

non-manual to manual ratio for all neoplasms combined was high (1.71) compared to England & Wales (1.21) and in Finland (1.39) (Kunst et al. 1998d).

In contrast relative inequality for deaths due to accidents is high in many countries but again the level of inequality varies by country. For example inequality by education was much higher in Hungary and Finland than in England and Wales (Valkonen 1987; Valkonen 1989) and by occupational class in Portugal (Kunst et al. 1998d).

Cardiovascular diseases are of particular interest as both a major cause of death and a disease which socioeconomic position is strongly associated with mortality in many countries. Furthermore substantial declines in cardiovascular mortality rates in many countries mean that the contribution of cardiovascular mortality to overall inequality is changing.

Different occupational class mortality gradients are observed for ischaemic heart disease, cerebrovascular disease and other cardiovascular diseases (Table 2-13). Within Europe during the 1980s there was a strong North-South gradient. Gradients of mortality are strongest in the northern countries where ischaemic heart disease causes over 25% of all deaths – Finland, Sweden, Norway, Denmark, England and Wales and Ireland. In the countries for whom the manual: non-manual rate ratio for ischaemic heart disease mortality were either close to 1.0 or less than 1.0, ischaemic heart disease was a much less important cause of death (Kunst et al. 1999; Kunst et al. 1998d).

The North-South gradient was most marked for men aged 30-44 years but was less obvious for men aged 60-64 years as a consequence of lower rate ratios at these ages in the northern European countries (Mackenbach et al. 1999).

**Table 2-13 Ischaemic Heart Disease (IHD) Mortality Rate Ratios Comparing Manual Classes with non-Manual Classes among men aged 30-44, 45-59 and 60-64 Years at Death**

Country	Rate Ratio (95% CI)		
	30-44 years	45-59 years	60-64 years
Finland	1.91 (1.72, 2.12)	1.47 (1.41, 1.53)	1.26 (1.19, 1.33)
Sweden	1.80 (1.52, 2.15)	1.36 (1.31, 1.41)	
Norway	1.77 (1.55, 2.03)	1.35 (1.28, 1.43)	1.26 (1.19, 1.33)
Denmark	1.52 (1.35, 1.71)	1.28 (1.22, 1.34)	1.16 (1.10, 1.22)
England & Wales	1.68 (1.16, 2.44)	1.50 (1.32, 1.71)	1.26 (1.10, 1.45)
Ireland	1.42 (1.12, 1.80)	1.23 (1.12, 1.35)	... <sup>a</sup>
France	1.18 (1.08, 1.30)	0.96 (0.92, 1.00)	... <sup>a</sup>
Switzerland	1.03 (0.83, 1.29)	0.96 (0.95, 1.04)	1.07 (0.98, 1.18)
Italy (Turin)	1.35 (0.97, 1.88)	1.08 (0.95, 1.22)	0.85 (0.69, 1.06)
Spain	... <sup>a</sup>	0.98 (0.94, 1.03)	... <sup>a</sup>
Portugal	0.82 (0.66, 1.03)	0.76 (0.69, 0.84)	... <sup>a</sup>
United States	1.32 (0.91, 1.92)	1.25 (1.08, 1.44)	1.22 (1.03, 1.45)

Source Mackenbach et al. 1999, Table 2. <sup>a</sup>data not available.

When IHD mortality inequalities by educational levels were considered European countries were ranked the same as for occupational class (Kunst 1997:page 167). However, whereas inequality by occupational class for the United States was lower than in northern Europe, inequality according to educational level was of a similar magnitude (Table 2-14).

**Table 2-14 The size of IHD mortality differences associated with educational level. Men, 20-44 and 45-59 years at start of follow-up.**

Country	20-44 years	45-59 years
	RII (95% CI)	RII (95% CI)
Finland	3.62 (3.19 - 4.12)	2.12 (1.98 - 2.27)
Norway	3.63 (3.19 - 4.12)	2.05 (1.91 - 2.21)
Denmark	3.32 (3.19 - 4.12)	1.83 (1.69 - 1.98)
Italy	3.48 (3.19 - 4.12)	1.51 (1.13 - 2.02)
United States	3.35 (3.19 - 4.12)	2.21 (1.81 - 2.70)

Source Kunst (1997:page 167).

When stroke mortality was considered (Kunst 1997; Kunst et al. 1998a). The rate differences were highest for Ireland, England and Wales, Finland and Portugal. Manual:non-Manual Rate ratios were highest for England and Wales, Ireland and Finland (Table 2-15). Rate ratios are largest for younger men, aged 30-44 and least for men aged 60-64 years. These results suggest that the north south gradient that exists for ischaemic heart disease within Europe is not as evident for stroke. As with IHD when considered by educational level the ranking of countries was similar to that for occupational class gradients except that the United States has relatively high inequality by educational level compared with occupational class.

**Table 2-15 Stroke mortality by occupational class: manual vs. non-Manual rate ratios for men aged 30-44, 45-49 and 60-64 Years at Death and Absolute rate differences for manual and Non-manual classes, men aged 45-59 at death.**

Country	Rate Ratio (95% CI)			Rate Difference
	30-44 years	45-49 years	60-64 years	45-59 years
United States	1.56 (0.65-3.74)	1.42 (0.95-2.20)	1.02 (0.63-1.70)	12
England & Wales	4.23 (1.53-12.3)	1.74 (1.23-2.48)	1.51 (1.10-2.10)	24
Ireland	1.33 (0.85-2.13)	1.57 (1.23-2.03)	... <sup>a</sup>	19
Finland	1.75 (1.50-2.06)	1.55 (1.40-1.71)	1.33 (1.15-1.55)	28
Sweden	1.18 (0.86-1.63)	1.31 (1.18-1.45)	... <sup>a</sup>	9
Norway	2.01 (1.49-2.73)	1.21 (1.04-1.41)	1.19 (1.02-1.38)	6
Denmark	1.66 (1.35-2.06)	1.28 (1.14-1.43)	1.06 (0.93-1.20)	9
France	1.36 (1.21-1.53)	1.35 (1.27-1.43)	... <sup>a</sup>	13
Switzerland	0.97 (0.62-1.52)	1.43 (1.18-1.74)	1.27 (1.02-1.59)	8
Italy (Turin)	1.16 (0.69-2.00)	1.24 (1.00-1.54)	0.82 (0.61-1.17)	11
Spain	... <sup>a</sup>	1.18 (1.10-1.27)	... <sup>a</sup>	8
Portugal	1.34 (1.03-1.77)	1.44 (1.29-1.61)	... <sup>a</sup>	31

Source Adapted from Kunst (1998c), Tables 3 and 4. <sup>a</sup>data not available

## 2.5.2 Comparisons over time.

Changes over time in socioeconomic inequalities have been investigated within a number of countries. In this section I review studies of trends in mortality by socioeconomic status, with a particular focus on all cause and cardiovascular disease mortality. I consider trends in Europe, the United States and Australia.

Most Western countries enjoyed substantial gains in life expectancy post World War II. Throughout this period cardiovascular mortality was a major contributor to overall mortality. Background trends in mortality from cardiovascular causes are therefore fundamental to understanding the changing socioeconomic patterns of inequality in mortality. Overall mortality rates from coronary heart disease increased in many western countries in the period from 1930 to around the mid-1960s. The epidemic was much more pronounced for males than for females, with little if any evidence of any increase in mortality among women in many countries post World War II (Lawlor et al. 2001). In contrast stroke mortality trends vary with general declines in haemorrhagic stroke since the early twentieth century, but a peak in cerebral infarction mortality during the mid-twentieth century (Lawlor et al. 2002).

The point of onset of the mortality decline for cardiovascular diseases varied in different countries (Beaglehole 1990; Beaglehole et al. 1981; Beaglehole et al. 1997; Pearce et al. 2002; Pearce et al. 1993; Thom et al. 1985; Uemura and Pisa 1988). Furthermore there is evidence of substantial heterogeneity between countries with regard to the impact of changing incidence and changing case-fatality rates on the changing mortality rates (Tunstall-Pedoe et al. 1999; Tunstall-Pedoe et al. 2000)).

### 2.5.2.1 *The United Kingdom*

#### (1) *All Cause Mortality*

The longest series of data available on socioeconomic variation in mortality are the British decennial supplements, which have published mortality rates by social class since 1921. These studies are based on cross-sectional analyses of occupational class gradients in mortality for the years close to each census. At face value these studies suggest a widening of social class gradient over time (Townsend et al. 1988). However problems inherent in

these cross-sectional occupational class studies led to considerable debate about the validity of these trends. Critiques drew attention to, numerator-denominator bias, health selection effects, the changing size and definition of the social classes and the measures of inequality used (Illsley 1990; Illsley and Baker 1991; Pamuk 1985; Valkonen 1987; Valkonen 1993).

In order to take account of the changing size of the social classes between 1920 and 1972, Pamuk (1985) reanalysed the social class gradients using the slope index of inequality, (adjusted for total mortality) as the measure of inequality. Class inequality among occupied and retired males *decreased* from the 1920s until the 1950s but then began to increase from, reaching levels higher than the 1920s by 1970-72. For married women inequality also increased between 1950-52 to 1970-72. Koskinen (1985) found that the increasing social class gradient over this period was due to a more favourable mortality experience of the higher occupational classes for almost all causes of death.

Studies using similar data reported widening inequalities into the 1980s and early 1990s (Marmot and McDowall 1986). Trends towards widening relative inequality were more pronounced in Scotland than in England and Wales for the period from 1951 to 1981 (Table 2-16). Cardiovascular diseases contributed almost one half, and malignant neoplasms one quarter, to the inequality gradient but the contribution of cause specific mortality to the inequality gradient changed over time and was different in the two countries.

**Table 2-16 Age standardised relative indices of inequality in mortality (RII) and 95% confidence intervals (95%CI) over time in England and Wales and Scotland (men 15-64 years of age)**

Year	RII (95% CI)		Significance of difference between England and Wales and Scotland
	England & Wales	Scotland	
1951	1.40 (1.38-1.42)	1.22 (1.18-1.25)	p<0.001
1961	1.91 (1.88-1.93)	1.82 (1.76-1.87)	p=0.005
1971	1.97 (1.94-2.00)	1.78 (1.73-1.84)	p<0.001
1981	2.43 (2.40-2.47)	2.57 (2.48-2.67)	p=0.006

Source: Marang-van de Mheen (1998)

Although studies using inequality measures such as the RII will not be affected by changes in the size of the social classes, the unlinked analyses are still subject to numerator denominator biases in the unlinked data sets. However linked longitudinal analyses based on the Office of Population Censuses and Surveys Longitudinal Study (OPCSLS) also suggest divergent mortality and life expectancy trends by socioeconomic position - whether

measured by social class, educational level, housing tenure or car access (Filakti and Fox 1995; Fox et al. 1985; Goldblatt 1989; Harding 1995; Hattersley 1997; Hattersley and Office for National Statistics 1999).

The most recent studies confirm widening socioeconomic inequalities throughout the 1990s, on the basis of area level analyses. Shaw et al (1999) report increasing inequality by deprivation level from the 1970s onwards, while an analysis of poverty and mortality in parliamentary constituencies found that relative inequalities in mortality, increased steadily throughout the 1990s (Davey Smith et al. 2002). Inequalities were greatest for 45-64 year old men but increases were greatest for younger men aged 20-44 years.

## (2) *Cardiovascular Diseases*

The issue of whether cardiovascular mortality, and especially heart disease, has always been higher in lower social classes has been a source of considerable debate.

Marmot et al. used the Registrar General's decennial supplements for England and Wales to examine trends in the social class distribution of *nonvalvular* heart disease mortality between 1931 and 1971 (Logan 1954; Marmot et al. 1978). The study found that whereas in 1931 mortality was slightly greater for men in social classes I and II than social classes IV and V, by 1961 mortality was higher among lower social classes, with an increased excess in classes IV and V by 1971. The pattern for women for whom mortality rates throughout the period were consistently higher mortality rates for social classes IV and V compared to classes I and II. The changing mortality ratios between high and low social classes are shown in Table 2-17.

**Table 2-17 Ratio of mortality from non-valvular heart disease (mortality in social class I and II: mortality in social classes IV and V) by age and year of death**

Year of death	Age in Years		
	35-44	45-54	55-64
<i>Men</i>			
1949-53	1.0	1.2	1.2
1959-63	0.7	0.9	1.0
1970-72	0.6	0.7	0.9
<i>Married women</i>			
1949-53	0.5	0.7	0.8
1959-63	0.5	0.6	0.7
1970-72	0.3	0.5	0.6

Source: Marmot (1978).

Studies since the 1970s all show widening social class inequalities for coronary heart disease mortality and cerebrovascular disease mortality by social class continued to widen throughout the 1970s (Marmot and McDowall 1986). Increased inequality was especially notable at younger ages and was greater in Scotland than England and Wales (Marang-van de Mheen et al. 1998).

Several authors have questioned whether there was ever a cross-over in the social class distribution coronary heart disease (Antonovsky 1968). Davey Smith (1997) argues that differences in cause of death coding, as a consequence of differing diagnostic practices for different social groups, together with numerator denominator bias, as a result of occupational misclassification, could explain the apparent cross-over in coronary heart disease mortality in Great Britain. Coronary Heart disease was frequently misclassified on death certification data as other forms of heart disease, cerebrovascular disease, renal and respiratory disease up until the 1950s.

Aggregating cause of death classification to broad groups removes the apparent positive gradient in the early twentieth century, as demonstrated in Table 2-18. The broader cause of death definition, '*Diseases of the Circulatory System*' shows consistent excess mortality for low social classes (Classes VI and V) however the most restricted grouping, '*Coronary Artery Diseases etc*', appears to show a change from an excess in higher social classes to an excess in lower social classes. At the same time *coronary artery disease* accounts for a growing proportion of all heart diseases. This illustration shows the potential importance of changes in cause of death coding, for time trend analyses.

Whether or not coronary heart disease mortality rates were ever higher for higher social classes, there is consistent evidence that both men and women in less advantages socioeconomic positions did not experience the same level of mortality decline for either coronary heart disease or stroke from the 1960s onwards (Davey Smith and Hart 1998; Mackenbach et al. 2003; Marang-van de Mheen et al. 1998; Marmot et al. 1978; Marmot and McDowall 1986; McLoone and Boddy 1994).

**Table 2-18 Cardiovascular disease by social class among men 1911-1981: standardised mortality ratios.**

<b>Disease of the circulatory system</b>	<b>I</b>	<b>II</b>	<b>IIIN</b>	<b>IIIM</b>	<b>IV</b>	<b>V</b>
1911	89	94		95	96	141
1921	92	101		94	96	117
1931	102	102		96	100	106
1951	123	102		102	86	102
1971	86	89	110	106	110	118
1981	68	79	100	105	112	145

<b>Heart Disease</b>	<b>I</b>	<b>II</b>	<b>IIIN</b>	<b>IIIM</b>	<b>IV</b>	<b>V</b>
1911	-	-		-	-	-
1921	92	101		93	97	105
1931	98	101		65	102	109
1951	123	102		103	85	101
1971	86	89	113	107	109	115
1981	69	80	101	105	111	141

<b>Coronary artery disease etc</b>	<b>I</b>	<b>II</b>	<b>IIIN</b>	<b>IIIM</b>	<b>IV</b>	<b>V</b>	<b>% of all heart disease</b>
*1911	161	106		98	92	99	9*
*1921	156	109		93	85	115	14
1931	237	147		96	67	67	14
1951	147	110		105	79	89	70
1971	88	91	114	107	108	111	67
1981	69	81	102	106	110	137	90

Source: Davey Smith (1997), Table 11.4, page 251.

Ecological studies also support the conclusion of increasing socioeconomic inequalities throughout the 1980s and 1990s. Shaw et al (1999) found that SMRs for coronary heart disease increased by 20.5% in the most deprived decile but decreased by 5.7% in the least deprived decile.



### 2.5.2.2 *Europe*

Few studies consider socioeconomic inequalities in mortality in Europe prior to the 1950s. In this section I begin with studies that have compared recent trends in socioeconomic inequalities between countries and supplement this data with consideration of studies of trends in particular countries.

Valkonen (1987) considered changes in inequality by education between the early and late 1970s in five countries – England and Wales, Finland, Sweden, Norway and Denmark. He found that apart from England and Wales, any increase in inequality, for both total mortality and mortality due to CVD, was small and not statistically significant. In England and Wales there was a substantial increase in inequality for mortality due to circulatory diseases but no change for other causes. The increase in inequality arose because low educated males experienced almost no decrease in circulatory disease mortality while other educational categories showed a clear 10-20% decline.

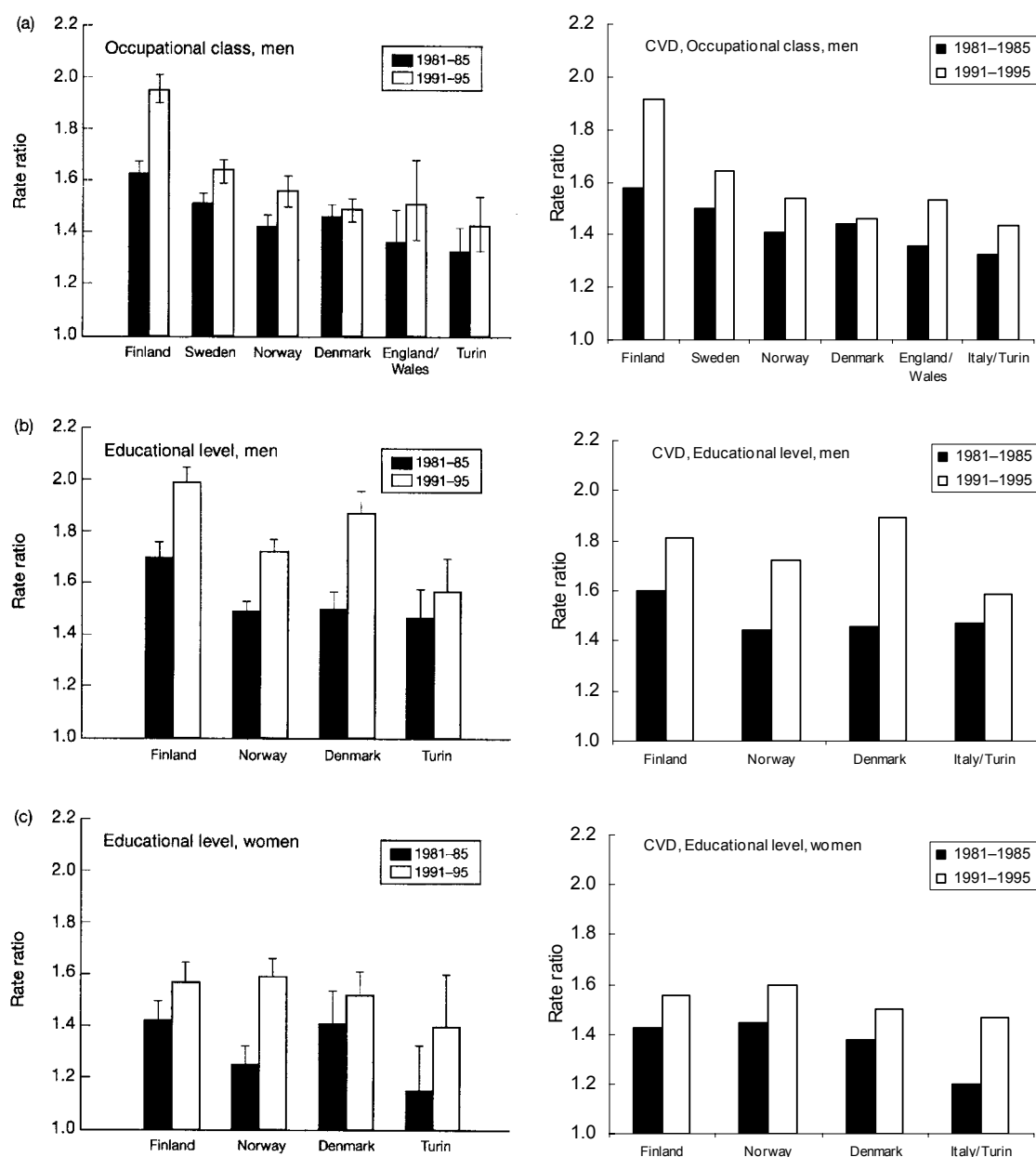
More recently Mackenbach (2003) published a comparison of trends in mortality over the 1980s and early 1990s in six European countries – Finland, Sweden, Norway, Denmark, England and Wales, Italy (Turin). The results drew on longitudinal analyses of mortality by education and occupational class using nationally representative datasets.

Mortality rates declined between 1981-85 and 1991-95 in most socioeconomic groups. The exceptions were low educated males for in Denmark, for whom mortality increased, and low educated females in Norway and Denmark, for whom mortality remained relatively stable. In all cases mortality declined proportionately more in the higher socioeconomic groups and least in the lowest. However absolute declines in all-cause mortality have generally been similar across all socioeconomic groups. Thus relative inequality (measured by the Rate Ratio) has increased, but absolute inequality (measured as the Rate Difference) has remained relatively stable (Figure 2-6).

For CVD relative inequality increased in Finland, Norway Sweden and Denmark. However in Italy, although relative inequalities did increase for females by education, for males relative inequalities decreased. All socioeconomic groups included in this study experienced substantial declines in cardiovascular mortality; the proportional decline in mortality ranged

from 13% in low educated Norwegian males, to 45% in non-manual classes of Finnish males.

**Figure 2-6 Rate Ratios for total and CVD mortality by educational level and occupational class and country, 1981-1985 and 1991-1995**



Source Mackenbach (2003) Figure 1 (Total Mortality) CVD abstracted from Table 2

In contrast absolute differences between socioeconomic categories generally decreased or remained relatively stable. The exception to this pattern was the rate difference by education in Norway, where among males only the rate difference increased by 31%; low educated

males experienced only a 13% decline in mortality compared to 33% for high-educated males. It is possible the low educated group in Norway, which makes up a smaller proportion of the total population in Norway than in other countries, comprises a more extreme end of the socioeconomic spectrum than in other countries.

