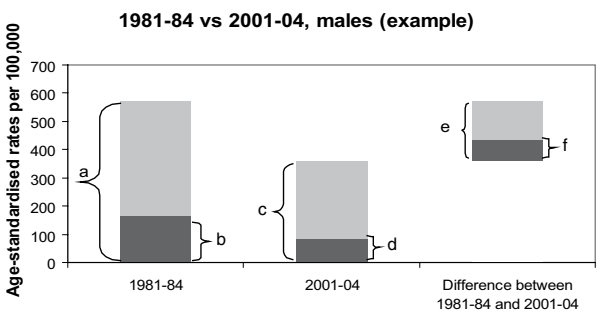
Pacific

In 1981-84 amenable causes accounted for 22.6% (95% CI: 17.8%-27.6%) and 27.1% (20.1%-34.9%) of all mortality in the age range 1-74 years among Pacific males and females respectively.

Figure 2: Standardised rate differences, total population 1-74 years, 1981-84 vs 2001-04.

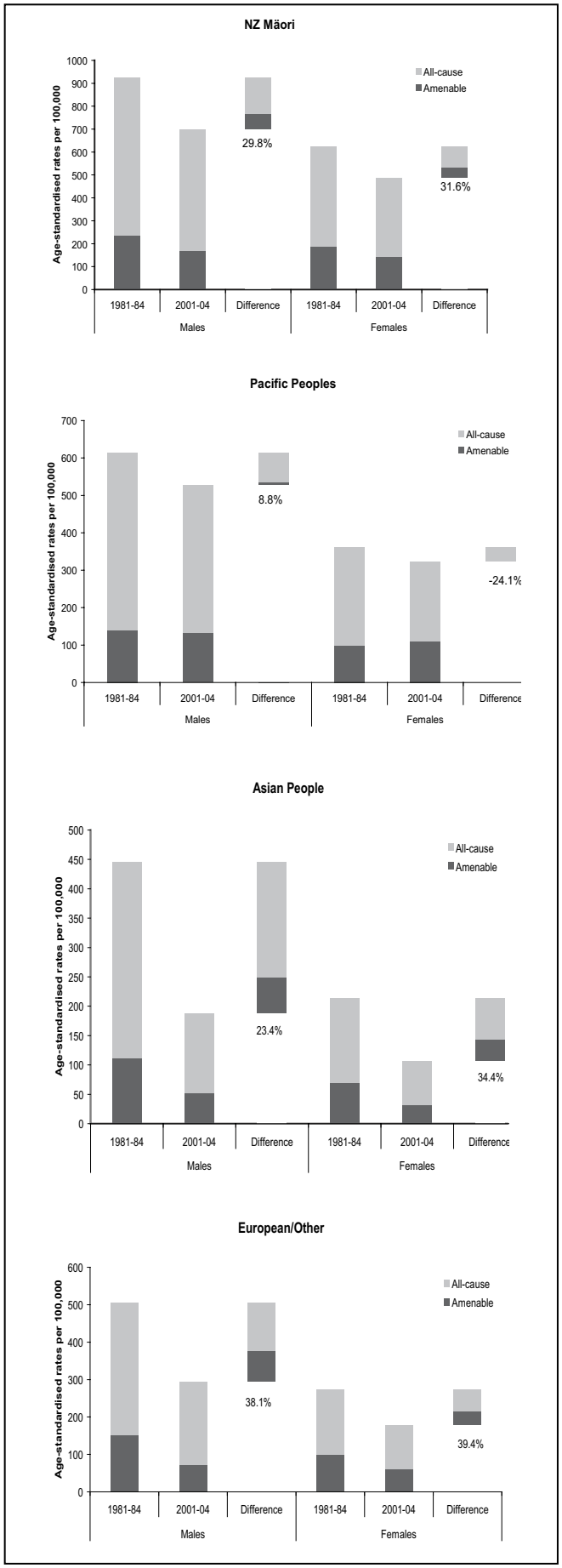


Key to figure 2 and similar figures.



a *= All-cause mortality rate in 1981-84*
b *= Amenable mortality rate in 1981-84*
c *= All-cause mortality rate in 2001-04*
d *= Amenable mortality rate in 2001-04*
e *= a-c (difference in all-cause mortality rates, 2001-04 – 1981-84)*
f *= b-d (difference in amenable mortality rates, 2001-04 – 1981-84)*
g *= (b-d) / (a-c) (this is the amenable mortality contribution to health gain [or health inequality])*