Kunst (2000) reported trends in mortality rates for ischaemic heart disease and cerebrovascular disease by level of education, using the same data as (Mackenbach et al. 2003) but limited to ages 30-59 years. Among males, greater proportionate decline in IHD mortality was associated with high education in all countries but the pattern of decline in stroke mortality by educational level varied by country. For females the declines in IHD and stroke mortality are clearly related to education level in Finland but not in other countries.

These comparative trend studies are limited to countries and time periods where similar data are available. Longer time series or studies covering earlier periods are available in some countries. A number of themes emerge from these studies:

1. *Inequalities increased at a faster rate during 1980s than at other times in a number of countries.* In Norway Dahl (1993) inequality by occupational class increased more over the 1960s than 1970s. In Sweden Diderichsen (1997) occupational class inequalities, differences in the time of onset of the decline in cardiovascular disease by occupational group account for much of the changing inequality over this period.

Finish longitudinal data, for the period from 1970 to 1995 provide one of the most robust studies to date of changing socioeconomic gradients of mortality. Over this period the gap in life expectancy between manual and non-manual occupational classes widened (Martikainen et al. 2001b). Although mortality declined in all occupational groups, among men, the greatest decline for non-manual workers occurred between 1980 and 1995 (Valkonen 2000). In contrast mortality decline flattened between 1986 and 1990 for non-manual workers and as a consequence the increase in relative inequality was greatest in the 1980s. During the early 1990s the mortality rate difference actually decreased. The pattern was similar for IHD, stroke and other cardiovascular diseases. For women the pattern similar but less pronounced. The increase in relative and absolute inequalities was greater in the 1980s than the 1990s. However for all cause mortality the absolute mortality rate continued to increase in the 1990s primarily as a consequence of increasing rate differences for cancer.

2. *Several countries demonstrate a change in the direction of the inequality gradient for cardiovascular diseases.* A number of studies report a change in the relative position of high and low occupational classes. The Swedish study (Diderichsen and Hallqvist 1997), reported above, reports a change in the relative position of managerial and professional classes. The ratio comparing managerial and professional occupations to industrial occupations changes from 0.77 in 1961-65 to 1.33 in 1986-90. This change arose because CVD mortality was declining throughout the period for managerial and professional occupations but was still increasing among industrial occupations up until 1980.

A change in the direction of inequalities for CVD by areal socioeconomic indicator also occurred in the Netherlands. Kunst et al (1990) found that between 1950-1984 regions with better socioeconomic indicators had experienced larger declines in IHD mortality than less advantaged regions. Prior to 1972 ischaemic heart disease mortality was positively associated with regional socioeconomic indicators but this association became negative from 1972. Similarly the direction of the association between regional socioeconomic indicators and stroke mortality was positive before 1982 but reversed thereafter.

In Spain Regidor et al. (1995; 1997) observed a change in the direction of the occupational inequality gradient for IHD between 1981-82 and 1988-90. Thus it appears that the change in the direction of the class gradient, observed in earlier periods in Northern Europe, England and Wales and the United States occurred later in Spain. Lostao et al. (2001) et al. extended the Spanish occupational class analysis by Regidor (1995), to consider two provinces in France. Among men aged 45-64 years, mortality was highest for the managerial/professional class in 1980-82 but by 1988-90 the rates were highest for clerical workers and manual workers for men. For younger men aged 25-44 years IHD mortality was consistently higher in clerical and manual workers (Table 2-19). These results are consistent with a changing social class gradient, that first began in younger age groups.

**Table 2-19 Ischaemic and cerebrovascular disease mortality by occupational class: manual vs. non-manual rate ratio for men aged 25-44 and 45-64 years at death, 1980-82 and 1988-90**

	Spain		France	
	1980-82	1988-90	1980-82	1988-90
<i>Ischaemic heart disease</i>				
25-44 years	1.03 (0.75-1.41)	1.58 (1.07-2.32)	1.07 (0.97,1.17)	1.07 (0.98-1.17)
45-64 years	0.98 (0.87-1.10)	1.59 (1.36-1.85)	0.89 (0.86-0.92)	1.10 (1.05-1.14)
<i>Cerebrovascular disease</i>				
25-44 years	1.25 (0.78-1.99)	2.49 (1.47-4.21)	1.18 (1.05-1.34)	1.20 (1.06-1.37)
45-64 years	1.33 (1.12-1.58)	1.51 (1.20-1.89)	1.22 (1.06-1.18)	1.37 (1.28-1.46)

Source: Lang (1995))

3. *The causes of death important for explaining trends in inequalities in mortality vary over time and country.*

Although in many European countries cardiovascular disease inequalities, dominated trends in inequality for the later decades of the twentieth century trends in other causes are important in specific contexts. For example Borrell (1997) reported greater increases in mortality during the 1980s in low compared to high socioeconomic wards in Barcelona. The increased inequality arose primarily for increasing deaths due to AIDS and drug overdose. In contrast there was a decrease in inequality due to stroke.

Covering an earlier period in France Valkonen (1987) cites two French language papers by Desplanques (1976 and 1984). Desplanques used broad groupings of occupations, to analyse trends in inequality in the two longitudinal studies taken from the 1951 and 1974 censuses. Increased occupational inequality over the period from 1955-59 and 1975-79 was particularly affected by increased inequality for deaths due to cancer and alcohol related diseases, especially cirrhosis of the liver. For both causes mortality rates increased in all occupational classes but increased more for manual classes. In comparison deaths from CVD fell in all classes, but fell more among non-manual workers. (Valkonen 1987:page 212).

More recently in Finland, increasing socioeconomic mortality rate differences for women during the 1990s were primarily the result of increasing rate differences for cancer (Valkonen 2000).

Some of the most rapid increases in inequality recorded in Europe in the later 20<sup>th</sup> century occurred in Estonia in the 1990s, a period of rapid social and economic change (Leinsalu et

al. 2003). Leinsalu compared trends in mortality by education level for 1987-1990 with 1999-2000 on the basis of unlinked census and mortality data. Increasing mortality in the lowest education group, and decreasing mortality rates for medium and high education groups, resulted in substantial increases in both absolute and relative inequality over the 1990s. Inequality was particularly high and increased most among young adults (ages 20-39 years), however mortality ratios were still substantial at older ages.

### 2.5.2.3 *The United States of America*

#### (1) *All Cause Mortality*

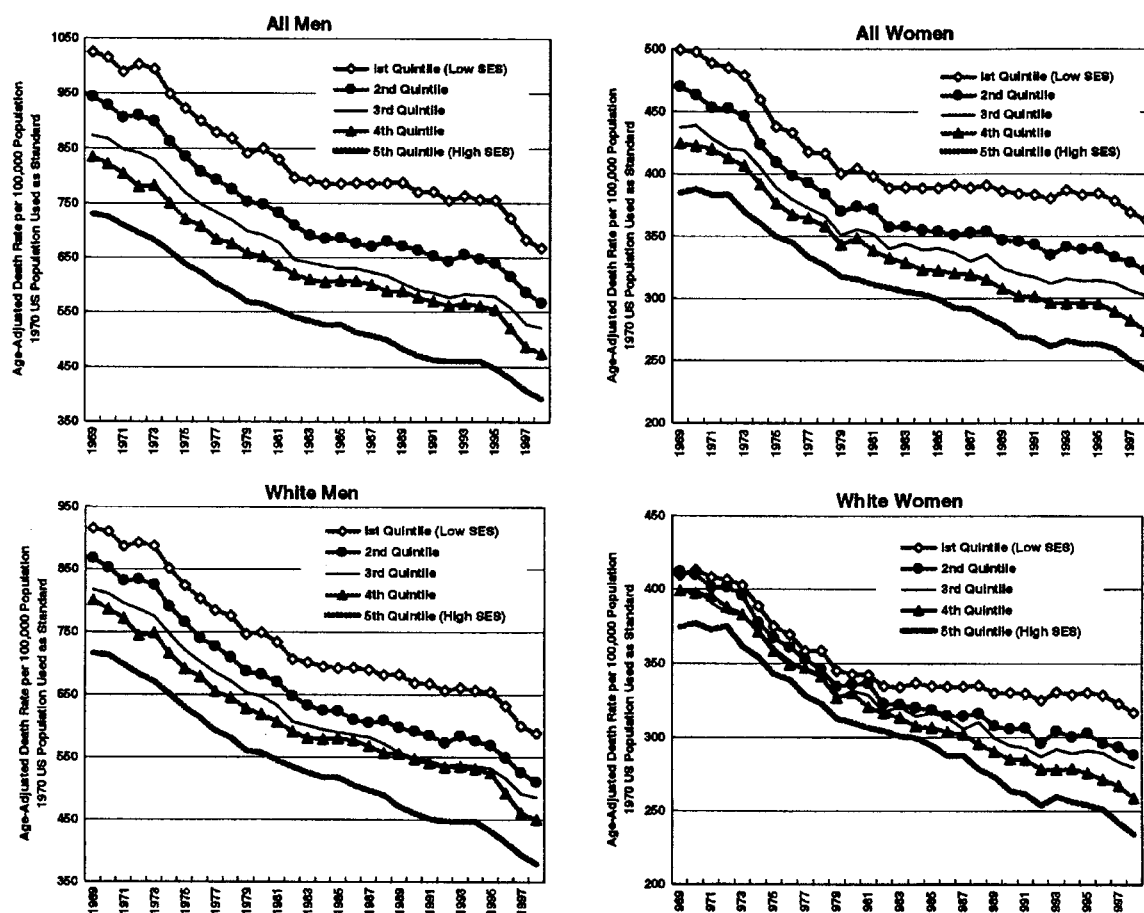
The study of trends in socioeconomic inequalities in mortality in the United States has been limited by a lack of comparable data.

Area level (census tract) analyses of socioeconomic gradients in mortality for 1929-1930, 1940, 1950 and 1960 (Kitagawa and Hauser 1963) showed that mortality declined in all area socioeconomic groups. However, the relative difference between the highest and lowest SES areas remained fairly constant (a RR of around 2) suggesting little change in relative inequalities up till 1960s. It should be noted that area socioeconomic position was defined different in the first two periods (median rental) compared to the later two (median income)

Since the 1960s a number of area level studies have shown increasing socioeconomic inequalities, however the findings have not been consistent. Yeracaris and Kim (1978), using a census tract level composite measure of socioeconomic position, reported that inequality in Birmingham and Buffalo doubled between 1960 and 1970 but increased only slightly in Indianapolis. Over the same period Lerner and Stutz (1977) also reported a doubling of the excess mortality between low and high-income states, arising from differences in the rate of mortality decline for people aged over 45 years.

More recently a number of area level studies consider socioeconomic trends into the 1990s. Singh et al (2003; Singh et al. 2002; Singh and Siahpush 2002) report mortality rates by county socioeconomic position and year for the period 1969 to 1998. Considerable divergence in the all cause mortality trends was observed with an average annual mortality decline of 1.97% and 1.27% in the highest and lowest socioeconomic areas respectively for males, and declines of 1.58% and 0.97% for females. Relative inequality thus increased substantially and consistently over time (Figure 2-7).

**Figure 2-7 All cause mortality among US men and women aged 25-64 years by the 1990 area socioeconomic status (SES) index, 1969-1998**



Source: Singh (2002: figure 1)

Studies at the level of individual socioeconomic status examined inequality by education or income. A number of studies compare the association of socioeconomic status in the 1970s and 1980s with the association found in the 1960 matched records study (Kitagawa and Hauser 1973). These studies consistently report increased relative inequality by education (Feldman et al. 1989). Pappas et al (1993) report greater increases between 1960 and 1986 in the RII according to income compared to education, and greater increases among men compared to women. Although limited by the unlinked cross-sectional nature of the analyses the results of both studies were consistent.

A further study by Preston (1995) using linked cohort data considered trends in both relative and absolute inequality by education. Trends varied by sex (Table 2-20). Males showed increases in both relative and absolute inequality at all ages, but especially at older ages. In

contrast for females absolute inequality declined at all ages, but relative inequality increased at for 65-74 year olds and decreased at younger ages (25-64 years).

**Table 2-20 Educational Differences in Mortality, United States 1960 and 1979-1985, white males and females**

Sex and Year	Age standardised death rate (per 100)	Slope Index* of Inequality (SII)	SII/Death Rates‡	Index of Dissimilarity
<i>25-64 years</i>				
Males				
1960	0.80	-0.39	-0.49	0.060
1979-85	0.51	-0.41	-0.80	0.090
Females				
1960	0.41	-0.23	-0.56	0.076
1979-85	0.27	-0.11	-0.41	0.050
<i>65-74 years</i>				
Males				
1960	4.89	-0.66	-0.13	0.016
1979-85	3.59	-1.93	-0.54	0.058
Females				
1960	2.86	-1.25	-0.44	0.051
1979-85	1.78	-0.98	-0.55	0.059

\* The Slope Index of Inequality presented here is multiplied by 100 and shows the average decline in standardised death rate as one moves from the lowest to the highest levels of schooling, that is from 0 to 1 in the proportionate education distribution. Note that the age standardised death rates in this table are also given per 100

†(Preston and Elo 1995) Table 3

‡ A form of the relative index of inequality

The trends in absolute inequality reported by Preston(1995) are at odds with those reported by Schalick (2000) over a similar period by for inequality by income. Schalick et al (2000) observed a marked increase in relative inequality - the RII doubled for both black and white males and increased by 51% for white females and 67% for black females. However absolute inequality declined for both men and women - by approximately 14% for both black and white men compared to 3% for white women and 10% for black women.

## (2) CVD

In the United States coronary heart disease and stroke mortality began to decline in the mid-1960s, with an accelerated decline throughout the early 1970s and 1980s (Harlan 1989; Higgins and Thom 1989; Higgins and Thom 1993; Rosamond et al. 1998). Unlike the United Kingdom, there has never been a consistent finding that higher socioeconomic status was ever associated with coronary heart disease mortality in the United States. Early studies from the United States provide conflicting evidence about the nature of social gradient in



cardiovascular disease mortality. These studies were reviewed extensively by Antonovsky (Antonovsky 1968).

For the period close to the 1930 population census area level Studies in New Haven (Sheps and Watkins 1947) and Chicago (Coombs 1941) both report an association between low census tract SEP and high mortality. The results of the Chicago study are summarised in Table 2-21.

**Table 2-21 Age Standardised Mortality Ratios for disease of the circulatory system, Chicago 1928-32, by census tract economic level, sex and nativity\*<sup>†</sup>**

	Census Tract SEP Grouping				
	<u>I (high)</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V (low)</u>
Native White Males	100	104	112	133	157
Foreign-born white males	100	108	114	122	163
Native white females	100	141	159	185	237
Foreign-born white males	100	120	121	148	172

<sup>†</sup> cited in (Antonovsky 1968) page 69

Yet when mortality by occupational class was considered there was no consistent finding of an association between social (occupational) class and mortality. Whitney (1934) did however report an excess mortality from heart disease, cerebral haemorrhage and softening of the brain among unskilled employed males in ten states. There was however no clear gradient of mortality associated with social class. In contrast Hedley (1939) observed excess mortality *from acute coronary occlusions* among white professional males, aged 35-64 years in Philadelphia.

Studies throughout the 1940s and 1950s continue to report varying associations between socioeconomic position and mortality from cardiovascular diseases (Altenderfer 1947; Ellis 1958; Lilenfield 1956; Patno 1960). Patno (1960) reported mortality in Pittsburgh in 1940 and 1950 by area level SEP. This is the only comparison across time periods, where similar methods are used in both. The results suggest a change in the direction of the mortality gradient for males. In 1950 there was a weak *inverse* gradient between low area socioeconomic position and high mortality rates for both males and females.

The importance of the level of analysis is illustrated by Stamler and colleagues who studied mortality from arteriosclerotic and degenerative diseases in Chicago according to both area income level and according to occupational class (Berkson et al. 1960; Kjelsberg and Stamler 1960; Stamler et al. 1960). They observed that whereas there was a substantial

excess mortality for all cardiovascular diseases among labourers compared to professionals (although no overall gradient in mortality by occupational class was observed); when analysed by census tract median income the results show a strong inverse gradient by area median income. The authors however seemed sceptical of their own results. An SMR of 318 for arteriosclerotic heart disease for females in the lowest income areas was described as “*an apparently false rate*”.

A number of studies report the association between socioeconomic position and mortality for different categories of cardiovascular disease Breslow & Buell (1960). Furthermore many studies suggest that higher rates of coronary heart disease mortality for low socioeconomic groups was first evident among younger age groups (Guralnick 1963). Although study design issues make the discernment of clear trends problematic, taken together the evidence suggests that cardiovascular disease mortality declined first among more advantaged populations, but that the onset of decline varied by geographic area and was first evident at young ages.

That the socioeconomic distribution of coronary heart disease mortality did indeed change in the 1940s to 1960s in the United States is supported by the results of a number of cohort studies. The Evans County cohort study compared the association between socioeconomic status and coronary heart disease mortality for 1960-67, and 1967-74 (Morgenstern 1980). Coronary heart disease incidence, prevalence and mortality declined over the period of the study for men but not for women. At the same time the association between social status and coronary heart disease mortality reversed for men less than 55 years. These results are summarised in Table 2-22. The change in association between mortality and social status was mirrored by a change in association between social class and serum cholesterol (Tyroler et al. 1980). The cross over in the social distribution of serum cholesterol adds weight to the finding of a cross over in the social distribution of coronary heart disease mortality in the community.

**Table 2-22 Evans County, US, Coronary Heart Disease Mortality age- standardised SMRs for high vs. low social status, 1960-67 and 1967-74, males.**

Age at start of follow-up	1960-67	1967-74
<55	2.22	0.34
>55	1.08	1.04
Total	1.22	0.70

Source: Adapted from Morgenstern (1980), Table 3

From the 1960s onwards the evidence for an indirect association between both heart disease and stroke mortality is more consistent with evidence of increasing socioeconomic inequality especially for coronary heart disease in males (Feldman et al. 1989; Lerner and Stutz 1977; Rogot and Hrubec 1989). These trends are supported by data from area level studies. Several studies have demonstrated that coronary heart disease mortality began to decline later and declined less in geographical areas (states, economic areas and metropolitan areas) that were less economically advantaged, less urbanised, were less industrially advanced and had lower concentrations of people in white collar occupations (Jones et al. 2000; Leaverton et al. 1984; Liao and Cooper 1995; Sempos et al. 1988; Wing 1988; Wing et al. 1992; Wing et al. 1990; Wing et al. 1988b; Wing et al. 1987; Wing et al. 1986). Similarly the economic development and structure of geographically defined communities is associated with the decline in stroke mortality (Barnett et al. 1996; Casper et al. 1995; Cooper et al. 2000; National Institutes of Health 1995; Tyroler 1999; Wing et al. 1988a).

A number of recent studies report greater increases in socioeconomic inequality for blacks than whites. Barnett et al. analysed the social class distribution of deaths due to coronary heart disease from men aged 35-54 years who resided in North Carolina between 1984 and 1993 (Barnett and Halverson 2001). Social class disparities in coronary heart disease trends for both white and black men. The rate of decline in varied monotonically from -4.7% for the highest social class to -1.6% for the lowest social class. However lower class black men experienced no decline or and increase in CHD mortality between 1984 and 1993.

**Table 2-23 Average annual change in coronary heart disease mortality among men aged 15-64 years by social class, North Carolina, 1984-1993.**

<b>Social Class</b>	<b>Black men</b>	<b>White men</b>
I (High) ( 95% confidence Interval)	-4.7 % (-12.4, +3.7)	-4.7 % (-6.7, -2.6)
II ( 95% confidence Interval)	+3.5 % ( -4.7,+12.4)	-4.2 % (-6.7, +1.2)
III ( 95% confidence Interval)	-0.0 % ( -4.0, +4.2)	-2.1 % (-4.0, -0.2)
IV (low) ( 95% confidence Interval)	+0.8 % ( -1.9, +3.5)	-1.6 % (-3.7, +0.5)

Source: Barnett (2001) Table 3

#### 2.5.2.4 *Australia*

##### (1) *All Cause Mortality*

There have been a number of studies showing large socioeconomic inequalities in mortality in Australia, most confined to limited geographical areas or working age males. (Bennett 1996; Burnley 1998; Mathers 1994; Mathers 1996; McMichael 1985; Siskind et al. 1987; Siskind et al. 1992; Turrell and Mathers 2001; Turrell et al. 1999). Trends in socioeconomic inequalities have however received little attention (Hayes et al. 2002; Quine et al. 1995).

A series of analyses of small area socioeconomic status (the Index of Relative Socioeconomic Disadvantaged - IRSD) and mortality enabled examination of trends in inequality over the periods 1985-87 to 1998-2000 (Turrell and Mathers 2001) and 1995-97 to 1998-2000 (Draper et al. 2004). Table 2-24 combines the data from these studies. The ratio of mortality in quintiles five compared to quintile one increased for all causes, cancers and circulatory system for both males and females aged 25-64 years across the whole period, however there appears to have been a dip in the relative inequality for all causes in 1995-97. For people aged 65 or more, there was a small increase in inequality for males, but no evidence of any increase for females.