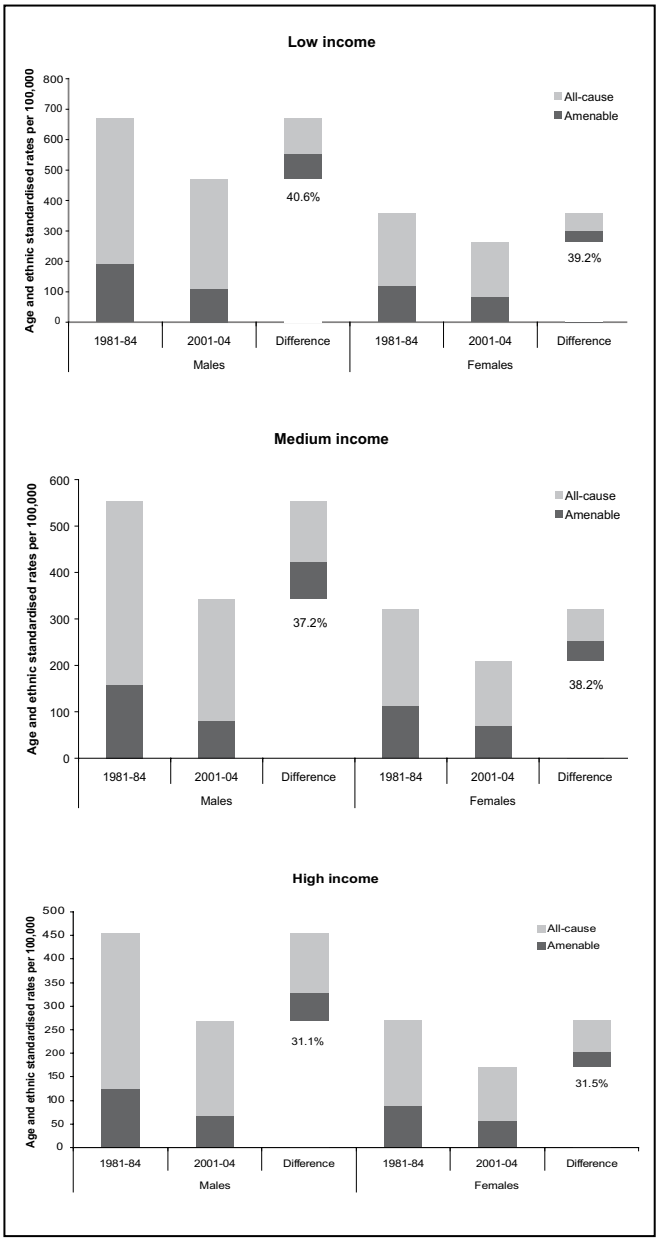
Figure 3: Standardised rate differences, ethnic populations, ages 1-74 years, 1981-84 vs 2001-04.



All-cause mortality declined faster than amenable mortality among Pacific males (although the decline in both was small), such that by 2001-04, the latter accounted for 24.9% (21.2%-28.6%) of deaths in the age range 1-74 years. Among Pacific females the trend was even less favourable, with all-cause mortality declining by only 10% while amenable mortality increased by 12%. Thus, Pacific peoples do not show statistically significant trends in age standardised amenable mortality rates over the observation period. Note however, the relatively wide confidence intervals for Pacific people's rates, especially in the early 1980s.

Given this level of imprecision, all that can be said is that amenable causes contributed little (if at all) to the relatively small decline observed in all-cause mortality over the 23 year observation period in Pacific peoples.

Figure 4: Standardised rate differences, income groups, ages 1-74 years, 1981-84 vs 2001-04.



Asian

In 1981-84 amenable causes accounted for 24.9% (95% CI: 15.4%-37.0%) and 32.1% (14.3%-54.5%) of all mortality in the age range 1-74 years among Asian males and females respectively. All-cause mortality declined faster than amenable mortality among Asian males, such that by 2001-04, the latter accounted for 27.1% (20.6%-34.0%) of deaths in the age range 1-74 years. This was not the case for females, among whom the amenable proportion declined to 29.9% (21.7%-40.0%). As with Pacific people, wide confidence intervals preclude precise interpretation.

European/Other

In 1981-84 amenable causes accounted for 29.9% (95% CI 28.7%-31.2%) and 35.8% (33.8%-37.9%) of all mortality in the age range 1-74 years among European/Other males and females respectively. By 2001-04 these proportions had fallen to 24.0% (22.5%-25.5%) and 33.9% (31.6%-36.2%) of deaths in the age range 1-74 years respectively, relative improvements of approximately 20% for males and 5% for females. Amenable causes contributed close to 40% of the substantial decline in all-cause mortality over the 23 year observation period in both European/Other males and females.

Socio-economic (income) groups

Figure 4 reproduces Figure 2 for each income tertile separately.

Figure 4 shows that all-cause mortality declined relatively faster in high than in low income groups (i.e., 41% and 37% reductions in high versus 30% and 27% reductions in low income males and females respectively). This reflects much greater relative improvements in non-amenable mortality in high compared to low income groups, offset by lesser relative improvements in amenable mortality in the former versus the latter group. Thus amenable causes contributed approximately 40% of the decline in all-cause mortality over the quarter century in low and middle income males and females, but only approximately 30% in their high income counterparts.

Contribution of health care to health inequalities

Ethnic inequalities

Because of space limitations, we do not show these results graphically, but only in summarised tabular form (Table 3; a key is also provided for this table and Table 4). Note that the health care contribution is estimated for two time periods only: 1981-84 and 2001-04; results are available from the first author for the intervening time periods but are not shown here. Trends in the health care contribution to health inequality over time are not quantified as the path was not linear. Rather, the focus of this report is on the current situation (2001-04). The reference group in each case is the European/Other ethnic group.

In 2001-04, amenable mortality contributed 23.6% and 26% to the Māori:European/Other health gap for males and females respectively, up from 19.6% and 24.6% respectively in 1981-84.

Pacific:European/Other inequality

Here we see the emergence of inequality in amenable mortality. Thus, in 1981-84, amenable mortality rates (adjusted for age) were either identical (females) or lower (males) among Pacific than European/Other ethnic groups (this is not due to numerator-denominator bias leading to undercounting of Pacific rates, as the linked dataset eliminates such bias). By 2001-4, however,

Table 3: Contribution of amenable mortality to the ethnic gaps in mortality, ages 1-74 years, 1981-84 and 2001-04.

		Male			Female		
		All-cause SRD	**Amenable SRD**	**Contrib %**	**All-cause SRD**	**Amenable SRD**	**Contrib %**
M:E	1981-84	418 (364-472)	82 (55-109)	19.6 (16.3-23.0)	354 (310-397)	87 (64-110)	24.6 (20.3-29.0)
	2001-04	403 (373-433)	95 (81-110)	23.6 (20.8-26.5)	311 (287-334)	81 (68-93)	26.0 (22.7-29.5)
	Δ	15	-13		43	6	
P:E	1981-84	107 (13-201)	-13 (-60-34)	-10.8 (-0.4 - -19.6)	88 (22-154)	0 (-34-34)	0.0 (0.0-0.0)
	2001-04	233 (192-274)	61 (40-81)	26.2 (20.5-32.6)	145 (116-175)	49 (32-67)	33.8 (26.4-43.3)
	Δ	-126	-74		-57	-49	
A:E	1981-84	-61 (-159-38)	-40 (-91-10)	65.6 (23.5-150.0)	-60 (-124-5)	-29 (-65-7)	48.3 (13.3-233.3)
	2001-04	-107 (-128-85)	-20 (-31-8)	18.7 (11.2-26.4)	-72 (-87-57)	-29 (-37-21)	40.3 (27.4-55.4)
	Δ	46	-20		12	0	

Notes: Rate differences are per 100,000
M:E = Maori : European/Other P:E = Pacific : European/Other A:E = Asian : European/Other
Δ = absolute change in SRD from 1981-84 to 2001-04

Key to Table 3 and similar tables (example: M:E males)

The SRD is the difference between the age standardised mortality rates for Maori and European ethnic groups (eg 418 per 100,000 for all-cause and 82 per 100 000 for amenable mortality among males in 1981-84).

The contribution % is the ratio of the SRD for amenable to the SRD for all-cause mortality (19.6% in 1981-84 and 23.6% in 2001-04 for males). This estimates the contribution of amenable mortality (in this case, to health inequality between Maori and European ethnic groups).