**Table 2-24 Age-Standardised mortality rate ratios by Quintile of Deprivation (IRSD), Quintile 5 to Quintile 1 (high SEP), 1985-87\*, 1995-97<sup>†</sup> and 1998-2000\*.**

Cause of Death	1985-87* <sup>†</sup>	1995-97 <sup>†</sup>	1998-2000*
<b>Males</b>			
<i>Ages 25-64 years</i>			
All Causes	1.68	1.64	1.75
Cancers	1.28	1.39	1.45
Circulatory System	1.65	1.87	2.10
<i>Ages 65+ years</i>			
All Causes	1.14		1.17
Cancers	1.09		1.14
Circulatory System	1.10		1.15
<b>Females</b>			
<i>Ages 25-64 years</i>			
All Causes	1.50	1.45	1.51
Cancers	1.10	1.14	1.31
Circulatory System	1.97	2.01	2.15
<i>Ages 65+ years</i>			
All Causes	1.11		1.11
Cancers	0.99		1.03
Circulatory System	1.11		1.11

Source Draper (2004) Tables 5.3.4 and 5.4.3 <sup>†</sup> Turrell(2001) Table 2

## (2) CVD Mortality

Variations in the level of decline in ischaemic heart disease mortality within subpopulations in Australia, over the period from 1969-73 to 1974-78, were reported by Gibberd et al. (1984). The proportional decline in mortality varied by geographical area, sex and country of birth and occupational grouping. Although not based on a hierarchical classification of socioeconomic position, the results point to greater declines among professional, sales, service and clerical occupations than for administrative, farming, mining, transport and communication, and trade occupations.

The study of trends in inequality by occupational class has been complicated in Australia by changes in the occupational class classification system over time. Nevertheless Bennett (1996) undertook an analysis of trends in mortality by occupational class. During the period from 1979-1983 Coronary heart disease declined in all occupational groups but the average annual rate of decline was higher for professional occupations (6.4% p.a.) than for manual occupations (1.7% p.a.). The decline was however highest for clerical/sales occupations, with the result that mortality for clerical/sales occupations were lower than for professional occupations by 1990-1993. The differences in rates of decline in coronary heart disease

mortality for different occupational classes produced a widening of the inequality between manual and non-manual workers, but also a decrease in the difference between categories of non-manual occupations.

The ecological analyses by Turrell et al (2004) cited earlier (see page 84), also found widening relative inequalities in circulatory system diseases but only among adults aged 25-64 years. The rate of increase in relative inequality was much greater towards the late 1990s compared to the previous decade, especially for women (see Table 2-24, page 89).

## **2.6. Summary**

Substantial socioeconomic inequalities in mortality have been demonstrated in all western countries where the inequalities have been studied. However the size of the inequalities varies according to country, cause of death, and the socioeconomic measure.

In countries where cardiovascular diseases are, or have been, a major cause of death (including Britain and Northern Europe, Australia and New Zealand), socioeconomic inequalities in CVD mortality have also been substantial at least during the late twentieth century. Furthermore, more advantaged socioeconomic groups have generally experienced earlier, and more rapid declines in mortality than their less advantaged compatriots. As a consequence relative inequalities in CVD mortality have increased, at the same time as substantial declines in CVD mortality have reduced the overall burden of CVD mortality in many countries.

A number of studies have sought to compare the extent of inequalities in different countries. However, comparative studies, both between countries and over time face particular problems in ensuring the comparability of socioeconomic measures over time. Measures of inequality that take account of the socioeconomic distribution of the population, provide an alternative method of comparison to simple rate ratio and rate difference measures, that is less susceptible to issues around the definition of socioeconomic position.

In New Zealand the evidence for socioeconomic inequalities in mortality exists according to a variety of socioeconomic measures, however there is limited information about trends in inequalities. The evidence that does exist is problematic. Large amounts of missing data, a limited age range, and the potential for substantial numerator denominator biases in cross-sectional studies make interpretation of trends difficult.

The persistence of socioeconomic inequalities in the face of dramatic improvements in life expectancy and health is a challenge for the New Zealand Health system if it is to meet the goal of the New Zealand Health strategy to reduce inequalities in health. The monitoring of health inequalities becomes an important measure of progress towards that goal. This thesis explores historical trends in socioeconomic inequalities. Particular attention is given to methods of measurement to address the substantial methodological problems inherent in comparative studies.

## Chapter 3 Methods

### 3.1. Structure of the NZCMS Cohorts.

A report describing construction of the data-sets and data dictionaries have been published elsewhere (Hill et al. 2002). A brief description is included here for completeness.

The NZCMS comprises four census cohorts. The 1981, 1986, 1991 and 1996 census unit records were anonymously and probabilistically linked to mortality records for the three years subsequent to each census using AUTOMATCH® software. SNZ staff undertook the record linkage.

This method matches census and mortality records within small areas, using variables occurring on both the census and mortality records. Variables used for the matching included month, day and year of birth, sex, country of birth, and ethnicity. Addresses were geocoded to meshblocks and census area units – the two smallest geographical units available on the New Zealand census.

The data matching was successful in linking approximately 75% of all eligible mortality records back to a census record. The percentage linked was higher in the later cohorts (Table 3-1). The proportion of links estimated to be true links was over 96% for all four cohorts (Blakely & Salmond 2002).

**Table 3-1 Success of Census-Mortality Linkage by Cohort**

Census Year	Eligible Census Records (n)	Eligible Mortality Records (n)	Linked Records (n)	Linkage rates for Mortality Records (%)	Estimated Accuracy of the Linkage Process
1981	3,000,653	44,932	31,741	71.01	96.9
1986	3,098,339	44,506	32,837	73.78	96.7
1991	3,342,261	41,310	31,635	76.58	98.1
1996	3,314,066	39,525	30,889	78.15	97.4

Methods for adjusting analyses for the incomplete linkage are described in section 3.5, page 105.

The NZCMS cohorts data-sets are held by SNZ and available to researchers via the SNZ data laboratories. The data are configured as SAS® datasets. Variables have been carefully



scrutinised to ensure the anonymity of unit records. In some cases variables have been reformatted to ensure this anonymity. This is particularly the case for age variables, detailed occupation descriptions and detailed cause of death information. The following sections describes the variables and co-variates used for the analyses in this thesis.

## **3.2. Demographic Variables**

### **3.2.1 Sex**

Sex is collected as a dichotomous variable. When missing, sex was imputed by SNZ on the census unit data and so is never missing on the cohorts.

### **3.2.2 Age**

Age variables available on the census cohorts are age at census and, for cohort members who linked to a mortality record, age at death. Age is recorded as age in months. Exact dates of birth and death, although used for the linkage are not available on NZCMS data-sets.

The cohorts are limited to census respondents aged less than 75 years on census nights. Because the cohorts are followed for three years, cohort members are aged between three and 77 years at the end of follow-up.

Throughout this chapter results are presented for the total 25-77 year age group and, when numbers allow, by age. The age groups were 25-44 years, 45-59 years and 60-77 years. I chose the 59/60-year cut-point because of the effect of retirement on both the income and occupational class measures. The age of qualification for national superannuation was 60 years until 1992. After this time the age of qualification increased in regular increments until it reached 65 years in 2002. Retirement produces substantial changes in income levels for most people and so it is preferable to consider populations with large numbers of retirees separately from populations where income is derived mainly from work.

### **3.2.3 Ethnicity**

The New Zealand census survey instrument for collecting information about ethnicity changed with each census in the NZCMS. The major change was a change from an ancestry-based definition of “race” in 1981 to self-identification of ethnic group in 1986. Changes in definition and collection methods mean that there have been considerable shifts

in the categorisation of ethnic origin/identity, with substantial changes to the size of the various ethnic groups. Census ethnicity questions are reproduced in the appendices, page 361.

I have used a three-way classification of ethnicity based on the SNZ definition of “prioritised” ethnicity. This definition has three categories: Māori includes all census respondents who identified as Māori; Pacific includes those who did not identify as Māori and who identified a Pacific Island ethnicity; and the non-Māori non-Pacific group is the residual group.

### **3.3. Socio-economic Exposures**

Three measures of socioeconomic position were used in these analyses – educational level, occupational class and income.

#### **3.3.1 Education**

##### *3.3.1.1 Census Education Data*

As the New Zealand Census does not collect a direct measure of the level of education completed, the highest qualification completed while at school and since leaving school are used as a measure of level of education. In 1981 the highest level of education attended (but not necessarily completed) was also collected.

The wording of questions about educational qualifications changed for every census (Appendix section 12.1.1.1, page 354). Two particular changes to the content of the census questions are of note.

- Overseas qualifications were not specifically prompted for until 1991
- Trade Certificate qualifications were not prompted for until 1986

As a result of these changes mean that people recorded as having qualifications in the later cohorts may have been misclassified as either having no qualifications or having unspecified qualifications in the earlier cohorts. When considering trends in mortality and inequality by education misclassification of education is of particular concern as it may bias

the analyses of time trends if the degree of misclassification was different for each census-cohort (see page 111).

### 3.3.1.2 *Categorisation of the Educational Qualification Variable*

In order to ensure that the categorisation of education across the four cohorts was as comparable as possible an inter-censal classification of education, developed by Statistics New Zealand, was used. This classification was further grouped into five and three level groupings to obtain categories of sufficient size for robust analyses. The decision about grouping of qualifications into five and three groups, was based on the ideal of maintaining a hierarchy of qualifications from low (none) to high (university degrees) while at the same time maintaining consistency across the four cohorts.

Maintaining a consistent hierarchy of qualifications was problematic for several reasons. Firstly the status of some qualifications changed over the time span of the four cohorts. For example, in more recent years polytechnics have been able to offer degree courses for what were previously diploma qualifications. Secondly, the level of detail available about specific qualifications varied from cohort to cohort. For example in 1996 it was possible to distinguish between basic, intermediate and advanced trade qualifications, whereas for previous cohorts this was not possible. Furthermore determining whether a post-school non-university degree qualification ranked higher than a higher school qualification was not always possible. This is particularly so for qualifications aimed at bridging the gap between school and the workforce or second-chance education courses providing prevocational training for people without any school qualifications. The level of detail available on the cohort data-sets meant these qualifications were often indistinguishable from other non-university qualifications for which school qualifications were a prerequisite for entry.

The five and three level education classifications used in these analyses (Table 3-2) also needed to take account of the numbers of people in each category to ensure adequate numbers for analyses by sex and broad age categories and for ethnicity specific analyses.

**Table 3-2 Five and three level groupings of educational qualifications.**

<b><u>Five Level Education Grouping</u></b>		<b><u>Three Level Education Grouping</u></b>	
<b>Description</b>	<b>Label</b>	<b>Description</b>	<b>Label</b>
No qualifications	No Qualifications	No qualifications	Low
5 <sup>th</sup> Form School Qualification	School-Low	Any School Qualification	Medium
6 <sup>th</sup> /7 <sup>th</sup> Form School Qualification	School-High		
Trade and other post-School	Post-School – Low	Any Post-School Qualification	High
University degree, nursing or teaching diploma or NZCS or Technician's Certificate	Post-School – High		

### 3.3.2 Income

#### 3.3.2.1 *Census income data*

Gross (before tax) personal income data were collected from all individuals aged 15 years and over at each census. The income questions varied slightly from year to year (See appendix, page 358). In 1981 two questions were asked – income from social security benefits and estimated gross income from other sources. Subsequent censuses asked about total income from all sources before tax. Data was collected in bin categories that also varied by census (Table 3-3).

**Table 3-3 Characteristic of Income Data, and CPI adjustment factors by Census Year**

	<b>Census Year</b>			
	<b>1981</b>	<b>1986</b>	<b>1991</b>	<b>1996</b>
Number of Bins	24*	16	13	13
Minimum bin	≤ \$0	≤ \$0	≤ \$0	≤ \$0
Maximum bin	≥ \$60,000	≥ \$50,001	≥ \$70,001	≥ \$100,001
CPI Adjustment factor	0.390045	0.663196	0.902499	1.0

\*24 categories for both social security benefits and gross income from other sources

#### 3.3.2.2 *Household Income*

If income is understood as a measure of access to goods and services and to the social goods associated with wealth, then it is appropriate to measure income at the level at which income is pooled and decisions around expenditure and consumption are made. The standard of living of individuals is determined by the pooled resources, to which they

contribute and from which they benefit. Two groupings of individuals are recorded on the New Zealand census, which are likely to identify groups of individuals who pool income and expenditure – the family and the household.

In the SNZ census statistics a household is either “*one person who usually resides alone, or two or more people who usually reside together and share facilities (such as eating facilities, cooking facilities, bathroom and toilet facilities, and a living area), in a private dwelling*” (Statistics New Zealand 1995). A household may thus comprise one or more individual or families, who may or may not be related. Residents in non-private dwellings are not part of households and are therefore excluded from these analyses. One family households comprised 77%, 76%, 71% and 69 % of all households for the four censuses from 1981 to 1996. Single person households comprised 17%, 19%, 20% and 21% of all households for the respective censuses (Statistics New Zealand 1984; Statistics New Zealand 1998a). Analyses based on families exclude all individuals living in non-family households. Households therefore provide a more inclusive sampling frame within which to consider the effects of income.

### 3.3.2.3 *Income equivalisation*

Households of different size and composition require different incomes to produce similar standards of living. However there are economies of scales in households such that a household of four does not require four times the income as a household of one to purchase the same standard of living. Equivalisation is a procedure for adjusting the incomes of households to produce incomes that are comparable in terms of the resources available to family members.

The most commonly used method for equivalisation of household incomes is to divide the total household income by the square root of the number in the household. This adjustment scale has been used for international comparisons of income (Atkinson et al. 1995) However Easton (2002) found that differences in the relative prices of various goods and services in different contexts affect the performance of equivalence scales. It is therefore preferable to use a context specific equivalence scale.

The Jensen index is a New Zealand specific scale for adjusting household income in relation to the relative needs of a household, based on household composition by numbers of adults

and children. The index assigns different weights to adults and children according to the formula

$$I_{a,c} = (a+wc)^u/2^u$$

Where  $I_{a,c}$  is the income equivalence for a household with  $a$  adults and  $c$  children

$w$  is the weight for a child compared to an adult

$u$  is the power parameter to be estimated.

Following an international review of equivalence indices, Jensen (1988) estimated values for  $w$  (0.73) and  $u$  (0.62) based on two anchor point values of  $I_{a,c}$ : 0.65 for single adult household with no children and 1.75 for a household with two adults and four children.  $I_{a,c}$  values for other household compositions were then calculated by substitution into the formula.

Compared to dividing by square root of the household size, the Jensen scale produces higher household equivalised incomes. Blakely (2001, page 34) calculated the ratio of Jensen:LIS adjusted incomes for various household compositions (Table 3-5). The ratio of incomes is similar for households with the same number of adults, irrespective of the number of children, however for household with the same number of children the ratio declines with increasing number of adults<sup>1</sup>. Thus the economies of scale for each additional adult in a household, is relatively greater with the Jensen equalisation than the LIS equalisation. As consequence adjustment by the Jensen scale results in a relative shift downward in equivalised income for households with more adults compared to adjustment by the LIS scale (Figure 3-1).

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The algorithm allows for a maximum of four adults and six children per household. 0.8%, 0.9%, 0.9% and 0.9% of households with household income values had more than four adults in 1981, 1986, 1991 and 1996 respectively. The corresponding percentage of households with greater than six children were 0.2%, 0.1%, 0.1% and 0.1%. Overall less than one percent of households in all years had more than four adults or six children.

**Table 3-4 Revised Jensen Index values used for equivalisation**

Number of Adults	Number of children (less than 18 years)						
	0	1	2	3	4	5	≥6
1	0.65	0.91	1.14	1.34	1.52	1.69	1.85
2	1.00	1.21	1.41	1.58	1.75	1.91	2.06
3	1.29	1.47	1.65	1.81	1.96	2.11	2.25
≥4	1.54	1.71	1.87	2.02	2.16	2.30	2.44

\*Source Blakely (2002)

**Table 3-5 Ratio of adjustment ratios for the revised Jensen Index compared to Division by Square Root of Household Size scale, by household composition \***

Number of Adults	Number of children						
	0	1	2	3	4	5	≥6
1	1.54	1.55	1.52	1.50	1.47	1.45	1.43
2	1.41	1.43	1.42	1.41	1.40	1.39	1.38
3	1.35	1.36	1.36	1.36	1.35	1.34	1.34
≥4	1.30	1.31	1.31	1.31	1.31	1.31	1.30

\*Source Blakely (2002) page 33

Just as differences in the relative prices of goods and services in different countries will affect the performance of any equivalence scale, changes over time in the relative prices of goods and services will also affect the performance of equivalence scales. However as the Jensen scale has not been updated since 1988 the same scale has been used in all four cohorts.

#### 3.3.2.4 Calculation of Household Equivalised Income

Household income was calculated by summing the total personal income of the individual members of each household. Households were included only when all members of the household 18 years and older were present on census night and had a non-missing income variable.

For 1986, 1991 and 1996 each eligible cohort member was assigned an income value equivalent to the median income value of the same income bracket in the New Zealand Household Economic Survey (NZHES) data. For 1981 no median income values were available from the NZHES and so each cohort member was assigned an income at the midpoint of their income bin category. The value for the top income value was estimated using the

Pareto method (Miller 1966; Parker and Fenwick 1983)<sup>2</sup>. Household income was summed for all household members aged 15 and over. To adjust for the number of adults and children in the household the total household income was divided by the Jensen Index (Jensen 1978; Jensen 1988). A further adjustment was then made to adjust the 1981, 1986 and 1991 equivalised household income for spending parity with the 1996 income values (i.e. all cohorts were adjusted to be equivalent to 1996 real income) The CPI adjustment factors are given in Table 3-3. The CPI adjusted household equivalised income was then assigned to each member of the household, including children.

The same CPI adjustment factor was used for all cohort members, irrespective of household composition or of total income. It should however be noted that the average package of goods and services purchased by households of different compositions with different incomes is likely to vary. As a consequence households of different compositions with different incomes will be affected differently by the changing relative costs of the goods and services by which the CPI adjustment is calculated. For example, if the cost of rental accommodation rises relative to other forms of accommodation costs, then households in rental accommodation, that are paying a larger proportion of their household income in rent, would be more affected by the rental rise than households for whom rent comprises a lesser proportion of their household costs. The use of a uniform CPI adjustment in each census year does not capture these changing relative costs for different households by income or composition.

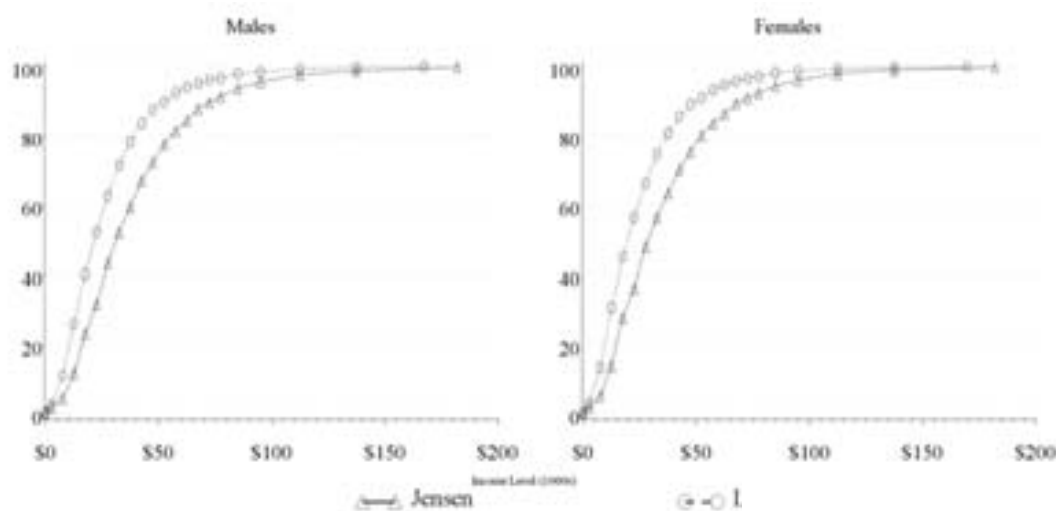
When applied to the NZCMS cohorts the different methods of equivalisation produce different distributions of income. Figure 3-1 illustrates this shift for the 1996-99 cohort. Similar results were obtained for all cohorts (not shown).

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<sup>2</sup>Parker and Fenwick developed an algorithm to calculate the Pareto value and produce a web-based tool for calculating the Pareto value <http://ipumsi.anu.edu.au/calculate.phtml>



**Figure 3-1 Cumulative Percentage of Cohort by Household Equivalised Income. Comparison of Division by Square Root of Household Size and Jensen Equivalisation Scale, By Sex for the 1996-99 Cohort**



### 3.3.2.5 Categorisation of the income variable.

Initial exploration of the data was done using a ten level grouping of Jensen Equivalised CPI adjusted household equivalised income. The income categories for these analyses were; Low - <\$10,000; \$10,000 - <\$15,000; \$15,000 - <\$20,000; \$20,000 - <\$25,000; \$25,000 - <\$30,000; \$30,000 - <\$35,000; \$35,000 - <\$40,000; \$40,000 - <\$50,000; \$50,000 - <\$60,000; and \$60,000 – High. The distribution of income values varied substantially by age, sex and ethnicity as illustrated in Figure 3-2, which shows the distribution of person-time, by age, sex, cohort and income category. Older cohort members and females were distributed more towards the lower end of the income distribution than younger cohorts and males. The use of the 10 categories of income for all age, sex and cohorts produced some very small category sizes for some cohort subsets of interest. Small category sizes in the high-income groups for older people, females and Māori meant that, for these groups, mortality rates and RII measures had wide confidence intervals.

To overcome this problem, five equal sized quintiles of income for the 1986-89 cohort were established and these cut-points were applied to all four cohorts. The 1986-89 cohort was used as the baseline because this cohort had the lowest proportion of respondents with high

incomes. The income level categories<sup>3</sup> created in this way were; \$0-<\$20,100; \$20,100-<\$29,300; \$29,300-<\$38,900; \$38,900-<\$52,800; and \$52,800-\$300,000. This strategy was successful in producing category sizes of adequate size for most of the analyses – although for 60-77 year old Māori and Pacific people, less than 10% were in the highest income group in most cohorts. Income specific mortality rates, SRR and SRD presented throughout this chapter use this summary 5 category income grouping.