The final row Δ shows the absolute change in all-cause SRD (15 per 100 000) and amenable SRD (-13 per 100,000) between the two time periods. A positive number represents a decrease in SRD from 1981-84 to 2001-04 and a negative number represents an increase.

Pacific amenable mortality rates were higher than European/Other for both sexes due to the more rapid fall in amenable mortality among the European/Other ethnic group, such that amenable causes accounted for 26.2% and 33.8% of the total mortality gap for males and females respectively.

Asian:European/Other inequality

Throughout the observation period, Asian mortality has been lower than European/Other, for all causes and for amenable causes. Perhaps the most interesting point to note is that, while the all-cause SRD has become more favourable towards Asians over the observation period, the amenable SRD has either remained stable (females) or become less favourable (males). That is, the gap between Asian and European/Other ethnic groups has widened over the observation period, but none of this (further) change can be attributed to amenable causes.

Income inequalities

Absolute inequality between income groups is measured via both the SRD and the SII (the latter being sensitive to changes in the population income distribution) (Table 4).

For the SRD, the comparison shown is between the low and the high income group, with the latter as the reference group. Note that rates are standardised for both age and ethnicity.

Amenable causes of death contributed 20.8% and 27.4% to socio-economic inequality in all-cause mortality in 2001-04 for males and females respectively (when measured by the ratio of amenable to all-cause mortality SII). This was a reduction from the 28.4% and 32.6% contributed in 1981-04 for males and females respectively.

Discussion

Contribution of trends in amenable mortality to health gain over the past quarter century

Reductions in amenable causes accounted for approximately one third of the mortality decline in New Zealand over the past quarter century. The relative contribution did not vary greatly by ethnic group – with one exception: amenable mortality accounted for little of the gain in survival of the Pacific population over this period. However, as the reduction in all-cause mortality for Pacific people was only modest, and given the relatively small size of this population, precise estimation of the contribution of amenable causes is not possible for this ethnic group.

Reductions in amenable relative to reductions in all-cause mortality also did not vary widely by socio-economic group. If anything, there was a possible trend for this contribution to be highest in the low income group (40%), followed by the middle income group (38%) and finally the high income group (31%).

Contribution of amenable mortality to current health inequalities

Ethnic inequalities

The key finding is that amenable mortality makes a substantial contribution to the Māori – European/Other and Pacific – European/Other health gaps, accounting for about one quarter of these disparities at present. Among Asian peoples, the disparity is in the opposite direction, but amenable causes once again contribute about one third of this.

Socio-economic inequality

Our findings show that amenable causes also make an important contribution to the mortality differentials between socio-economic groups, accounting for approximately one quarter of the income mortality gradient overall (once adjusted for age and ethnicity) – slightly less for males and slightly more for females.

Comparison with other studies

While many studies have examined trends and contrasts in amenable mortality,[17] only one other study to our knowledge has used this information to quantify the contribution of health care to health status.[14] Mackenbach estimated that 5-19% of the gain in life expectancy in the Netherlands from 1875 to 1970 could be attributed to health care, with the proportion increasing in more recent decades.

Table 4: Standardised rate difference, slope index of inequality and income health inequality contribution estimates, ages 1-74 years, 1981-84 and 2001-04.

			1981-04	2001-04	Change	% Change
Male	SRD	All-cause	215 (183-248)	202 (182-222)	13	6.0
		Amenable	65 (49-81)	42 (33-52)	23	35.4
		Contribution	30.2 (28.4-32.1)	20.8 (19.5-22.2)		
	SII	All-cause	331 (244-418)	313 (243-382)	18	5.4
		Amenable	94 (62-126)	65 (44-86)	29	30.9
		Contribution	28.4 (27.1-29.8)	20.8 (19.6-21.9)		
Female	SRD	All-cause	87 (59-115)	92 (77-106)	-5	-5.7
		Amenable	30 (17-44)	25 (17-32)	5	16.7
		Contribution	34.5 (31.7-38.0)	27.2 (24.4-29.2)		
	SII	All-cause	135 (99-172)	157 (143-171)	-22	-16.3
		Amenable	44 (36-52)	43 (35-51)	1	2.3
		Contribution	32.6 (30.3-35.0)	27.4 (25.6-29.2)		

Note: Contribution = amenable / all-cause mortality rate in each time period

Bunker and colleagues made use of a slightly different approach, which they called the 'inventory' approach.[15] This consisted of estimating the efficacy of all major health care innovations and their coverage (dissemination) over time, so allowing their individual impacts on life expectancy to be estimated and summed. The inventory approach yielded broadly consistent results for the US, with health care estimated to account for approximately one-sixth of the life expectancy gain over the 20th century, increasing to one-third or more over the past quarter century. With regard to cardiovascular mortality alone, several authors including ourselves have estimated that at least one quarter to one half of the recent decline is attributable to medical care.[13]

Thus, at least three studies (including ours) have provided reasonably consistent estimates (ranging from approximately one fifth to one third) for the recent contribution of health care to health gain, allowing for differences in study design.

Our study is unique, however, in going further and attempting to identify whether all important subgroups of the population benefited to the same extent from health care. Comparing income groups, our results are reassuring: if anything, low income people in New Zealand benefited more from health care over the past quarter century than did their high income counterparts. Of course, this may simply reflect their respective baseline positions i.e., low income people may have had more to gain. Nevertheless, this finding is reassuring in that it suggests an absence of significant institutional discrimination in the health care system on the basis of social class. However, with respect to ethnic groups our results are less sanguine. Both Māori and Asian people benefited less than European/Others (albeit only slightly), while Pacific peoples gained little benefit from health care (and indeed showed less improvement in mortality from all causes than the other ethnic groups).

The only other study we are aware of that used a similar approach to estimate the contribution of health care to social inequalities in health, was an ecological time series analysis carried out earlier by ourselves.[16] Despite the difference in study design, in choice of socio-economic measure (small area deprivation instead of equivalised household income) and in time period (2000-02 instead of 2001-04), the results of that study and this study (based on individual level microdata from mortality-census linked datasets) are highly consistent. Overall, the current estimates are slightly lower than the earlier estimates (typically a few percentage points), but the patterns are identical (e.g. higher contribution in females than males, higher contribution for ethnic than income inequalities, higher contribution for Pacific-European/Other than Māori-European/Other inequalities). The fact that two entirely separate study designs have provided similar estimates for the contribution of health care to health inequalities should increase confidence in the reliability of these estimates.

While we have presented estimates for the health care contribution to health inequalities for both the beginning and the end of the observation period, we have not attempted to quantify the path taken between these time points (although the estimates for the remaining time points are available from the first author on request). This is because the pathway has tended not to be smooth, with an apparent steepening of the trend for all groups – including Pacific peoples – from 1996-99 to 2001-04, so resisting simple summarisation. Instead, we prefer to focus attention on the contribution of health care – and hence the health sector – to current health inequalities.

Strengths and limitations

This study has several major strengths. Being based on individual level microdata it is free of cross level bias. Linkage of mortality to census data permits use of individual or household measures of socio-economic position (such as equivalised household income) rather than having to rely on small area measures of deprivation. Most importantly, the linked dataset removes numerator-denominator bias, a phenomenon that previously led to substantial undercounting of Māori and Pacific deaths.

At the same time, our study – like all studies – has several weaknesses that should be borne in mind when interpreting and applying the results. At the technical level, about 20% of deaths could not be linked to a census record, and income data was missing for about 15% of households. However, the use of linkage weights has been shown to be effective in controlling linkage bias, and sensitivity analysis shows that the missing income data has not introduced serious bias either (data not shown).

At the conceptual level, our indicators – being confined to mortality – are obviously limited in their coverage of the domain of 'health' and 'health care'. Yet premature mortality offers some advantage as a metric, both in terms of the salience and the quality of the data. Also, while categorical attribution of most causes of death as 'amenable' or 'not amenable' is straight forward, this is not the case for others – especially for a time series (i.e. some causes classified as amenable in 2001-04 should not have been so classified in 1981-84 given the state of health care technology pertaining at that time). However, this limitation is less problematic from an inequalities perspective (provided the same list of conditions is used for all groups being compared), since the focus then is on contrasts between ethnic groups rather than on absolute levels of mortality. The distinction between 'amenable' and 'avoidable (but not amenable)' causes of death is also sometimes problematic; this may again have led us to under-estimate the contribution of health care to health gain.