The use of the same income cut-points for all four cohorts enables direct comparisons of mortality rates to be made across the four cohorts, for each income level. For example the mortality rates for cohortes with CPI adjusted household equivalised income between \$29,300 and \$38,900 can be compared directly across cohorts. SRD and SRR are similarly comparable across cohorts because the same income categorisations are used.

A quintile grouping of income was used for the calculation of the RII and SII whereby the income variable was categorised into equal sized categories *within each subset for analysis*. For example, when considering females, aged 25-44 years, quintile groupings of income were produced within this subset.

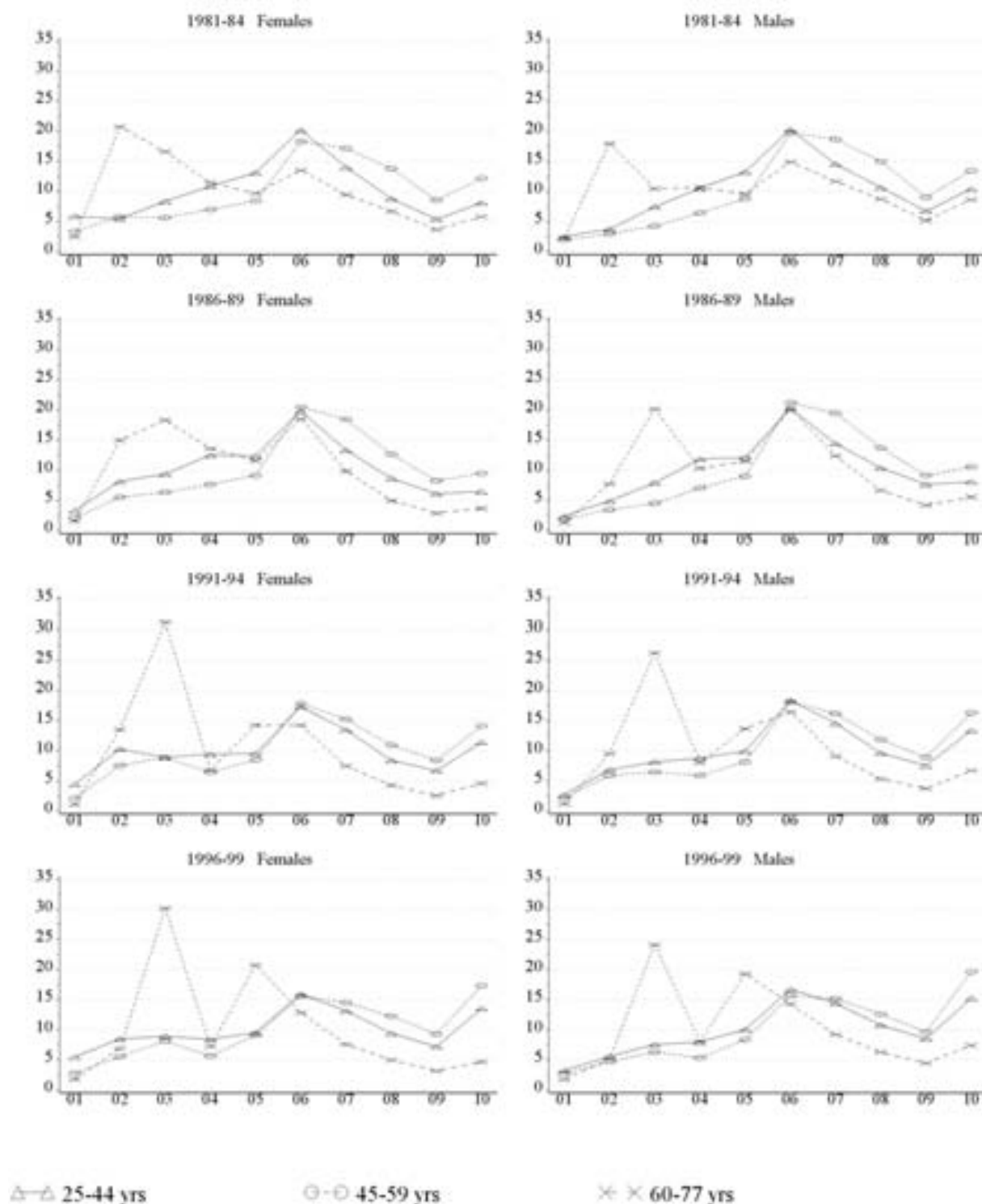
The category cut-points for each subset and cohorts were thus unique. The cut-points were calculated using the *proc freq* command in SAS® and identifying the income value at the percentage cut-points. For example, to produce ranked quintile groupings within a subset it was sorted by income level and the income value of the observation at the 20%, 40%, 60% and 80% cumulative percentage identified as the cut-points for the categories. Because of clumping of income values, the group sizes were not always exactly 20% of the sub-population. Nevertheless this process was largely successful in producing equal sized categories, except for cohortes aged 60-77 years. In this case a large group of cohortes with the same household equivalised income fell on the category cut-points.

The sensitivity of the RII to the income grouping is discussed further with the results (section 6.3.1, page 212).

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<sup>3</sup> Cut-point labels are rounded to the nearest \$100.

**Figure 3-2 Percentages of person-years in each 10-way Income-Level Category by Age, Sex and Cohort**



Key  
 01=Low      -    02=\$10.000      -    03=\$15.000      -    04=\$20.000      -    05=\$25.000      -  
 06=\$30.000    -    07=\$35.000      -    08=\$40.000      -    09=\$50.000      -    10=\$60.000      -

### 3.3.3 Occupation

#### 3.3.3.1 *Census Occupation Data*

Census information about occupation was collected using questions that asked about the respondents occupation and the main tasks or duties undertaken in their job. In 1981 the respondent was asked their current occupation or their main previous occupation if unemployed. For later censuses respondents were asked about current occupation in their main job. The census occupation questions are reproduced in the appendices (page 360).

The census data were coded by SNZ to the New Zealand Classification of Occupations (NZSCO) codes. The NZSCO is related to the International Classification of Occupations, and has been updated on several occasions. A fundamental change in the basis of the occupational coding occurred in the update from the NZSCO68 to the NZSCO90; a classification closely related to the International Classification of Occupations 1988 (ISCO88). The earlier coding was a task based coding system but the later NZSCO90 was a skill based coding system.

The 1981 and 1986 census information is coded to the NZSCO68, The 1991 census information was coded to both NZSCO68 and NZSCO90 codes while the 1996 census was also coded to the NZSCO95.

#### 3.3.3.2 *Classification of Occupational Class and Choice of Occupational Class Classification*

The New Zealand occupational class scales are not amenable to grouping into manual, non-manual and farming classes. In order to facilitate this comparison I developed, with assistance from SNZ, an algorithm linking the NZSCO68 codes to the EGP occupational classification scheme (Appendices, page 362).

The 4-digit NZSCO68 occupational codes were linked to the Elley Irving Occupational Class scale and the EGP scale. Farmers were classified separately. The EGP scale was further grouped into manual, non-manual and farmer classes.

The Elley-Irving Occupational class classification and the EGP four-way classification could be applied to all four cohort periods, the SEI91 to the 1991-94 and 1996-99 cohorts

and the SEI96 class scales to the 1996-99 cohorts only. The main analyses of trends therefore used the Elley Irving classification, with farmers categorised separately. A supplementary analyses using the manual and non-manual EGP classes was also undertaken as this has been commonly used in overseas publications. The impact of the choice of occupational class variable on the mortality trends is explored in section 7.3.1 page 251.

### **3.4. Mortality Outcome**

Where census records were linked to a mortality record the cause of death from the NZHIS data were included on the cohort data set. Causes of death were coded to the 3-Digit International Classification of Diseases, 9<sup>th</sup> Revision Version (ICD9-CM) classification. The ICD-9 codes outcomes considered in this thesis are given in Table 3-6

**Table 3-6 Cause of Death by ICD-9 codes**

<b>Cause of Death</b>	<b>ICD-9 Codes</b>
CVD	393-438, 440-459
IHD	410-414
Stroke	430-438
Cancer	140-209
Breast Cancer	174
Prostate Cancer	185
Lung Cancer	162
Colorectal	153,154
non-lung Cancers	140-161, 163-209
Injury (unintentional)	800-949

### **3.5. Weighting to Adjust for Incomplete Linkage**

To adjust for incomplete linkage of mortality and census record linked mortality records were weighted to represent the full mortality cohort. This process is described in detail in a report, authored by myself with Tony Blakely and June Atkinson (Fawcett et al. 2002), reproduced in the appendices (appendices, section 12.1.4 page 371).

The linkage process is summarised diagrammatically in Figure 3-3. Briefly, the incomplete linkage process means that, when considering all the mortality records in a socio-demographic strata, the number of mortality records linked to a census record is a proportion of the total number of deaths in that strata. However by multiplying the number of linked mortality records in each strata by a weighting factor ( $W_L^i$ ) we can estimate the number of deaths in that strata had all the records been successfully linked.

$$\begin{aligned} \text{Hence} & & (1) N_{Di} &= W_{Li} \cdot N_{Li} \\ \text{and thus} & & (2) W_{Li} &= N_{Di} / N_{Li} \end{aligned}$$

Where  $N_D^i$  is the total number of death records in strata  $i$  of the *mortality data* and  $N_L^i$  is the number of death records in strata  $i$  *linked* to a census record.

*For example if 126 of 200 mortality records for Māori men aged 45-50 years were linked to a census record then applying a weight of  $200/126 = 1.587$  to all linked mortality records for Māori men aged 25-44 years will weight up the linked deaths to approximate the known actual number of deaths. That is  $1.587 \times 126 = 200$ .*

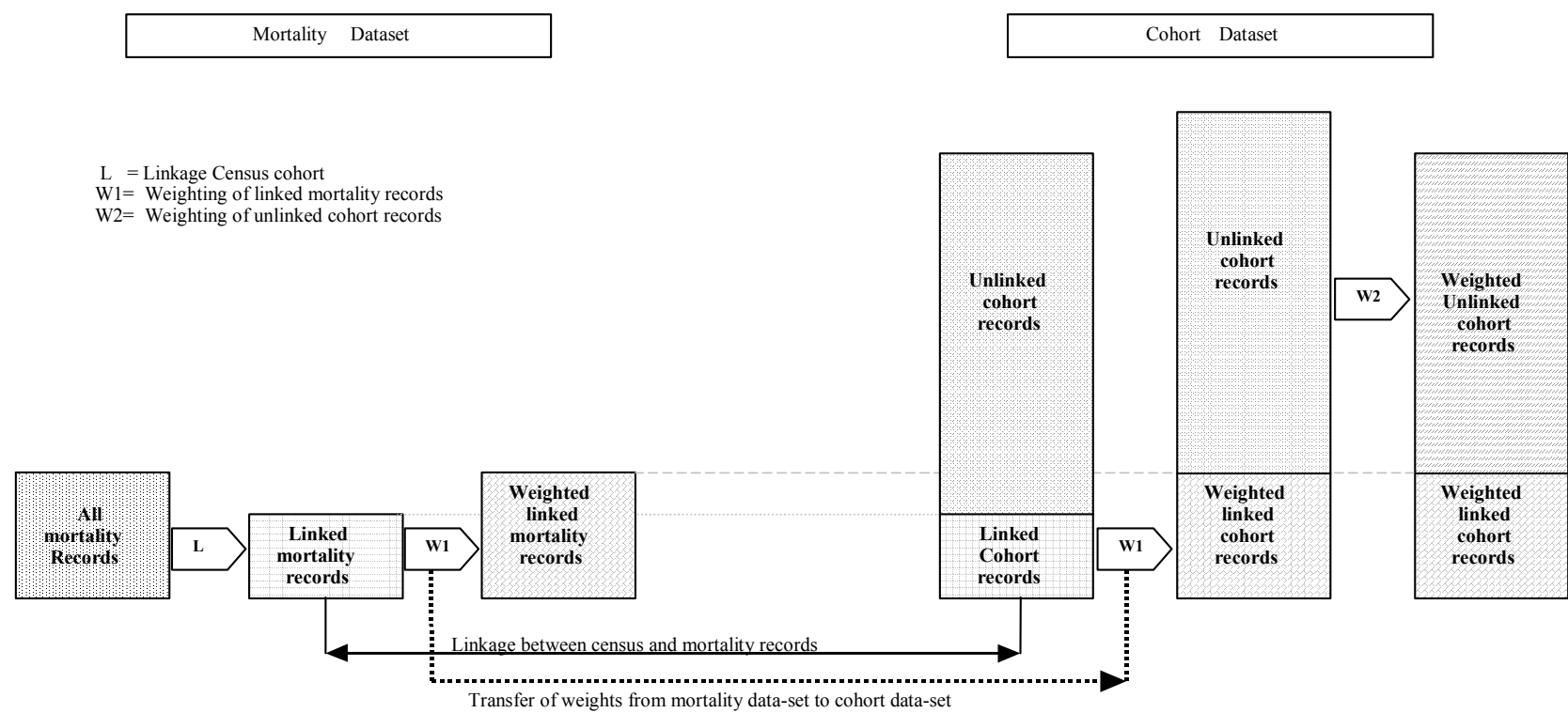
For each of the four cohorts there was an associated unlinked mortality data set, the **Bias** data-set. The bias data set included socio-demographic information and a flag indicating whether or not the record had been successfully linked to a cohort record. Weights were calculated by socio-demographic strata - [ethnic group] x [sex] x [age on census night] x [New Zealand Deprivation Index Rurality of residence] x [broad cause of death group]. The value of  $W_L^i$  was then calculated for each strata. In practice it was necessary to merge some strata to ensure at least three linked deaths in each strata.

The calculated weights were then transferred to the **Cohort** data-set (which includes all eligible census records) by linkage between individual ID numbers in the Bias and Cohort data-sets. Statistics New Zealand staff carried out the transfer of weights.

On the cohort datasets, linked cohort members represent a person who was alive at the time of the census but died in the subsequent three years. Applying weights to the linked cohort members compensates for the incomplete linkage of the mortality data-set back to the census and allows the calculation of mortality rates for the total population. It is however also necessary to weight down the unlinked cohort members to allow for the fact that some of the unlinked census records actually did die during follow-up.

In order for the weighted sum of all census records in each cohort to still equal the total number of census records, each *unlinked* census record was assigned a weight of (usually) just less than 1.0. The unlinked mortality records represent a census record for which the mortality outcome is misclassified as not dead. The cohort weights were calculated for strata of 5-year age groups, sex, ethnicity, Deprivation index and rurality. No stratification by rurality was done for Pacific and Asian (1996 only) ethnic groups. The ethnic groupings

Figure 3-3 Diagrammatic summary of linkage weighting process.



were based on prioritised ethnicity further subdivided into those with one or multiple ethnicity stated on their census record

The unlinked census records must be adjusted by a weighting factor ( $W_U^i$ )

This can be expressed mathematically

$$\begin{aligned} N_C^i &= N_{\text{LINKED(ADJUSTED)}} + N_{\text{UNLINKED (ADJUSTED)}} \\ &= N_L^i \times W_L^i + N_U^i \times W_U^i \end{aligned}$$

where  $N_C^i$  = total number of cohort members in strata i.

$$N_L^i \times W_L^i = N_{\text{LINKED(ADJUSTED)}}$$

= the weighted number of linked cohort members

$$N_U^i \times W_U^i = N_{\text{UNLINKED (ADJUSTED)}}$$

= the weighted number of unlinked cohort members

and hence  $W_U^i = (N_C^i - N_L^i \times W_L^i) / N_U^i$  (equation 2)

*For example, assume that there were 10,000 Māori male census respondents aged 0-14 years living in urban areas with a NZDep decile score of 9 or 10 ( $N_C^i = 10,000$ ). Of these, assume 50 ( $N_L^i = 50$ ) were linked to a mortality record and 9950 ( $N_U^i = 9,950$ ) were unlinked. If each of the 50 linked records had a  $W_L^i$  value of 2.0 the adjusted number of deaths  $N_L^i \times W_L^i$  would be  $2.0 \times 50 = 100$ . The estimated true number (adjusted unlinked) of respondents who were not dead would therefore be  $10,000 - 100 = 9,900$ .*

*Using equation 2 to calculate the weighting for the unlinked census cohort records*

$$\begin{aligned} W_U^i &= (10,000 - 2.0 \times 50) / 9950 \\ &= 0.994975 \end{aligned}$$

*and the number of adjusted number of unlinked cohort members is  $0.994975 \times 9950 = 9900$ .*



### 3.6. Data Analysis

#### 3.6.1 Standard Population

Analyses in this thesis are standardised to the 1991 cohort age and ethnicity structure in five-year age groups (Table 12-3, appendices page 370).

#### 3.6.2 Calculation of Person-Time

Person time of follow-up was calculated in five-year age bands. Where a cohort record was linked to a mortality record the person time was calculated as the age at death minus the age at census, otherwise the cohort member was assumed to be alive until the end of follow-up. In this case the person-time of follow-up was 36 months (3 years).

#### 3.6.3 Standardised Mortality Rates, SRR and SRD

Standardised mortality rates, ratios and rate differences were calculated using the method of Rothman and Greenland (1998, page 263). *Age* standardised and *age and ethnicity* standardised rates, rate ratios and rate differences were calculated.

#### 3.6.4 Relative Index of Inequality (RII) and Slope Index of Inequality (SII)

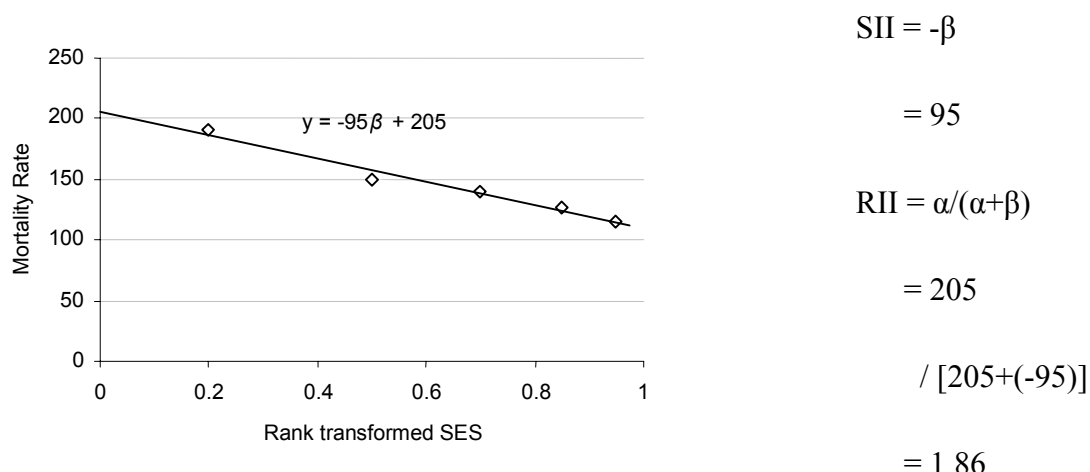
The RII is a measure of the total effect of the socio-economic factor of interest on the health or mortality in the study population. Differences in the meaning of the socioeconomic categories between populations are dealt with by the rank transformation of the socio-economic variable to have a value within the range from 0 (least advantaged) to 1 (most advantaged) (Kunst et al. 1996a). For example, where socio-economic groups, ranked from lowest to highest, comprise 25%, 15%, 20%, 30% and 10% of the study population the socio-economic variable is transformed to have the values 0.125 ( $0.5[0.25]$ ), 0.325 ( $0.25+0.5[0.15]$ ), 0.5 ( $0.25+0.15+0.5[0.20]$ ), 0.75 ( $0.25+0.15+0.20+0.5[0.30]$ ) and 0.95 ( $0.25+0.15+0.20+0.30+0.5[0.10]$ ). In a large sample this is equivalent to a modified ridit score.

The RII is calculated by the regression of the summary health or mortality measures on the rank transformed socio-economic (SEP) variable. However the methods used for the

regression and the definition of the RII have varied. An exploration of the different methods for calculating the RII and SII are included in the appendices, page 371.

In this thesis the RII was calculated by weighted least squares regression of the mortality rates on the rank transformed socio-economic (SEP) variable, using the *proc REG* procedure in SAS®. Weights were the person-time in each SEP category. Figure 3-4 illustrates the calculation of the RII for data in Table 3-7. In this example OLS regression, rather than WLS is used. The SII is thus the absolute difference in mortality between the 0<sup>th</sup> and 100<sup>th</sup> percentile of the socioeconomic variable in the population under investigation. The RII is the ratio of mortality across the full range of the socioeconomic variable under investigation.

**Figure 3-4 Calculation of the RII and SII by regression of the Category Specific Mortality Rates on the Rank transformed SEP**



**Table 3-7 Example of calculation of RII by income**

Income group	% total Person-years	Rank transformed SEP	Mortality Rate
1 (Low)	40%	0.20	190
2	20%	0.50	160
3	20%	0.70	140
4	10%	0.85	125
5 (High)	10%	0.95	115

Confidence intervals were calculated using the method of Hayes and Berry (2002), with the variance of the RII based on the variance of the mortality rates (see appendix, page 371 ).

Mortality rates used for the calculation of RII and SII were age and ethnicity standardised.

### 3.6.5 Tests for homogeneity

The Wald chi-square test was used to test for homogeneity of the SRD and SRR by ethnicity (Rothman and Greenland 1998:page 275).

Whereby 
$$\chi^2 = \sum (\hat{U}_i - \hat{U})^2 / V_i$$

Where  $\hat{U}_i$  is the estimated stratum specific MLE of the measure,  $V_i$  is the estimated variance of  $\hat{U}_i$  and  $\hat{U}$  is the MLE of the common value of the measure – in this case the age and ethnicity standardised measure. For testing the homogeneity of the SRR the log of the SRR and the variance of the strata were used.