Finally, amenable mortality could be criticised as an indicator of health care contribution in that a trend or disparity in amenable mortality may (potentially) reflect trends in disease incidence rather than trends in case fatality. That is, we assume that trends in amenable causes largely reflect trends in medical treatment (case fatality) and conversely that trends in avoidable but non-amenable causes largely reflect trends in disease incidence. Also, the estimated amenable mortality rate represents the sum of different component disease rates – some of which may be trending differently to others. Once again, this source of bias is likely to be less problematic for estimation of the health care contribution to health inequality at one point in time than for estimation of the contribution of health care to overall health gain over time.

So our estimates for the contribution of health care to health inequalities (whether ethnic or socio-economic) are likely to be more robust than are our estimates for the overall contribution of health care to health gain over the observation period. More sophisticated statistical models could be built to control for confounding by disease incidence and shifts in health care technology over time, if the necessary data could be collected.

Interpretation and policy implications

Health care contribution to health gain

Despite these limitations, our finding that health care contributed approximately one-third of the dramatic gain in health made by the New Zealand population over the past quarter century (approximately two years out of a six year gain in life expectancy) is a finding of considerable policy interest. Furthermore, this information helps to justify the substantial expansion in health care expenditure that occurred over this period.

Also of importance is the finding that this contribution was similar for all ethnic and income groups – with the exception of Pacific peoples. Unlike all other groups examined, Pacific peoples experienced relatively little decline in all-cause mortality in the age range 1-74 years over the past quarter century (approximately 12%) – and hardly any decline at all in amenable mortality. Why Pacific peoples appear to have experienced less mortality improvement (both for amenable and for non-amenable causes) over this period than the other ethnic groups is unclear and warrants further investigation. The first step is to drill down to specific causes, especially within the amenable category. This reveals, for example, that coronary heart disease mortality fell by only 14% among Pacific males compared to 63% among nonPacific males (data not shown). Further analysis should identify the relative contributions of incidence reduction versus case fatality reduction to this trend, and so point the way towards necessary improvements in access to, and quality and cultural safety of, the relevant primary and secondary health care services.

Health care contribution to health inequality

Our finding that health care makes a substantial contribution to both ethnic and socio-economic inequalities in health (accounting for at least one quarter of the current inequalities in each case), contradicts claims that structural change is the only effective strategy for reducing such inequalities. Instead, our results imply that improvements in access to and quality of health care for disadvantaged or marginalised groups could substantively reduce health inequalities between them and their more privileged counterparts. Furthermore, this is a strategy that does not require major structural change, is within the power of the health sector to implement on its own, and could be highly cost-effective.

At the same time, we do not wish to imply that access to (and navigation through) health care, as well as the quality of the health care provided, are not themselves shaped by upstream social structural, economic and cultural influences. Rather, a joint strategy that focuses simultaneously on both intra- and inter-sectoral change is likely to be the most successful in reducing health inequalities.

Acknowledgements

This study is an output of the New Zealand Census – Mortality Study, previously funded by the Health Research Council of New Zealand and receiving ongoing funding from the Ministry of Health. Access to the data used in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics New Zealand. The authors gratefully acknowledge technical assistance from June Atkinson and useful discussions with Tony Blakely, both of the University of Otago. This report is published with the approval of the Deputy Director-General of Health (Health and Disability Sector Strategy). However, views expressed are the authors' own, and do not necessarily reflect policy advice of the Ministry.