### 3.6.6 Tests of Trend

Change in SRR, SRD, RII and SII were assessed by two methods

1. Examination of the overlap or otherwise of confidence intervals for different periods
2. By a test of linear trend using ordinary least squares regression of the rates and SRD on the time period, or the log of the RII and SRR on the time period. The t-test for the variation of  $\beta$  from the null was the test for significance.

## 3.7. Assessment of Bias

### 3.7.1 Misclassification Bias

#### 3.7.1.1 *Misclassification of Exposure Variables*

Non-differential misclassification of the socio-economic exposures was likely to have been a problem to some degree for all the socioeconomic measures of interest. However, although non-differential misclassification will probably have biased the SRR, SRD RII and SII towards the null, the extent to which this occurred is largely unmeasurable. Of more concern is differential misclassification of the exposure variables, which could bias measures of association and, where the extent of differential misclassification varied by cohort, trends in the association.

Misclassification of exposures is least likely to have been an issue for the occupational class analyses where the standard census instrument for data collection remained largely unchanged over the four cohorts.

For education, changes in the classification of educational qualifications and the census instrument are likely to have produced some degree of misclassification of educational qualifications (see section 3.1 page 92). Qualifications are generally gained in early adulthood and so the distribution by educational qualifications of an age-cohort should remain relatively constant as the cohort ages – with a small shift towards higher qualifications as some cohort members gain additional qualifications in later life<sup>4</sup>. Thus if the inter-censal classification of qualifications was constant over the four cohorts the distribution of the age cohorts should show a small shift towards higher qualifications. However changes in the survey instrument could also produce misclassification of educational qualifications in different cohorts and shifts in the distribution of the cohort. Table 3-8 shows the proportion of the cohorts with low medium and high qualifications by age in 1981.

We would expect that the proportion of the cohort in each qualification group would remain relatively constant over the period of the four cohorts because most of the cohorts have passed the age when they would be gaining many more qualifications. However the proportion of the cohort members with no qualifications declines sharply between the first two cohorts. These results suggest that in 1981 in particular a proportion of cohort members with qualifications were misclassified as having no qualifications.

To estimate the potential effect of this misclassification on mortality rates and the RII and SII in cohort members with no qualifications were redistributed according to their level of educational attainment. Mortality rates, RII and SII were then recalculated based on the redistributed population and the effects on overall trends in inequality assessed.

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<sup>4</sup> Higher mortality rates among those with lower educational qualifications will also have this effect, although the impact on the educational distribution is small because death is a relatively rare event in younger cohorts.

**Table 3-8 Proportions of Cohortees in each Education Level by Age in 1981, by Sex and Cohort**

Age in 1981	Education Level	Females				Males			
		1981	1986	1991	1996	1981	1986	1991	1996
25-29 yrs	Low	39%	34%	30%	29%	36%	29%	27%	28%
	Medium	33%	30%	28%	32%	27%	22%	21%	25%
	High	28%	36%	42%	38%	37%	49%	52%	47%
30-34 yrs	Low	49%	44%	39%	38%	42%	34%	32%	33%
	Medium	24%	22%	22%	27%	21%	17%	17%	22%
	High	26%	34%	39%	35%	38%	49%	51%	45%
35-39 yrs	Low	56%	49%	44%	43%	47%	39%	37%	38%
	Medium	20%	19%	20%	26%	17%	14%	15%	21%
	High	24%	32%	36%	31%	36%	47%	48%	42%
40-44 yrs	Low	61%	53%	48%	48%	53%	42%	40%	41%
	Medium	17%	18%	20%	24%	14%	13%	14%	20%
	High	23%	29%	32%	28%	33%	45%	46%	39%
45-49 yrs	Low	65%	57%	51%	52%	57%	44%	42%	44%
	Medium	14%	17%	21%	23%	13%	14%	15%	19%
	High	21%	26%	28%	25%	30%	42%	43%	36%
50-54 yrs	Low	70%	59%	52%	56%	61%	45%	43%	48%
	Medium	11%	18%	26%	24%	12%	15%	19%	21%
	High	18%	24%	24%	23%	28%	43%	43%	38%
55-59 yrs	Low	74%	60%	46%	56%	65%	45%	39%	48%
	Medium	11%	19%	34%	26%	11%	17%	23%	21%
	High	15%	20%	21%	18%	24%	38%	38%	32%

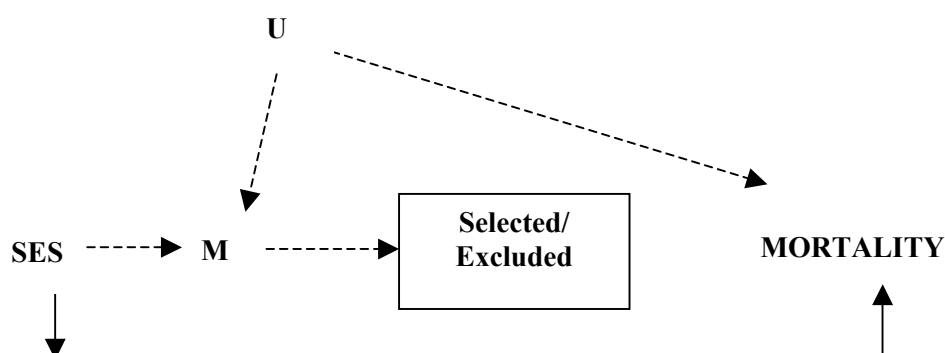
### 3.7.2 Selection Bias

Analyses for each socioeconomic variable – education, income and occupational class are necessarily restricted to cohortees with a valid value for the variable of interest. This restriction may introduce selection bias. When measuring trends, it is not so much the presence, or absence, of selection bias that is of concern, but the impact of different degrees of bias in each cohort on the interpretation of trends in the effect measures.

The potential for selection bias to affect the measures of effect is greater where a higher proportion of the NZCMS cohorts are excluded from the analyses. The proportion of cohortees with missing exposure values was greatest for occupational class and least for education. However for the 1981 cohort the proportion with missing education values was much greater than for the other cohorts.

Selection into the cohort analyses is dependent (conditioned) on each cohort member having a valid value for the socioeconomic (SEP) variable of interest. If mortality is also conditioned on factors that influence the presence of a valid socioeconomic variable then selection bias is likely to occur (Hernán et al. 2004). As an example, Figure 3-5, below, represents the conditions for selection bias in the income-restricted cohort. The solid arrows represent the relationship being measured in the selected cohort. The dashed lines represent associations that will lead to selection bias. If an unmeasured factor (U) is associated with a variable M (measured or unmeasured) that both affects selection into the cohort and is associated with the SEP, and the unmeasured factor is also associated with mortality, then selection bias will occur.

**Figure 3-5 Directed Acyclic Graph (DAG) Depicting Conditions for Selection Bias in the Income-Restricted Cohort**



Selection bias results in error in the estimation of the true effect measures. The most direct way to assess the presence of selection bias is to measure the difference in the effect measures between the selected and excluded cohorts. However when selection is based on the presence or absence of the exposure measure this is not possible (i.e. it is not possible to measure the association of the exposure and outcome among those with missing data). In this case it is sometimes possible to estimate the effect of selection bias by considering differences between selected and excluded cohorts in the association of a variable highly correlated with the exposure of interest.

The RII presents an additional complication because it is affected not only by mortality rate differentials between SEP categories but also by the size of the category. Where it was

possible to estimate the likely effect of changes in category size as a result of differential exclusion from the cohort, the RII was recalculated with adjusted category sizes to estimate the effect on the RII.

Below I briefly describe the specific methods used to estimate the effect of selection bias on the interpretation of trends in the inequality effect measures for each socioeconomic exposure.

### *3.7.2.1 Education*

In the later three cohorts the proportion of the cohorts with missing educational qualification variables was small. As a consequence, when comparing the selected and excluded cohort, even large differences in the observed association between education and mortality, would result in little difference between the observed association between education and mortality and the true association (unobserved). However in the 1981 cohort, when there were more missing data, an alternative measure of educational level (educational attendance) was available. SRR and SRD by level of educational attendance were compared for selected and excluded cohort members. The distribution by level of attendance was also used to estimate the likely effect of differential exclusion on the cohort distribution by education and consequently the RII.

### *3.7.2.2 Income*

Level of educational achievement is associated with income. As no indirect measure of household equivalised income was available on the NZCMS cohorts I instead compared effect measures for education for cohort members selected into and excluded from the income-restricted cohorts. That is I assumed that if there was any selection bias, the association between education and mortality would vary between those with and without an income value.

### *3.7.2.3 Occupational Class*

Selection bias was of particular concern for the occupational class analyses as not only are a large proportion of the cohorts excluded because they do not have a valid occupational class variable but also because movement out of the labour force due to illness is affected by occupational class. European studies have shown that higher social classes are more likely

to remain in employment in the face of illness. Selection bias, in this situation, is a type of differential health selection bias. I adapted a method developed by Kunst et al. (1998c; Kunst et al. 1996b) to adjust for the exclusion of the economically inactive from the occupational class analyses. This method apportions the excess risk among the inactive labour force to the various classes according to the proportion of the of each class that is inactive

(1) *Adjusting the class specific mortality rates using the formula of Kunst and Mackenbach*

According to the method of Kunst and Mackenbach (1998c; 1996b) the mortality rate of each occupational class can be adjusted for selection bias by weighting the mortality rate of the economically active in each class.

Thus for class X, where a proportion of the class ( $P_x^{\text{active}}$ ) has a current occupational class specification, and the rest ( $P_x^{\text{inactive}} = 1 - P_x^{\text{active}}$ ) have no current occupational class specification. The Mortality rates for class X ( $\text{Rate}_x^{\text{all}}$ ) is therefore

$$\text{Rate}_x^{\text{all}} = w_x \text{Rate}_x^{\text{active}} = P_x^{\text{active}} * \text{Rate}_x^{\text{active}} + P_x^{\text{inactive}} * \text{Rate}_x^{\text{inactive}}$$

$$\text{And } w_x = \frac{P_x^{\text{active}} * \text{Rate}_x^{\text{active}} + P_x^{\text{inactive}} * \text{Rate}_x^{\text{inactive}}}{\text{Rate}_x^{\text{active}}}$$

If we assume that the ratio of mortality of the inactive compared to the active in class x ( $\text{RR}_x^{\text{inactive/active}}$ ) is equal to the ratio of mortality of the selected compared to the excluded for the total cohort ( $\text{RR}^{\text{selected/excluded}}$ ) then we can substitute this relative risk into the formula for calculation of the adjustment weight can be rewritten as

$$w_x = 1 + (\text{RR}^{\text{inactive/active of}} - 1) * P_x^{\text{inactive}}$$

The adjusted mortality rate for class X was then calculated using the formula

$$\text{Rate}_x^{\text{all}} = w_x \text{Rate}_x^{\text{active}}$$

The assumption underlying this adjustment is that all the excess mortality of the excluded cohort compared to the selected cohort can be attributed to occupational class differences. However, this is unlikely to be the case. Unemployment and exclusion from the labour force may in themselves be associated with excess risk of mortality. The adjustments produced by this method are therefore likely to overestimate the impact of selection bias on the class specific mortality rates.



(2) *Determining the proportion inactive in each social class*

In New Zealand the New Zealand Household Labour Force Survey (HLFS) provides an alternative source of information about the occupational class distribution of the New Zealand populations. The HLFS is a random three monthly survey by Statistics New Zealand of approximately 16,000 households that collects information on household economic activity. All individuals within the household over the age of 15 years are surveyed. The HLFS has run since 1985 with very few changes. Survey results are weighted to the total population of New Zealand. Respondents are asked about current occupation or, if not employed last occupation, *during the past five years*. Using this information it is possible to distribute the unoccupied by social class and to calculate for each class the proportion not in the labour force (Kunst et al. 1998b). Age and ethnicity specific values weightings were calculated for each occupational class in 1986, 1991 and 1996.

Data was obtained from each HLFS for the quarter corresponding to the time of the 1986, 1991 and 1996 censuses. Survey respondents were grouped into three groups:

1. Group A - those currently employed;
2. Group B - those currently not employed who had been employed within the past five years; and
3. Group C - those who were not currently employed and had not been employed within the past five years.

Tables of the group distribution by social class, age, sex and ethnicity were obtained for Groups A and B. The occupational class distributions were based on the Elley Irving classification for 1986, the NZSEI for 1991 and the NZSEI96 for 1996. Occupations grouped into six social classes and those with an unspecified occupation<sup>5</sup>. Among those with a current occupation (Group A) a very small proportion had an unspecified occupation (<0.5%). However occupation was unspecified in up to 40% of females and 18% of males with a previous occupation but no current occupation (Group B).

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<sup>5</sup> For 1986 two digit occupational codes (NZSCO-68) only were available. These could not be mapped directly to the Elley Irving scale but could be mapped to the NZSEI two-digit concordance.

In order to estimate the distribution by occupational class of both Group C and those with an unspecified occupation in Group B I assumed that the class distribution of respondents without a specified current or previous occupation was the same as for respondents not currently employed had with a specified past occupation.

(3) *Adjustment of RII and SII for Health Selection Bias*

The RII and SII are affected by the size of the occupational class categories (3.6.4, page 109). The proportion of the inactive in each class was calculated from the HLFS data and the size of each class was adjusted accordingly. The RII were recalculated to take account of changes in the class size.

## Chapter 4 Trends in Overall Mortality

### **Text Box 3. Summary of Trends in Overall Mortality**

The purpose of this chapter is to describe the background temporal trends in mortality in the NZCMS cohorts between 1981-84 and 1996-99. An understanding of the background trends in mortality is important for understanding the changing patterns of socioeconomic inequalities in mortality.

#### ***Trends in Mortality***

Age and ethnicity standardised mortality rates for cohortes aged 25-77 years declined by 32% and 27% for females and males respectively. For CVD the decline was however much greater; CVD mortality declined by 52% for females and 48% for males, accounting for 84% and 73% respectively of the total mortality decline. Both Stroke and IHD contributed to the decline in CVD mortality.

Trends for other causes were variable. For females, Lung cancer rates increased by 37 % while rates declined for breast cancer (11%) and colorectal cancer (18%) and injury (5%). For males, lung cancer mortality fell by 31%, colorectal cancer rates were constant prostate cancer rates increased by 11%, and injury rates declined by 5%.

#### ***Trends in Mortality by Age***

For females proportional declines in mortality were similar (27-30%) at all ages but for males the rate of decline was least for the 25-44 year age group (11%) and most in the 45-59 year age group (39%).

However cause of death was important. CVD mortality declined most, in percentage terms, in the 45-59 year old age group. Overall cancer mortality fell most in the 25-44 year age group, and least for ages 60-77 year age group. This was because the 60-77 year old cohortes were most affected by increases in mortality for lung cancer (females) and prostate cancer (males).

#### ***Trends in Mortality by Ethnicity***

Rates of mortality from all causes and cardiovascular disease are substantially higher for Māori and Pacific ethnic groups. Furthermore Māori and Pacific people did not experience the same level of all-cause or cardiovascular mortality decline as the non-Maori non-Pacific ethnic group. For females and males respectively mortality rates declined by 12 and 8% for Maori, and 42% and 54% for non-Maori non-Pacific but were stable for Pacific female and increased by 6% for Pacific males.

#### 4.1. Deaths and Person-Time

Table 4-1 shows the total person-time in each cohort by sex, age and ethnicity. The size of the cohorts increases by 30% over the four cohorts. In particular the size of the Māori sub-group increases by around 70% while the size of the Pacific sub-group doubles. Increases are greater at older ages than at younger ages.

**Table 4-1 Person-Years (1000s) by Sex, and Age and Cohort**

Sex	Age	Ethnicity	Cohort			
			1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	ALL	1,179	1,336	1,458	1,589
		Māori	124	149	179	223
		Pacific	40	52	69	79
		non-M non-P	1,014	1,135	1,210	1,286
	45-59 yrs	ALL	659	695	764	923
		Māori	50	57	64	85
		Pacific	11	16	23	30
		non-M non-P	598	622	677	808
	60-77 yrs	ALL	572	607	624	644
		Māori	20	24	28	38
		Pacific	4	6	10	13
		non-M non-P	548	578	586	592
	Total	ALL	2,410	2,639	2,846	3,155
		Māori	195	230	271	346
		Pacific	55	74	101	122
		non-M non-P	2,160	2,335	2,473	2,687
Males	25-44 yrs	ALL	1,177	1,324	1,412	1,505
		Māori	121	141	164	201
		Pacific	41	52	64	70
		non-M non-P	1,015	1,131	1,185	1,234
	45-59 yrs	ALL	679	707	764	915
		Māori	49	56	62	82
		Pacific	12	17	22	29
		non-M non-P	618	635	680	805
	60-77 yrs	ALL	485	528	561	594
		Māori	19	21	25	34
		Pacific	3	5	8	11
		non-M non-P	463	501	528	549
	Total	ALL	2,341	2,559	2,737	3,015
		Māori	189	218	250	316
		Pacific	57	73	94	110
		non-M non-P	2,095	2,267	2,393	2,589

Despite the increasing size of the cohorts the number of deaths in each cohort has declined across the four cohorts, for all age groups except ages 25-44 years where the number of deaths increased by 5% for females and 19% for males (Table 4-2). The raw and weighted deaths by cause are given in the appendices (Table 12-6, page 377).

**Table 4-2 Raw (Linked) and Weighted Deaths\* by Sex, Age and Cohort**

Sex	Age	Cohort							
		1981-84		1986-89		1991-94		1996-99	
		Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted
Females	25-44 yrs	828	1,284	849	1,263	942	1,329	981	1,347
	45-59 yrs	2,445	3,387	2,424	3,231	2,445	3,123	2,607	3,273
	60-77 yrs	8,298	11,487	8,925	11,823	8,622	10,818	8,367	10,173
	Total	11,574	16,158	12,195	16,317	12,009	15,273	11,955	14,793
Males	25-44 yrs	1,212	2,013	1,404	2,289	1,461	2,424	1,410	2,400
	45-59 yrs	4,128	5,838	3,792	5,265	3,414	4,590	3,465	4,629
	60-77 yrs	13,047	17,610	13,551	17,529	13,176	16,365	12,672	15,408
	Total	18,387	25,464	18,747	25,086	18,054	23,379	17,547	22,434

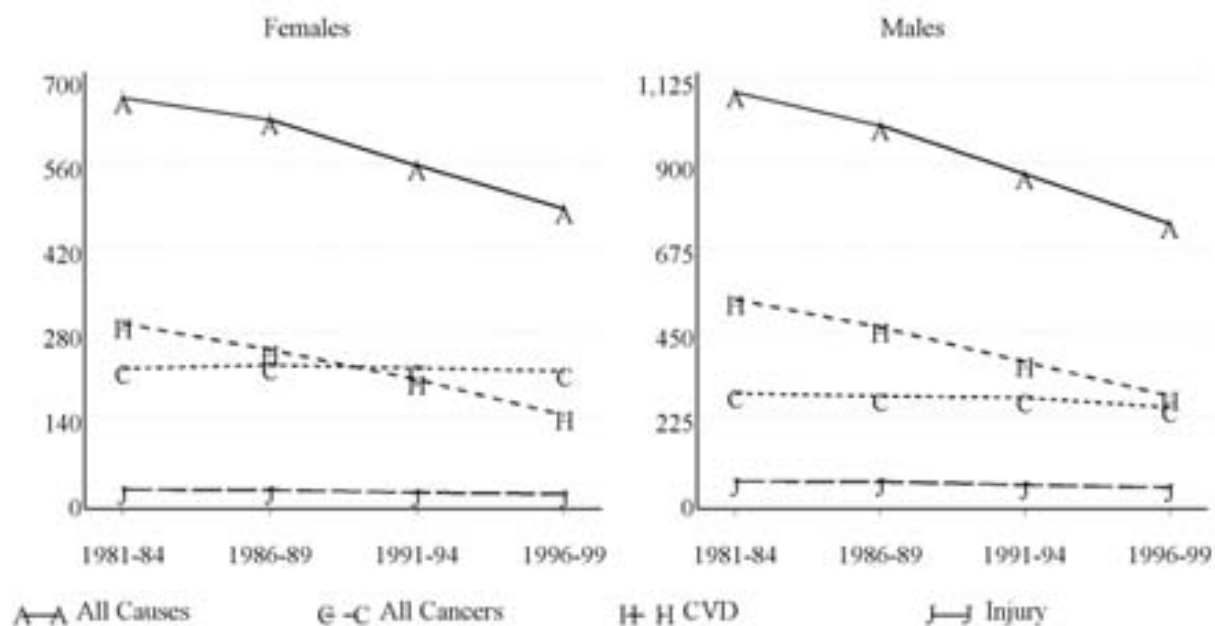
\*Random Rounded to Multiples of Three according to Statistics New Zealand protocol

CVD deaths accounted for a declining proportion of all deaths across the four cohorts; in the four consecutive cohorts CVD accounted for 50%, 45%, 40% and 33% of deaths cohorts for females aged 25-75 years, and 49%, 46%, 43% and 38% of deaths for males. In contrast the proportion of deaths due to cancer increased between 1981-84 and 1996-99; cancer deaths accounted for 34%, 37%, 41% and 45% of deaths for females and 27%, 28%, 32% and 34% of deaths for males.

## **4.2. Trends in Mortality Rates**

Figure 4-1 shows age and ethnicity standardised mortality rates for the period from 1981-84 to 1996-99 by sex, cohort and cause of death. Over the period between 1981-84 and 1996-99 mortality rates in the NZCMS cohorts fell by 32% for females (182 per 100,000 person-years) and 27% for males (349 per 100,000 person-years).

**Figure 4-1 Mortality Rates\* by Sex, Cohort and Major Causes – ages 25-77 years**

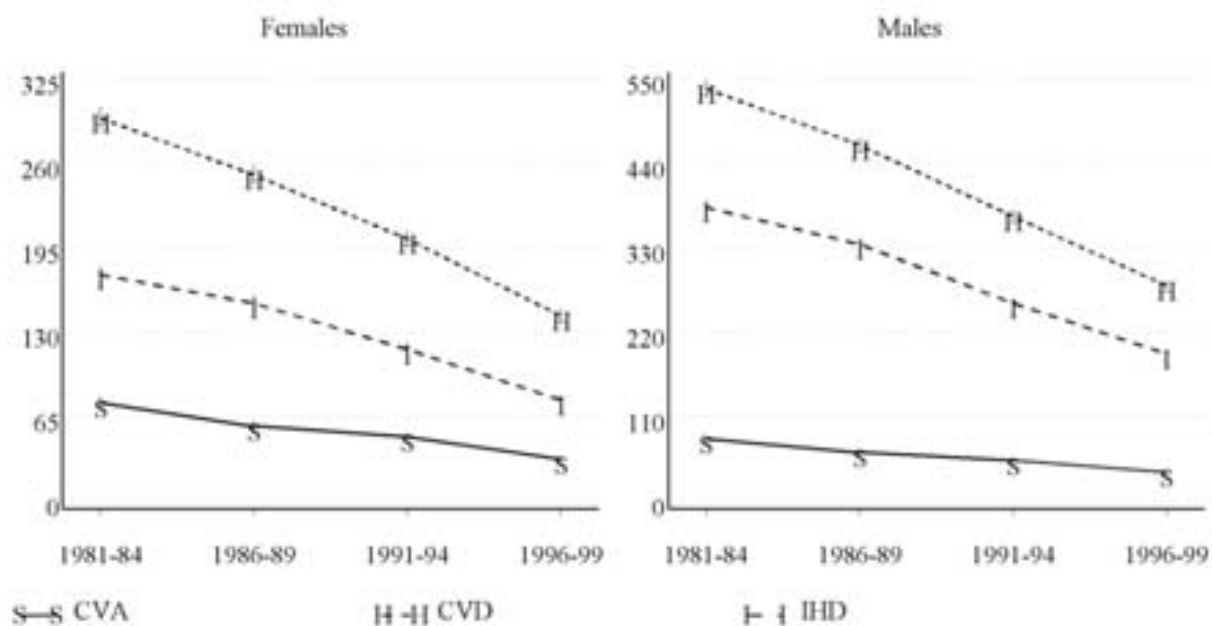


\* age and ethnicity standardised per 100,000 person-years

The decline in all-cause mortality was largely due to a substantial decline in CVD mortality; CVD mortality fell by 52% for females (152 per 100,000 person-years) and 48% for males (256 per 100,000 person-years). Although there were declines in a number of causes of death CVD mortality accounted for 84% of the decline in all-cause mortality for females and 73% for males.

Declines in both IHD and stroke mortality contribute to the decline in CVD mortality (Figure 4-2) with the proportional decline in Stroke being slightly greater than for IHD mortality. The proportionate decline in stroke mortality was greater for females (57%) than males (54%), although this translated into similar levels of absolute decline – 43 per 100,000 person-years for females and 44 per 100,000 person-years for males. IHD mortality declined by 55% for females (96 per 100,000 person-years) and 50% for males (191 per 100,000 person-years). As a consequence of these differences in decline in mortality from Stroke and IHD, IHD mortality accounts for a smaller proportion of total CVD mortality in 1996-99 than in 1981-84 cohort.

**Figure 4-2 CVD Mortality Rates\* by Cohort Period, Sex and Cause.**



\*Age and ethnicity standardised per 100,000 person-years

For females, cancer mortality rates remained fairly constant across the four cohorts. However the trends varied by type of cancer. For example mortality rates fell 18 % for colorectal cancer and 11% for breast cancer but increased 37% for lung cancer.

For males, total cancer mortality declined by 13%, but trends varied by cause: Lung cancer mortality declined by 31%; colorectal cancer rates remained relatively constant; and prostate cancer mortality rates increased by 10%.

Injury mortality also declined for both females (37%) and males (30%). The decline in injury mortality contributed about 5% to the overall mortality decline for both males and females.

**Table 4-3 Mortality Rates\* by Sex , Cause of Death and Cohort**

Cause	Sex	Cohort												
		1981-84			1986-89			1991-94			1996-99			% change
ALL CAUSES	Females	668	(656-	681)	633	(621-	645)	557	(547-	568)	486	(477-	495)	-27%
	Males	1090	(1073-	1106)	1002	(987-	1017)	872	(859-	885)	741	(730-	752)	-32%
CVD	Females	295	(286-	304)	251	(244-	259)	202	(196-	208)	143	(138-	148)	-52%
	Males	537	(526-	549)	464	(454-	474)	371	(363-	380)	281	(274-	288)	-48%
IHD	Females	174	(168-	181)	152	(147-	158)	117	(112-	122)	78	(74-	82)	-55%
	Males	383	(373-	392)	335	(326-	343)	258	(251-	265)	192	(187-	198)	-50%
Stroke	Females	76	(71-	80)	58	(54-	62)	50	(46-	53)	33	(30-	35)	-57%
	Males	82	(77-	86)	64	(60-	68)	54	(50-	57)	38	(36-	41)	-54%
ALL CANCERS	Females	220	(213-	227)	226	(219-	232)	221	(215-	227)	216	(210-	222)	-2%
	Males	287	(279-	296)	280	(273-	288)	276	(269-	283)	250	(244-	257)	-13%
Colorectal	Females	38	(35-	41)	38	(35-	40)	33	(31-	35)	31	(28-	33)	-18%
	Males	42	(39-	45)	42	(39-	44)	45	(42-	47)	41	(38-	43)	-2%
Lung	Females	27	(25-	30)	33	(30-	35)	35	(32-	37)	37	(34-	39)	37%
	Males	88	(84-	93)	83	(78-	87)	72	(68-	75)	61	(57-	64)	-31%
Breast	Females	47	(44-	51)	49	(46-	53)	45	(43-	48)	42	(40-	45)	-11%
Prostate	Males	21	(19-	24)	23	(21-	25)	25	(23-	27)	23	(21-	25)	10%
Injury	Females	19	(17-	22)	19	(17-	21)	14	(13-	16)	12	(11-	14)	-37%
	Males	53	(49-	57)	52	(49-	56)	43	(40-	47)	37	(34-	40)	-30%

\*age and ethnicity standardised per 100,000 person-years



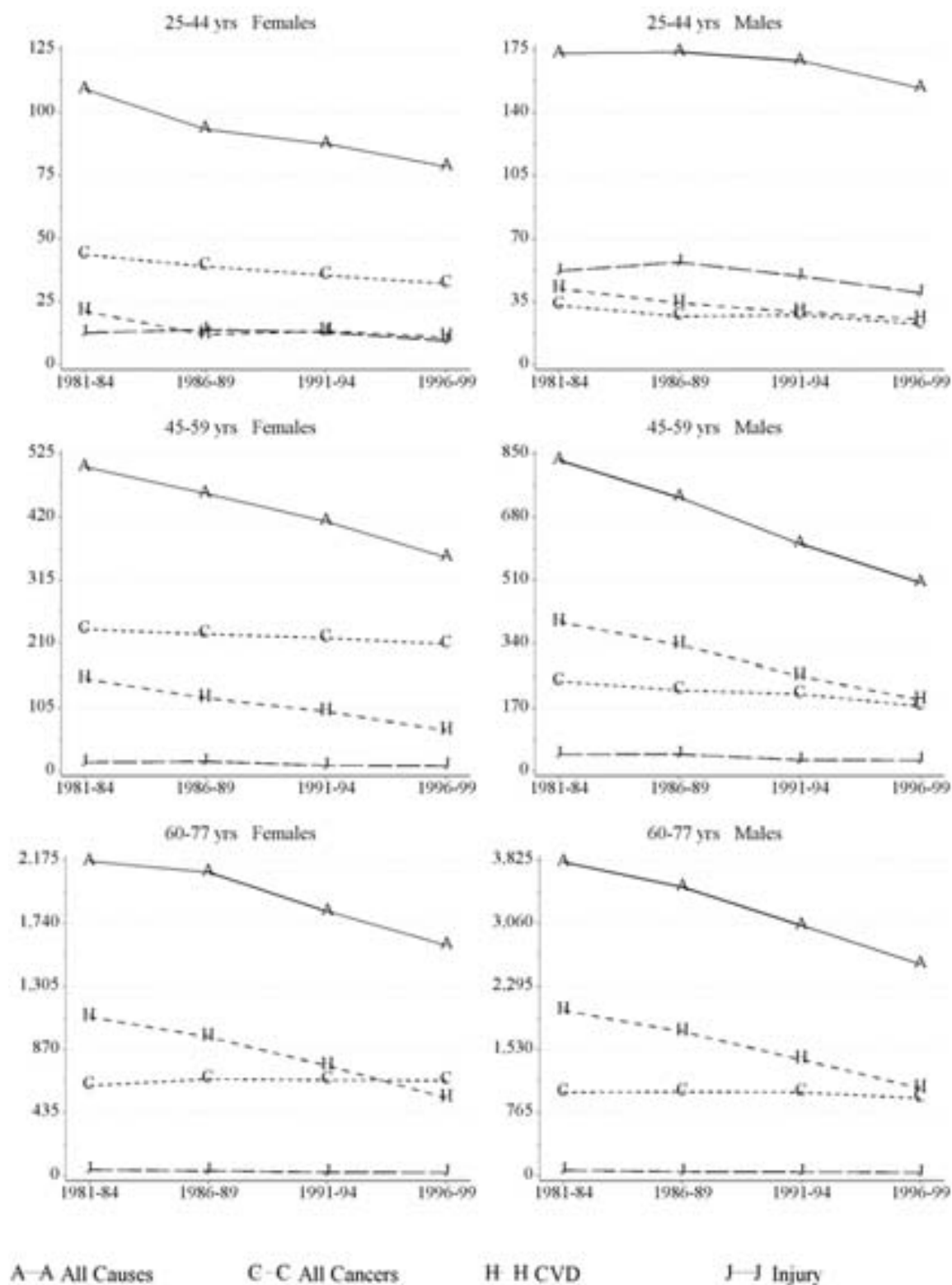
### **4.3. Trends in Mortality Rates by Age**

Declines in all-cause mortality have occurred for all age and sex groups (Figure 4-3). However men aged 25-44 years have experienced much smaller declines (11%) than men aged 45-59 years (39%) or 60-77 years (32%). Mortality rates for 25-44 year olds did not decline at all during the first inter-cohort period. For females, proportional declines in all-cause mortality were very similar at all ages (27-30%).

For CVD and IHD, mortality rates for both sexes declined most for 45-59 year olds and least for 25-44 year olds.

In contrast the 25-44 year old cohortes benefited most from declines in overall cancer mortality rates with declines of 27% for females and 30% for males. Cancer mortality fell by only 6% for 60-77 year old females and 7% for 60-77 year old males. This is because the 60-77 year old cohortes were most affected by increases in mortality for lung cancer (females) and prostate cancer (males).

**Figure 4-3 Mortality Rate\* by Cohort Period, Sex , Age and Cause.**



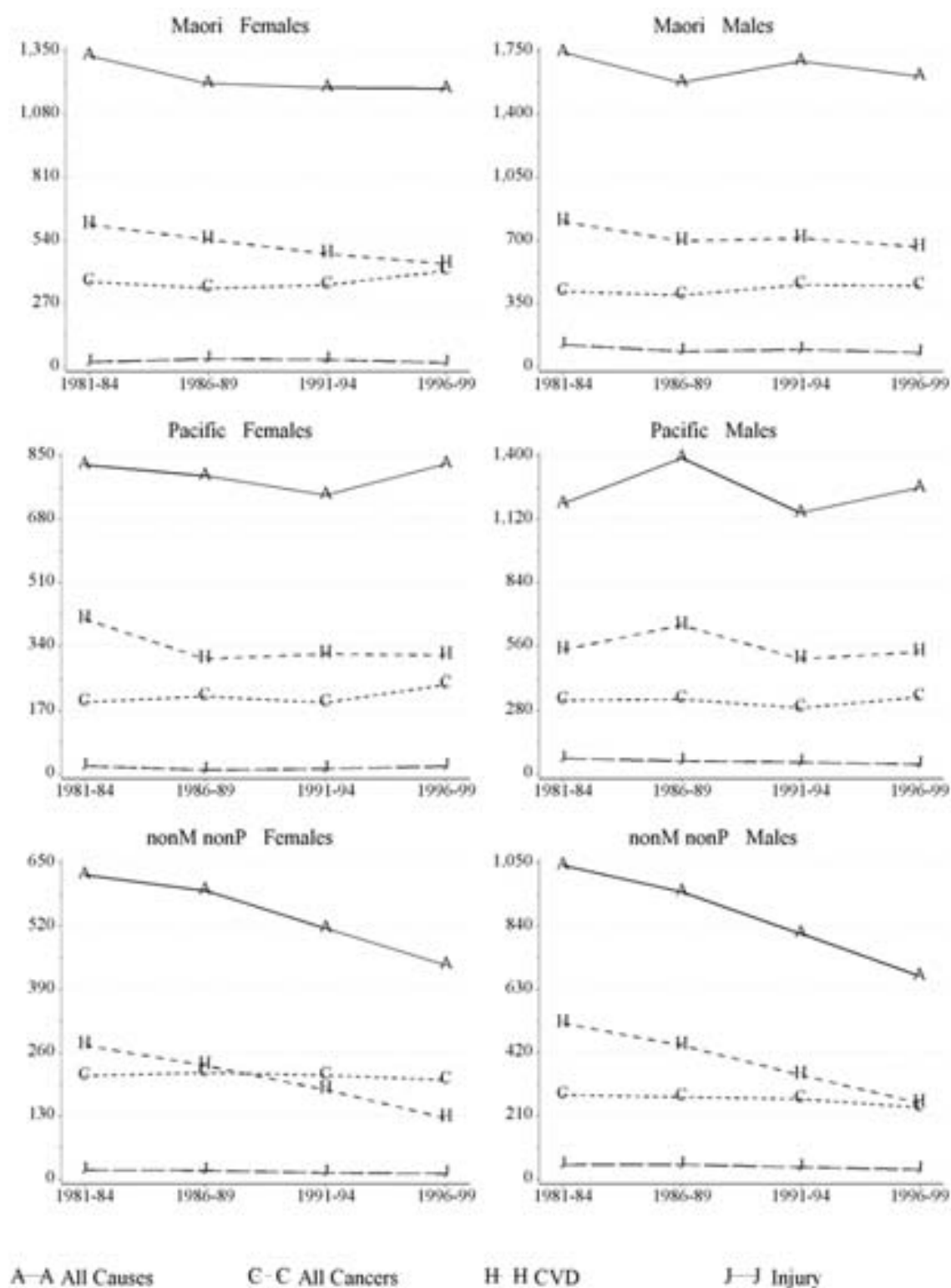
\*age and ethnicity standardised per 100,000 person-years Mortality rates and 95% Confidence intervals are give in the appendices- Table 12-8, page 380).

#### ***4.4. Trends in Mortality Rates by Ethnicity***

Mortality Rates from all causes and CVD are substantially higher for Māori and Pacific ethnic groups. Furthermore Māori and Pacific people did not experience the same level of all-cause or CVD mortality decline as other ethnic groups (Figure 4-4)

For Māori mortality declined by twelve and eight percent for females and males respectively, compared to declines of 42% and 54% for non-Māori non-Pacific females and males. Pacific females showed no change in total mortality and Pacific males experienced a six percent increase. The lower rates of mortality decline for Māori and Pacific cohorts were primarily due to smaller declines in cardiovascular disease mortality than non-Māori non-Pacific and increasing rates of cancer mortality, compared to declines for non-Māori non-Pacific.

**Figure 4-4 Ethnicity Specific Mortality Rates\* by Sex and Cohort - ages 25-77 years.**



\*age standardised per 100,000 person-years

Corresponding mortality rates and 95% CIs are given in the appendices Table 12-9 , page 382).

## Chapter 5 Trends in Mortality by Education Level

### Text Box 4. Summary of Trends in Mortality by Education Level

The size of the educational groups changes substantially over the period of the four cohorts. In particular, the proportion of the population with no educational qualifications has declined substantially.

#### *All Cause Mortality*

*Mortality Trends:* In each cohort there is an association between low educational level and high mortality rates for both females and males. Mortality rates within each educational level declined over the period of the four cohorts.

*Trends in Relative Inequality:* Relative inequality increased over the four cohorts. For females the RII peaked in 1991-94 before falling away again. For males there was a consistent but modest increase over time: RII increased from 1.58 (95%CI: 1.46-1.72) in 1981-84 to 1.66 (95%CI: 1.56-1.78) in 1996-99 and the SRR from 1.35 (95%CI: 1.18-1.54) to 1.72 (95%CI: 1.58-1.88).

*Trends in Absolute Inequality:* Absolute inequality by education remained relatively stable for females. For males however there was a significant downward trend in the SII from 467 per 100,000 to 389 per 100,000 person-years.

*Variation by Age:* Although lower levels of education were associated with higher mortality in all age groups, for both females and males in all four cohorts there were substantial variations by age in trends in inequality (see table below)

	25-44 years	45-59 years	60-77 years
<i>Females</i>			
Trends in mortality rates	No decline	Declined	declined
Relative inequality	No particular trend	Increased	no particular pattern
Absolute inequality	No particular trend	Decreased	stable
<i>Males</i>			
Trends in mortality rates	No decline, increases at low education levels	declined	declined
Relative inequality	No particular trend	increased	stable
Absolute inequality	No particular trend	stable	decreased

### ***CVD Mortality***

CVD mortality is associated with education in all four cohorts for both females and males. The SRR and RII are much higher for females than for males.

*Mortality Trends:* All age, sex and educational groups experienced declines in CVD mortality over the period of the four cohorts.

*Trends in Relative Inequality:* Relative inequality is greater in the 1990s than the 1980s for females but remains constant for males.

*Trends in Absolute Inequality:* Both the SRD and SII decline substantially over time; the SII declines by 43% for females and by 23% for males.

*Variation by Age:* Relative inequality measures were highest in the 45-59 year age group but still substantial at ages 60-77 years. Relative inequality, measured by the RII, increased while absolute inequality decreased in the 45-59 year age group. For older cohort members aged 60-77 years there was no evidence of increasing relative inequality, while the SII halved.

*IHD and Stroke Mortality:* Trends in IHD mortality by education level, and in both relative and absolute inequality are similar to those for total CVD, as are those for stroke among men. For females the RII for both causes increases over time and the SII decreases. The association between stroke mortality and education weakens over time, especially among 60-77 year old males.

*Contribution of Causes to Inequality by Education:* The contribution of different causes to the change in overall inequality was assessed by examining the changing contribution of broad cause of death groups to the SII for all causes. For males the change in the SII by education is almost entirely the consequence of the changing SII for CVD, which despite substantial declines in the last cohort remains the largest contributor to the all cause SII for males. For females the contribution of CVD is large but decreases over time, so that by 1996-99 cancers contribute more in total than any other broad cause of death group. Increases in the RII for both lung cancers and non-lung cancers contribute to the growing importance of cancer inequality.

### ***Assessment of Bias.***

Sensitivity analyses examining the potential impact of misclassification and selection bias on trends in inequality suggest that any bias that might exist would have a minimal effect on the reported trends.

## 5.1. Description and Assessment of Data

### 5.1.1 Counts of Deaths and Person-Time

Person-time in each cohort by sex, age are shown in Table 5-1. The weighted number of deaths by cause of death, age and sex in the education-restricted cohorts are given in the appendices (Table 12-12 page 385). Raw and Weighted deaths by cohort-period, age, sex and ethnicity are also given in the appendix (Table 12-11, page 385).

**Table 5-1 Person-Years (1000s) by Sex, Age and Cohort – Education Restricted Cohort.**

Sex	Age	Cohort			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	1,070	1,256	1,437	1,519
	45-59 yrs	583	638	747	882
	60-77 yrs	482	521	594	605
	Total	2,135	2,414	2,775	3,010
Males	25-44 yrs	1,089	1267	1,389	1,425
	45-59 yrs	615	666	748	872
	60-77 yrs	421	474	540	560
	Total	2,125	2,407	2,680	2,857

### 5.1.2 Cohort Restriction

In order to restrict the cohort to members who were likely to have completed their education, the analyses were restricted to the usually resident population aged 25 to 74 years on census night. It was also necessary to exclude from analyses all cohort members with missing, incomplete or unspecified educational qualifications.

Table 5-2 shows that the proportion of the eligible cohort for whom educational qualification data were missing by age and sex. The proportion of cohort members with missing qualifications was greatest in 1981 and declined substantially in 1986, reached a minimum in 1991 and increased slightly again in 1996. The proportion of cohort with missing education level was greater for females than males, and highest in the older age groups. In the earlier cohorts the proportion with missing education level data were higher for Māori and Pacific people, although this was no longer true by 1991. A detailed discussion of the possible impact of the exclusion of people with no educational data from the analyses is given in section 5.3.2, page 165.