References

1. Organisation for Economic Development and Coordination. *Health at a Glance 2007.* Paris (FRC): OECD; 2007.
2. Blank RH, Burau V. *Comparative Health Policy*. New York (NY): Palgrave Macmillan; 2004.
3. World Health Organization. *The World Health Report 2000. Health Systems: Improving Performance.* Geneva (CHE): WHO; 2000.
4. Ministry of Health. *The New Zealand Health Strategy*. Wellington (NZ): Government of New Zealand; 2000.
5. Nolte E, McKee M. Measuring the health of nations: how much is attributable to health care? An analysis of mortality amenable to health care. *BMJ.* 2003;327:1129-32.
6. Page A, Tobias M, Glover J, et al. *Australian and New Zealand Atlas of Avoidable Mortality*. Adelaide (AUST): University of Adelaide; 2006.
7. Tobias M, Jackson G. Avoidable mortality in New Zealand, 1981-97. *Aust N Z J Public Health.* 2001;25:12-20.
8. Nolte E, McKee M. *Does Healthcare Save Lives?* London (UK): The Nuffield Trust; 2004.
9. Blakely T, Tobias MI, Atkinson J, et al. *Tracking Disparity*. Wellington (NZ): Ministry of Health; 2007.
10. Jensen J. *Income Equivalences and the Estimation of Family Expenditure on Children*. Wellington (NZ): Department of Social Welfare; 1988.
11. World Health Organization. *Age Standardisation of Rates: A New WHO Standard*. Geneva (CHE): WHO; 2000. GPE Discussion Paper No.: 31.
12. Mackenbach J, Kunst A. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures. *Soc Sci Med.* 1997;44:757-71.
13. Tobias M, Taylor R, Yeh L, et al. Did it fall or was it pushed? The contribution of trends in established risk factors to the decline in coronary heart disease mortality in New Zealand. *Aust N Z J Public Health.* 2008;32:117-25.
14. Mackenbach JP. The contribution of medical care to mortality decline. McKeown revisited. *J Clin Epidemiol.* 1996;49:1207-13.
15. Bunker J. *Medicine Matters After All. Measuring the Benefits of Medical Care, A Healthy Lifestyle, and a Just Social Environment*. London (UK): The Stationery Office; 2001. Nuffield Trust Series No.: 15.
16. Tobias M, Yeh L-C. How much does health care contribute to health inequality in New Zealand? *Aust N Z J Public Health.* 2007;31:207-10.
17. Korda RJ. Butler JR. Effect of healthcare on mortality: Trends in avoidable mortality in Australia and comparisons with Western Europe. *Public Health.* 2006;120:95-105.
18. Blakely T, Atkinson J, Fawcett J. Ethnic counts on mortality and census data (mostly) agree for 2001-04: New Zealand Census-Mortality Study update. *N Z Med J*. 2008;121(1281).
19. Blakely T, Tobias M, Robson B, et al. Widening ethnic mortality disparities in New Zealand 1981-99. *Soc Sci Med*. 2005;61(10):2233–51.
20. Blakely T, Salmond C. Probabilistic record linkage and a method to calculate the positive predictive value. *Int J Epidemiol.* 2002;31:1246-52.
21. Blakely T, Fawcett J, Hunt D, et al. What is the contribution of smoking and socioeconomic position to ethnic inequalities in mortality in New Zealand? *Lancet.* 2006;368:44-52.

Appendix: Amenable causes of death

Condition	ICD-9 codes	ICD-10 codes	Comments
Tuberculosis	010-018,137	A15-A19, B90	
Selected invasive bacterial infections	034-036, 038, 084, 320, 481-482, 485, 681-682	A38-A41, A46, A48.1, B50-B54, G00, G03, J02.0, J13-15, J18, L03	
Colorectal cancer	153, 154	C18-C21	
Melanoma of skin	172	C43	
Nonmelanotic skin cancer	173	C44	
Breast cancer	174	C50	Females only
Uterine cancer	179, 182	C54-C55	
Cervical cancer	180	C53	
Bladder cancer	188	C67	
Thyroid cancer	193	C73	
Hodgkins disease	201	C81	
Leukemia	204-208	C97-C95	<45 years
Benign tumours	210-229	D10-D36	
Thyroid disorders	240-246	E00-E07	
Diabetes (type 2)	250	E10-E14	50% *
Epilepsy	345	G40-G41	
Rheumatic and other valvular heart disease	390-398	O01-I09	
Hypertensive heart disease	402	I11	
Ischaemic heart disease	410-414	I20-I25	50% *
Cerebrovascular diseases	430-438	I60-I69	50% *
Nephritis and nephrosis	403, 580-589, 591	I12-I13, N00-N09, N17-N19	
Obstructive uropathy and prostatic hyperplasia	592, 593.7, 594, 598, 599.6, 600	N13, N20-N21, N35, N40, N99.1	
Chronic Obstructive Pulmonary disease	490-492, 496	J40-J44	>45 years
Asthma	493	J45-J46	<45 years
Peptic ulcer disease	531-534	K25-K28	
Acute abdomen, appendicitis, intestinal obstruction, cholecystitis / lithiasis, pancreatitis, hernia	540-543, 550-553, 574-577	K35-K38, K40-K46, K80-K83, K85-K86, K91.5	
Birth defect	740-759	H31.1, P00, P04, Q00-Q99	
Complications of perinatal period	764-779	P03, P05-P95	

** 50% of cases are considered to be amenable (the remainder being avoidable)*