**Table 5-2 Percentage of person-years excluded from analyses as a result of missing education data**

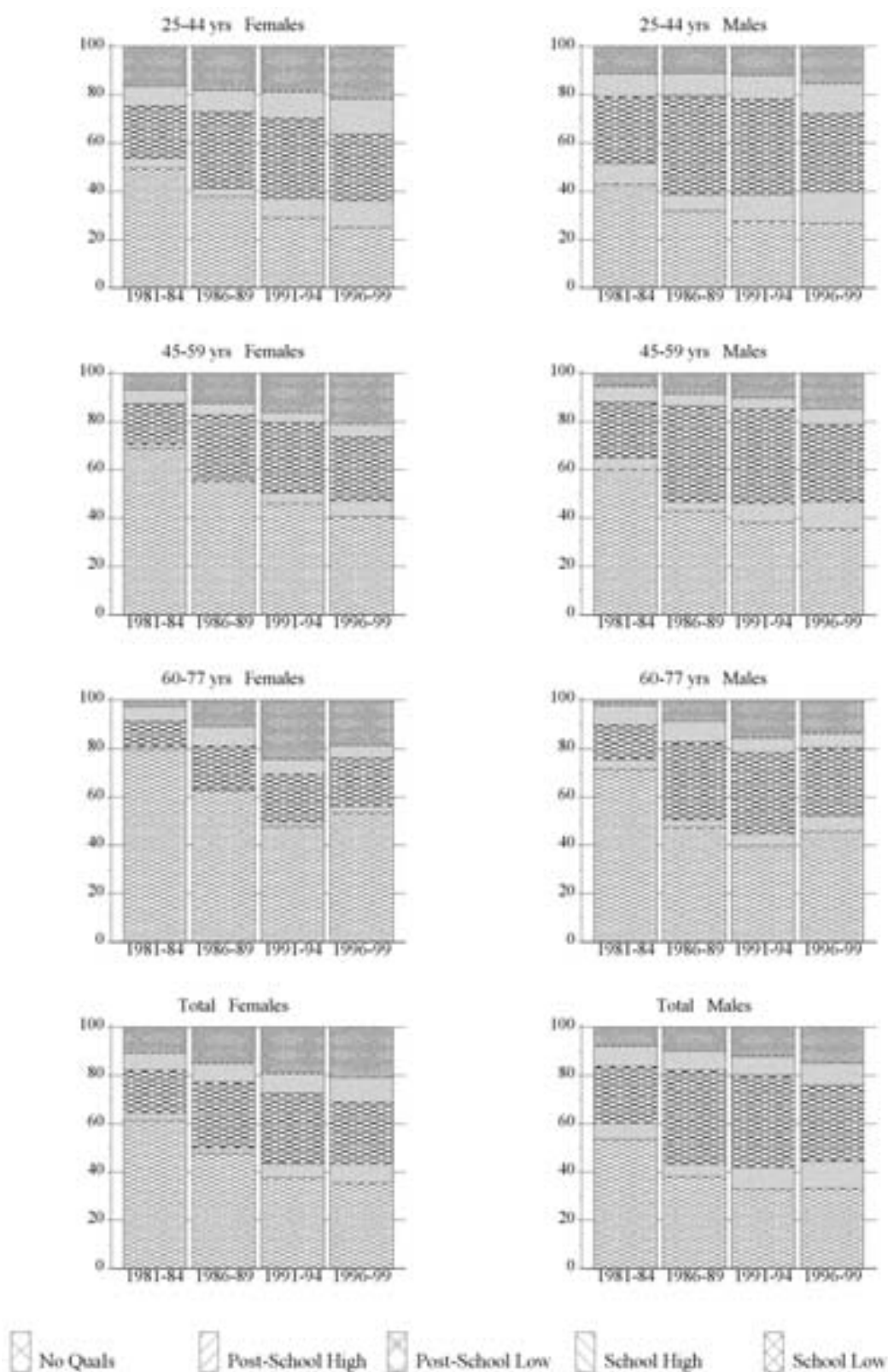
Sex	Age	Period			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	9	6	2	4
	45-59 yrs	12	8	2	4
	60-77 yrs	16	14	6	6
	Total	11	9	3	5
Males	25-44 yrs	7	4	2	5
	45-59 yrs	10	6	2	5
	60-77 yrs	13	10	4	6
	Total	9	6	2	5

### 5.1.3 Distribution of the Cohort by Education

The size of the educational groups changes substantially over the period of the four cohorts. This is illustrated in Figure 5-1, below. In particular, the proportion of the population with no educational qualifications has declined substantially. Although this reflects the increasing educational attainment of the population over time, for these analyses, changes in the data collection instrument may have also contributed to the reduction in the size of the group with no education. Summarising the inequality measurement in terms of the RII and SII takes account of the changing distribution of the education variable. The potential impact of the large proportion of the cohort with missing educational qualifications in first cohort (1981-84), on trends in inequality by education is explored in section 5.3, page 163.



**Figure 5-1 Percentage of person-years in each education category by age, sex and Cohort**

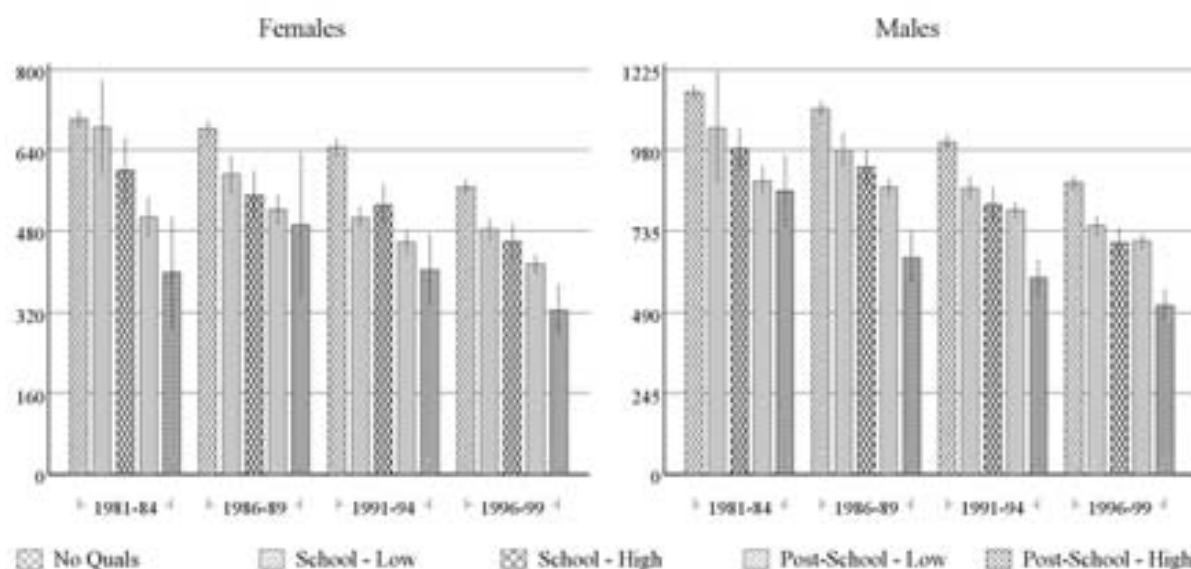


## 5.2. Mortality Trends by Education Level

### 5.2.1 All Cause Mortality

Figure 5-2, below shows mortality rates by education level for each of the four cohorts. SRD and SRR are also given in Table 5-3 and Table 5-4. RII and SII measures are given in Table 5- 6 and Figure 5-3. In each cohort there is an association between low educational level and high mortality rates for both females and males.

**Figure 5-2 All Cause Mortality by Education Level and Cohort, by Sex – age 25-77 years, Age and Ethnicity Standardised\***



\*age and ethnicity standardised per 100,000 person-years

Mortality rates within each educational category declined over the period of the four cohorts. This decline is consistent and monotonic for all educational groups for males and among women with no qualifications or with school qualifications only. Women with post-school qualifications experienced an increase in mortality during the two middle cohorts. Nevertheless the most educated women never lose their advantage over those with less education during these two periods.

*Trends in Relative Inequality:* For women, measures of relative inequality increased in the period from 1986-89 onwards. The SRR of the least educated to the most educated group, for each of the subsequent cohorts were 1.77, 1.39, 1.60 and 1.70. These results suggest a decrease in relative inequality between the two extreme educational groups from 1981-84 to 1986-89 followed by substantial rises in the following two inter-cohort periods. However a

slightly different picture emerges when relative inequality across the total educational distribution is measured using the RII (Table 5-5). The RII was greatest during the early 1990s. Although the test of trend was non-significant for change over the period of the four cohorts, the RII for both cohorts during the 1990s, were higher than for the 1980s cohorts.

For men, the results show more consistent evidence for increasing relative inequality by education. The SRR for the least educated to most educated were 1.35, 1.69, 1.69 and 1.72 for the respective cohorts - showing a consistent monotonic increase over time. This is also the case for the RII which increases from 1.57 (95%CI:1.41-1.76) to 1.70 (95%CI:1.59-1.82). The test for trend was significant ( $p < 0.01$ ).

*Trends in Absolute Inequality:* For women, the standardised rate difference (SRD) for each educational group, compared to the most educated, declined between 1981-84 and 1986-89 and increased in the subsequent two inter-cohort periods. Table 5-3 and Table 5-4.. However, there is considerable overlap of the confidence intervals for subsequent periods. The SII also shows no consistent trend

For men, the SRD for each educational group, compared to the most educated increased between 1981-84 and 1986-89 and then declined in each subsequent cohort. The SII decreased consistently between each cohort from 467 to 380 per 100,000 person-years between 1981-84 and 1996-99 (Table 3-5 and Figure 5-3).

*Confounding by Ethnicity:* Table 5-3 and Table 5-4 give *age standardised* and *age and ethnicity standardised* mortality rates by education. The results illustrate the effect of confounding by ethnicity on the age standardised rates. For example in 1991-94, for females, the age and ethnicity standardised rate (646.1 per 100,000 person-years) is 4% lower than the age standardised rate (671.4 per 100,000 person-years) for cohort members with no qualifications but is 4% higher for members with post-school high qualifications (402.6 compared to 388.7 per 100,000 person-years). This confounding occurs as a result of the differential distribution of different ethnic groups by qualification level and the independent association of ethnicity with mortality. Throughout this chapter age and ethnicity adjusted mortality rates, RII and SII are presented.

**Table 5-3 Summary of Mortality Rates by Education Level -Females**

Cohort	Education Level	Deaths (n)*	Crude Rate	Std Rate <sup>†</sup>	Std Rate <sup>‡</sup>	SRR (95% CI) <sup>‡</sup>	SRD (95% CI) <sup>‡</sup>
1981-84	No Qualifications	11,073	843.2	703.8	701.5	1.77 (1.34-2.34)	305.0 (193.0-417.1)
	School-Low	540	234.7	668.7	685.2	1.73 (1.27-2.36)	288.7 (143.8-433.7)
	School-High	717	475.0	568.1	599.4	1.51 (1.12-2.04)	202.9 ( 73.9-331.8)
	Post-School – Low	1,215	323.1	493.5	507.2	1.28 (0.96-1.71)	110.7 ( -7.4-228.7)
	Post-School – High	138	209.8	369.0	396.5	1.00	0.0
1986-89	No Qualifications	9,318	807.9	693.0	682.7	1.39 (1.03-1.86)	191.0 ( 45.6-336.5)
	School-Low	1,524	417.5	580.3	592.2	1.20 (0.89-1.63)	100.6 ( -48.8-249.9)
	School-High	909	488.1	533.2	550.2	1.12 (0.82-1.52)	58.5 ( -94.1-211.1)
	Post-School – Low	2,175	331.6	503.9	522.6	1.06 (0.79-1.43)	30.9 (-116.5-178.3)
	Post-School – High	111	205.4	461.2	491.6	1.00	0.0
1991-94	No Qualifications	7,902	756.8	671.4	646.1	1.60 (1.34-1.92)	243.5 (1,70.9-316.1)
	School-Low	3,063	573.6	493.4	505.7	1.26 (1.05-1.50)	103.1 ( 29.4-176.8)
	School-High	861	376.8	523.0	530.9	1.32 (1.09-1.60)	128.3 ( 45.9-210.7)
	Post-School – Low	2,484	307.8	444.1	456.9	1.13 (0.95-1.36)	54.3 ( -19.8-128.4)
	Post-School – High	282	173.7	388.7	402.6	1.00	0.0
1996-99	No Qualifications	8,190	771.2	602.4	566.7	1.74 (1.50-2.03)	242.0 (191.7-292.2)
	School-Low	2,574	411.1	480.9	482.2	1.48 (1.27-1.73)	157.4 (104.8-210.0)
	School-High	843	271.9	453.1	458.3	1.41 (1.19-1.67)	133.5 ( 72.6-194.4)
	Post-School – Low	2,424	317.0	412.4	413.1	1.27 (1.09-1.49)	88.4 ( 36.4-140.3)
	Post-School – High	348	141.6	315.1	324.8	1.00	0.0

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>Age standardised per 100,000 person-years

<sup>‡</sup>age and ethnicity standardised per 100,000 person-years

**Table 5-4 Summary of Mortality Rates by Education Level -Males**

Cohort	Education Level	Deaths (n)*	Crude Rate	Std Rate <sup>†</sup>	Std Rate <sup>‡</sup>	SRR (95% CI) <sup>‡</sup>	SRD (95% CI) <sup>‡</sup>
1981-84	No Qualifications	16,185	1,421.7	1,165.9	1,156.6	1.35 (1.18-1.54)	301.5 (186.8-416.1)
	School-Low	711	425.0	985.2	1,047.4	1.22 (0.99-1.51)	192.3 (-12.3-396.8)
	School-High	1,536	863.9	979.4	984.9	1.15 (0.99-1.33)	129.8 (0.2-259.5)
	Post-School – Low	2,844	567.7	861.1	885.9	1.04 (0.90-1.19)	30.8 (-90.5-152.2)
	Post-School – High	723	510.9	788.2	855.1	1.00	0.0
1986-89	No Qualifications	11,763	1,285.9	1,128.2	1,105.9	1.69 (1.50-1.91)	452.1 (369.6-534.6)
	School-Low	2,001	836.9	976.7	981.3	1.50 (1.32-1.71)	327.5 (233.4-421.6)
	School-High	1,695	885.7	912.1	927.6	1.42 (1.24-1.62)	273.9 (177.4-370.4)
	Post-School – Low	6,441	689.1	849.5	868.5	1.33 (1.17-1.50)	214.7 (131.4-298.1)
	Post-School – High	474	372.8	649.7	653.7	1.00	0.0
1991-94	No Qualifications	10,212	1,155.5	1,046.4	1,004.2	1.69 (1.54-1.87)	411.6 (350.8-472.4)
	School-Low	3,495	1,068.1	850.1	864.5	1.46 (1.32-1.62)	271.9 (205.8-337.9)
	School-High	1,314	638.5	802.6	815.9	1.38 (1.23-1.54)	223.3 (146.4-300.1)
	Post-School – Low	6,786	665.1	773.7	796.6	1.34 (1.22-1.48)	203.9 (143.4-264.5)
	Post-School – High	882	362.5	572.0	592.6	1.00	0.0
1996-99	No Qualifications	10,989	1,163.4	945.1	881.1	1.72 (1.58-1.88)	370.0 (321.8-418.1)
	School-Low	2,964	700.3	758.6	750.6	1.47 (1.34-1.61)	239.5 (185.8-293.3)
	School-High	1,329	494.2	698.1	697.4	1.36 (1.23-1.52)	186.3 (123.9-248.6)
	Post-School – Low	5,577	623.7	699.4	703.7	1.38 (1.26-1.51)	192.6 (144.0-241.2)
	Post-School – High	1,044	318.5	481.6	511.1	1.00	0.0

\*Random rounded to base three according to SNZ protocol

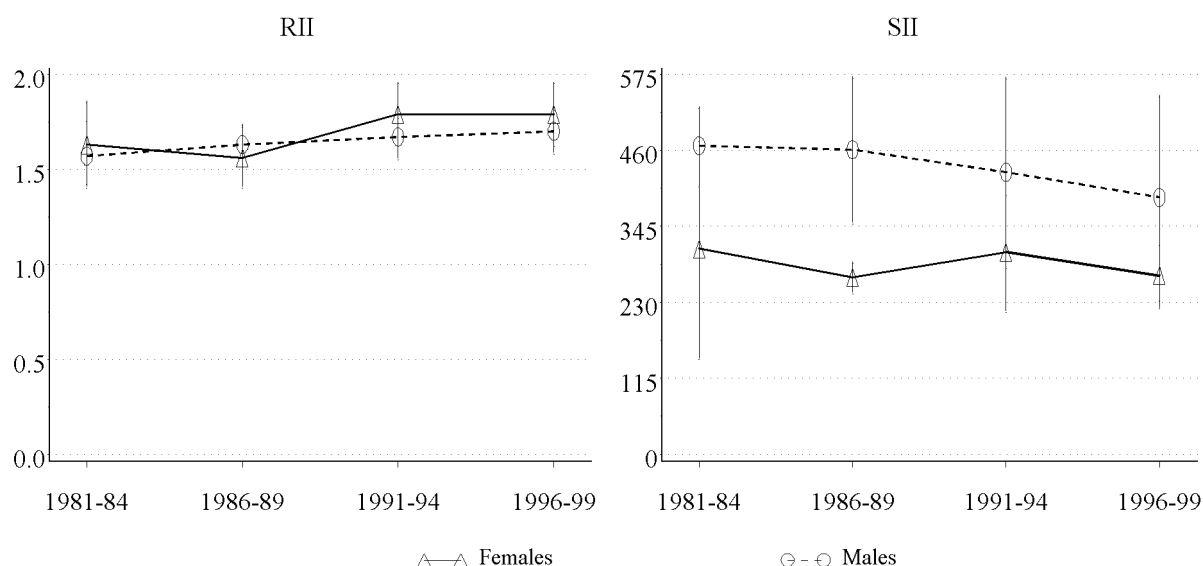
<sup>†</sup>Age standardised per 100,000 person-years

<sup>‡</sup>Age and ethnicity standardised per 100,000 person-years

**Table 5-5 All Cause Mortality by Education- RII and SII, by Cohort and Sex \***

Sex	Period	RII (95% CI)		P (Trend)	SII (95% CI)		P (Trend)
Females	1981-84	1.63	(1.43- 1.86)	.	311	(146- 477)	.
	1986-89	1.56	(1.41- 1.73)	.	268	(245- 291)	.
	1991-94	1.79	(1.63- 1.96)	.	306	(217- 394)	.
	1996-99	1.79	(1.63- 1.96)	0.20	271	(223- 319)	0.85
Males	1981-84	1.57	(1.41- 1.76)	.	467	(408- 526)	.
	1986-89	1.63	(1.52- 1.74)	.	461	(351- 572)	.
	1991-94	1.67	(1.56- 1.78)	.	427	(284- 571)	.
	1996-99	1.70	(1.59- 1.82)	<0.01	389	(235- 543)	0.05

\*age and ethnicity standardised

**Figure 5-3 All Cause Mortality by Education- RII and SII, by Cohort and Sex\***

\*age and ethnicity standardised

### 5.2.1.1 Variation by Age, in All-Cause Mortality Trends by Education

Figure 5-4 shows that the pattern of higher mortality for the least educated compared to the most educated was observed for each of the three age groups, 25-44 years, 45-59 years and 60-77 years, for both females and males in all four cohorts. For the 25-44 year age group, for both females and males, there was no consistent decline in mortality across the period of the four cohorts, in any of the education groups. The pattern of decline in mortality for the 45-59 year and 60-77 year age-groups was similar to the pattern for all age groups combined.

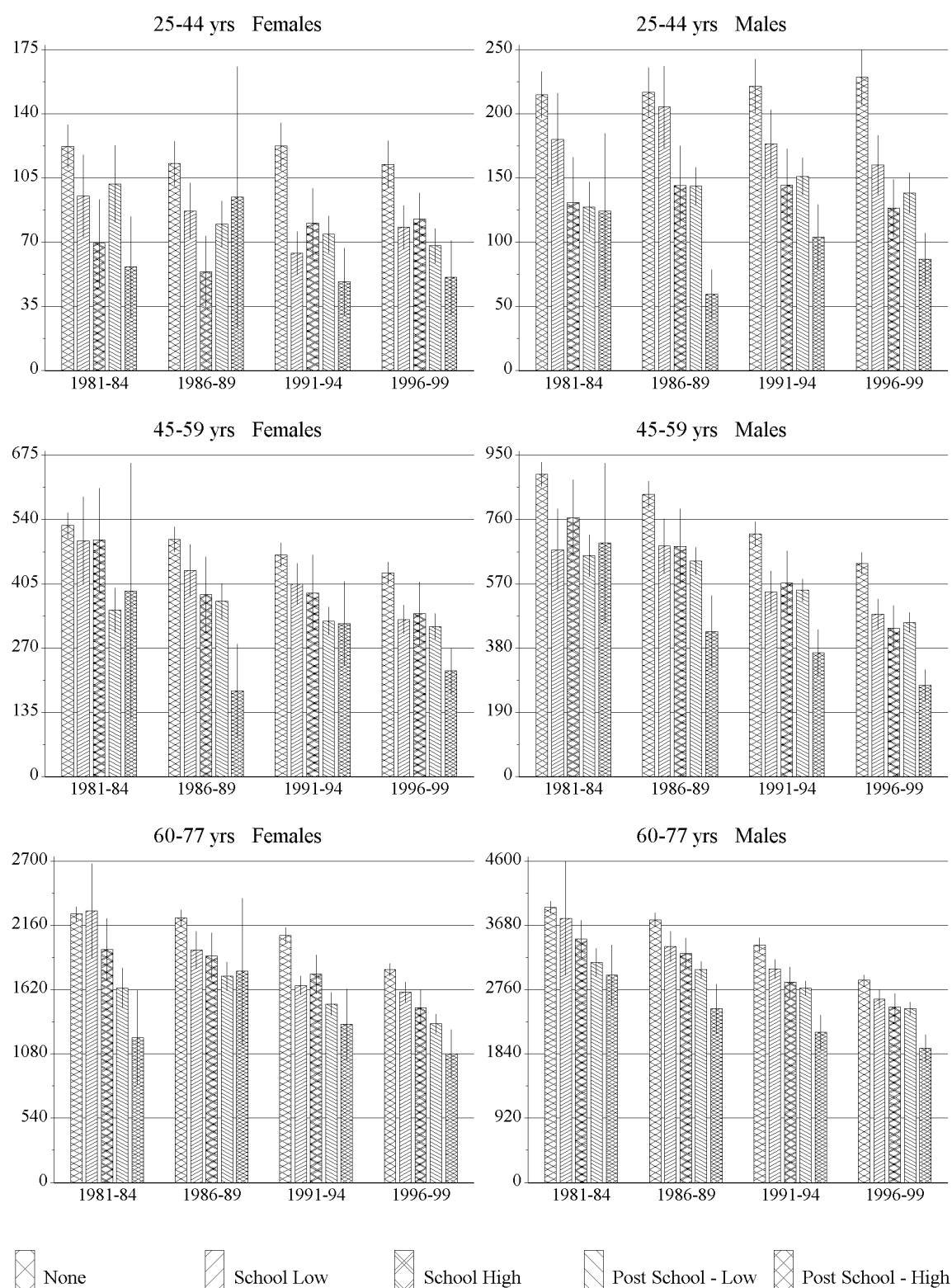
Relative inequality was highest at younger ages. Both SRR and RII (Table 5-6) measures decreased with increasing age. Higher mortality at older ages means that the older age groups experienced higher absolute inequality than younger age groups.

Among females, aged 25-44 years the SRD for no qualifications- post school high (low-high education SRD) is similar for 1981-84 and 1996-99. However the instability of the mortality rate for the post-school high group in 1986-89 makes it difficult to assess trends in the SRD over the total period. The SII shows no consistent trend. In this age group the RII are higher for the 1990s than the 1980s. However, the confidence intervals are wide (Figure 5-5 and Table 5-6).

Mortality rates for males aged 25-44 years with no qualifications increased across the four cohorts while rates for other educational groups changed little. Both relative (SRR and RII) and absolute (SRD and SII) inequality measures showed no particular change over time.

Both females and males, aged 45-59 years mortality rates fell for all education groups. The rates for this highest education group were fairly unstable, for the first two cohorts, due to the relatively small size of this group in the early cohorts. If the post-school low group is used as the reference group SRR are relatively stable across the four cohorts. The RII however increased consistently across the four cohorts, from 1.69 to 1.86 for females, and from 1.69 to 2.27 for males. At the same time, for females, the SII declined by 15% from 253 to 215 per 100,000 person-years. The SII for males was similar in all four cohorts.

Neither males nor females aged 60-77 showed any particular pattern of changing relative inequality over the four cohorts. However males in this age group experienced substantial declines in absolute inequality, when measured by the SII. For males, the SII fell from 1,386 to 923 per 100,000 person-years – a 33% decline.

**Figure 5-4 All Cause Mortality by Education Level, by Cohort, Sex and Age Group\***

\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices Table 12-14 and Table 12-14 page 393

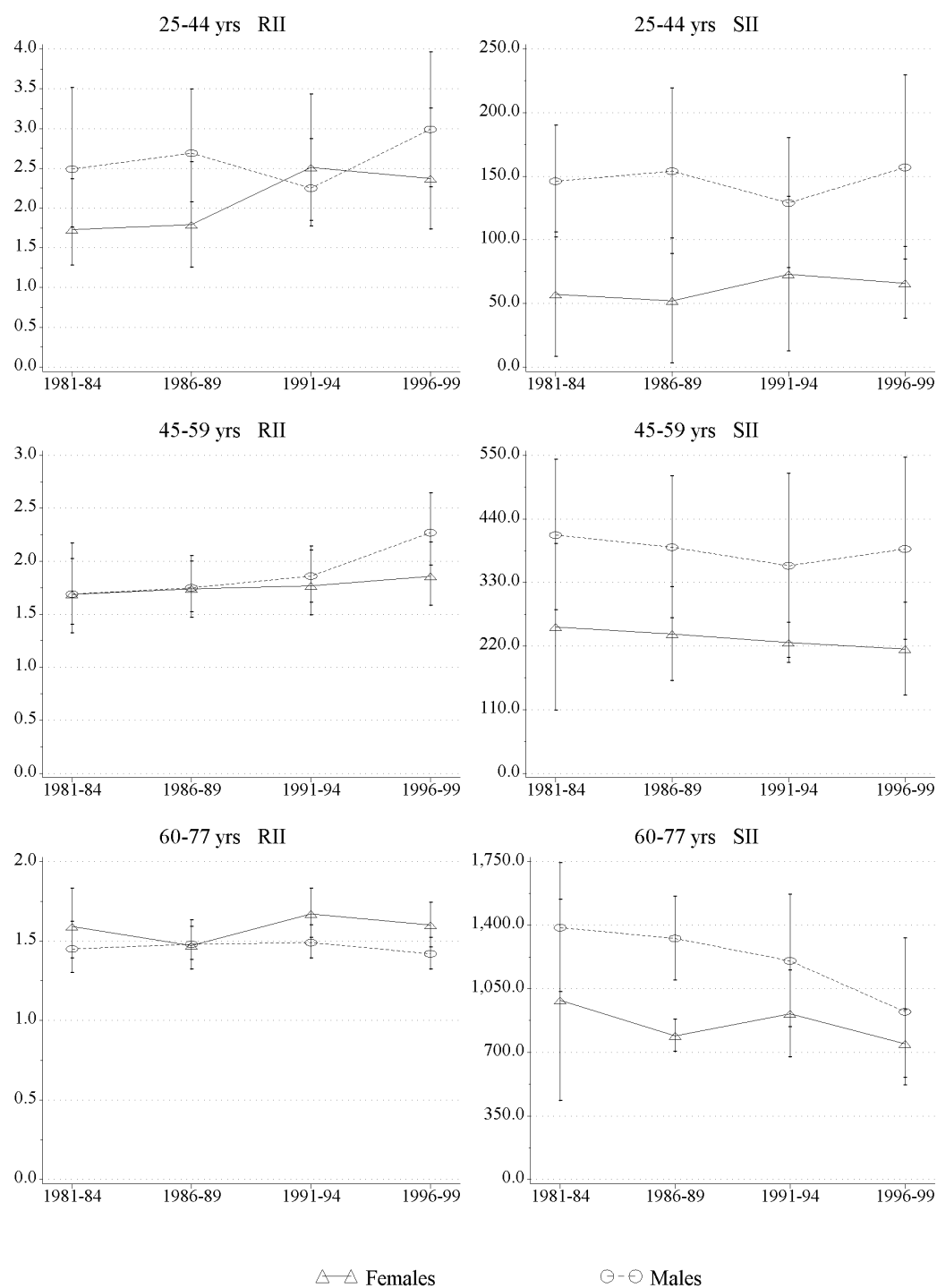


**Table 5-6 All Cause Mortality by Education -RII and SII by Cohort, Sex and Age Group**

Sex	Age	Cohort Period	RII (95% CI) *			P (Trend)	SII (95% CI)*			P (Trend)
Females	25-44 yrs	1981-84	1.73	(1.28-	2.36)	.	57	(8-	106)	.
		1986-89	1.79	(1.25-	2.58)	.	52	(3-	101)	.
		1991-94	2.51	(1.84-	3.43)	.	73	(13-	134)	.
		1996-99	2.37	(1.73-	3.25)	0.13	66	(38-	95)	0.28
	45-59 yrs	1981-84	1.69	(1.32-	2.17)	.	253	(109-	397)	.
		1986-89	1.74	(1.47-	2.05)	.	241	(160-	322)	.
		1991-94	1.77	(1.49-	2.10)	.	226	(191-	260)	.
		1996-99	1.86	(1.58-	2.18)	0.02	215	(135-	295)	<0.01
	60-77 yrs	1981-84	1.59	(1.39-	1.83)	.	986	(432-	1541)	.
		1986-89	1.47	(1.32-	1.63)	.	791	(703-	879)	.
		1991-94	1.67	(1.52-	1.83)	.	912	(673-	1152)	.
		1996-99	1.60	(1.46-	1.74)	0.61	746	(559-	933)	0.75
Males	25-44 yrs	1981-84	2.49	(1.76-	3.51)	.	146	(102-	190)	.
		1986-89	2.69	(2.07-	3.49)	.	154	(89-	219)	.
		1991-94	2.25	(1.77-	2.87)	.	129	(78-	180)	.
		1996-99	2.99	(2.26-	3.96)	0.68	157	(84-	229)	0.88
	45-59 yrs	1981-84	1.69	(1.40-	2.02)	.	412	(282-	542)	.
		1986-89	1.75	(1.52-	2.00)	.	391	(268-	514)	.
		1991-94	1.86	(1.61-	2.14)	.	359	(200-	519)	.
		1996-99	2.27	(1.96-	2.64)	0.08	388	(231-	546)	0.33
	60-77 yrs	1981-84	1.45	(1.30-	1.62)	.	1,386	(1031-	1741)	.
		1986-89	1.48	(1.38-	1.59)	.	1,327	(1097-	1558)	.
		1991-94	1.49	(1.39-	1.60)	.	1,203	(838-	1569)	.
		1996-99	1.42	(1.32-	1.52)	0.48	923	(519-	1327)	0.06

\*age and ethnicity standardised

**Figure 5-5 All Cause Mortality by Education -RII and SII by Cohort, Sex and Age Group\***

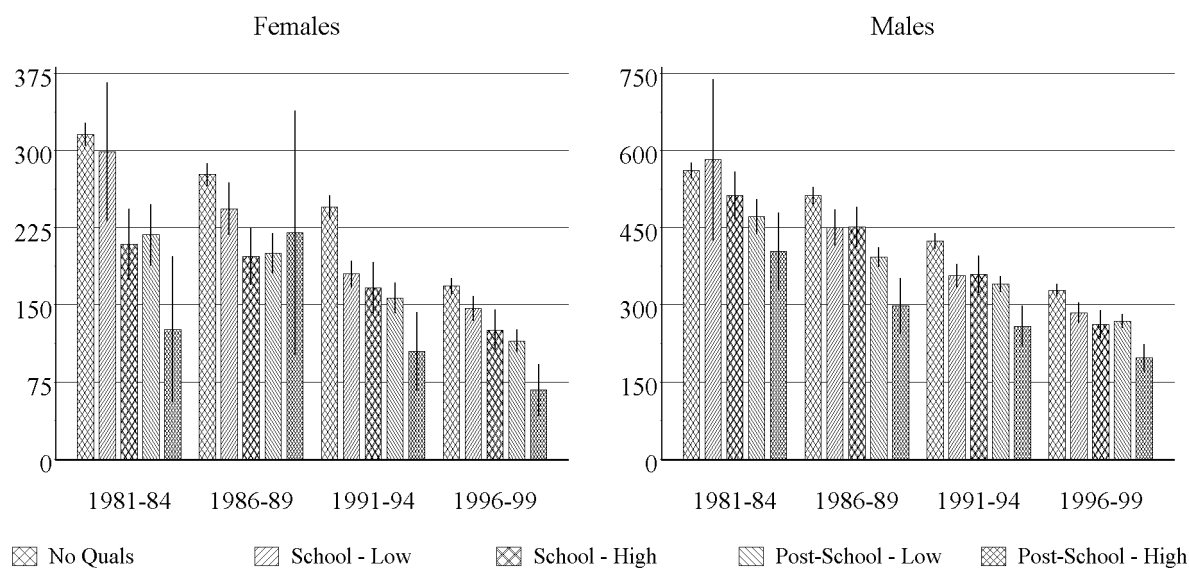


\*age and ethnicity standardised per 100,000 person-years

## 5.2.2 Cardiovascular Mortality

Between 1981-84 and 1996-99 the overall rate of mortality from cardiovascular diseases declined by 50% for females and 46% for males (Section 4.2, page121)

**Figure 5-6 CVD Mortality Rates by Education Level Cohort, and Sex\***



\*age and ethnicity standardised per 100,000 person-years

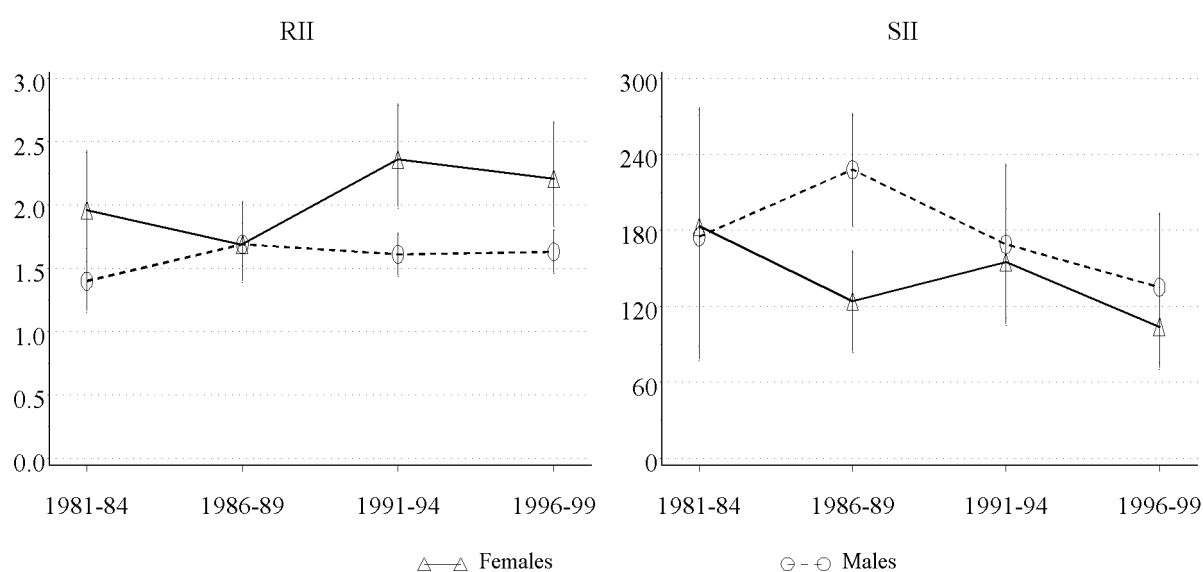
*Trends in Mortality:* Figure 5-6 shows CVD mortality by education level for all cohort members aged 25-77 years. The number of deaths, standardised mortality rates, rate differences and rate ratios are given in Table 5-8 and Table 5-9. CVD mortality is associated with education in all four cohorts for both females and males. All age, sex and educational groups experienced declines in CVD mortality over the period of the four cohorts.

*Trends in Relative Inequality:* For females, those with no qualifications have an excess mortality of about 150%, relative to the highest educated group, in three of the four cohorts. The trends in SRR are difficult to interpret because the small proportion of females in the highest educational groups means the rates for these groups unstable. However if the rates of those with no qualifications are considered relative to the second highest group the SRR remain relatively constant between 1.38 and 1.56, peaking in 1991-94. The RII is also highest for the 1991-94 cohort (Table 5-10). Although there is no consistent increase in the RII over the four cohorts the RII is higher in the 1990s cohorts than the 1980s cohorts (Figure 5-7).

For males, for whom the mortality rate estimates are more stable, relative inequality is highest for the 1986-89 cohort whether measured using SRR or the RII. However, overall the RII remains relatively constant after 1986-89. The relative excess in mortality for the lowest educated group varies by cohort between 39 and 72 percent - substantially less than for females.

*Trends in Absolute Inequality:* Absolute inequality measures declined substantially over the period of the four cohorts. For females, the SRD for no qualifications relative to the highest education groups declines between the first and last cohorts by 47%, from 189.8 to 100.8 per 100,000 person-years. The SII also declined from 183 to 104 per 100,000 person-years – a 43% decline. For males SRD and SII measures peaked in the 1986-89 cohort but declined substantially in each subsequent inter-cohort period (Figure 5-7). Overall the SRD declined between first and last cohorts by 17%, from 157.6 to 131.0 per 100,000 person-years, and the SII declined by 23 % from 175 to 135 per 100,000 person-years.

**Figure 5-7 RII and SII by Education Cohort and Sex – CVD Mortality\***



\*age and ethnicity standardised per 100,000 person-years

**Table 5-7 CVD Mortality by Education Level - RII and SII, by Cohort and Sex**

Sex	Period	RII (95% CI)*			P (Trend)	SII (95% CI)*			P (Trend)
Females	1981-84 <sup>†</sup>	1.96	(1.57-	2.43)	.	183	(90-	277)	.
	1986-89	1.69	(1.40-	2.03)	.	124	(85-	164)	.
	1991-94	2.36	(1.99-	2.80)	.	155	(112-	199)	.
	1996-99	2.21	(1.84-	2.66)	0.37	104	(72-	136)	0.36
Males	1981-84	1.40	(1.17-	1.67)	.	175	(78-	272)	.
	1986-89	1.69	(1.53-	1.87)	.	228	(184-	272)	.
	1991-94	1.61	(1.45-	1.78)	.	169	(106-	232)	.
	1996-99	1.63	(1.47-	1.81)	0.66	135	(77-	194)	0.22

\*age and ethnicity standardised

<sup>†</sup>Based on three way education grouping

**Table 5-8 CVD Mortality Rates by Education Level - Females**

<b>Cohort</b>	<b>Education Level</b>	<b>Deaths (n)*</b>	<b>Crude Rate</b>	<b>Std Rate<sup>†</sup></b>	<b>Std Rate<sup>‡</sup></b>	<b>SRR (95% CI)<sup>‡</sup></b>	<b>SRD (95% CI)<sup>‡</sup></b>
1981-84	No Qualifications	4,953	377.1	316.4	315.8	2.51 (1.43- 4.40)	189.8 (118.0- 261.5)
	School Low	180	77.7	284.7	298.8	2.37 (1.29- 4.34)	172.8 (75.0- 270.6)
	School High	252	166.2	203.9	209.1	1.66 (0.92- 2.98)	83.0 (4.2- 161.8)
	Post School - Low	435	115.5	202.9	218.0	1.73 (0.97- 3.08)	91.9 (15.2- 168.7)
	Post School - High	30	47.6	107.9	126.1	1.00 -	0.0 -
1986-89	No Qualifications	3,765	326.4	280.5	276.6	1.26 (0.73- 2.16)	56.4 (-62.5- 175.4)
	School Low	576	157.7	238.8	243.5	1.11 (0.64- 1.91)	23.3 (-97.9- 144.4)
	School High	330	177.1	195.4	197.2	0.90 (0.51- 1.56)	-23.0 -144.6- 98.6)
	Post School - Low	705	107.7	191.5	200.4	0.91 (0.53- 1.57)	-19.8 -139.8- 100.3)
	Post School - High	33	59.6	188.0	220.2	1.00 -	0.0 -
1991-94	No Qualifications	2,919	279.7	255.6	245.2	2.34 (1.62- 3.38)	140.4 (100.7- 180.2)
	School Low	1,131	211.4	174.8	180.0	1.72 (1.18- 2.49)	75.2 (34.9- 115.5)
	School High	255	111.8	161.6	166.3	1.59 (1.07- 2.35)	61.5 (15.8- 107.1)
	Post School - Low	717	88.7	151.6	156.7	1.50 (1.03- 2.18)	51.9 (11.0- 92.9)
	Post School - High	57	33.8	101.3	104.8	1.00 -	0.0 -
1996-99	No Qualifications	2,517	237.1	183.2	168.3	2.49 (1.72- 3.62)	100.8 (74.7- 126.9)
	School Low	744	119.1	146.2	146.4	2.17 (1.49- 3.17)	78.9 (51.3- 106.6)
	School High	213	67.9	124.3	125.5	1.86 (1.25- 2.78)	58.1 (26.2- 89.9)
	Post School - Low	597	77.7	115.5	114.9	1.70 (1.16- 2.50)	47.5 (20.3- 74.7)
	Post School - High	48	19.6	68.1	67.4	1.00 -	0.0 -

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>Age standardised per 100,000 person-years

<sup>‡</sup>age and ethnicity standardised per 100,000 person-years

**Table 5-9 CVD Mortality Rates by Education Level - Males**

<b>Cohort</b>	<b>Education Level</b>	<b>Deaths (n)*</b>	<b>Crude Rate</b>	<b>Std Rate<sup>†</sup></b>	<b>Std Rate<sup>‡</sup></b>	<b>SRR (95% CI)<sup>‡</sup></b>	<b>SRD (95% CI)<sup>‡</sup></b>
1981-84	No Qualifications	8,022	704.7	566.4	561.7	1.39 (1.15- 1.68)	157.6 (81.0- 234.2)
	School Low	303	182.8	513.7	581.9	1.44 (1.04- 2.00)	177.8 (4.4- 351.3)
	School High	792	444.3	511.4	512.7	1.27 (1.03- 1.56)	108.7 (20.6- 196.8)
	Post School - Low	1,410	281.3	459.1	471.1	1.17 (0.96- 1.42)	67.0 (-15.4- 149.5)
	Post School - High	321	228.3	375.9	404.1	1.00 -	0.0 -
1986-89	No Qualifications	5,547	606.2	522.0	512.7	1.72 (1.43- 2.06)	214.4 (158.4- 270.5)
	School Low	894	374.4	446.4	450.0	1.51 (1.24- 1.84)	151.7 (87.6- 215.9)
	School High	825	431.6	447.2	451.4	1.51 (1.24- 1.85)	153.2 (87.1- 219.2)
	Post School - Low	2,847	304.6	384.9	392.5	1.32 (1.09- 1.59)	94.2 (37.4- 151.0)
	Post School - High	204	159.7	301.0	298.3	1.00 -	0.0 -
1991-94	No Qualifications	4,413	499.6	443.3	423.7	1.64 (1.40- 1.92)	165.1 (122.9- 207.2)
	School Low	1,482	453.7	348.6	356.2	1.38 (1.17- 1.62)	97.6 (52.2- 142.9)
	School High	555	269.9	353.2	359.8	1.39 (1.16- 1.67)	101.2 (48.3- 154.1)
	Post School - Low	2,865	281.0	332.4	340.6	1.32 (1.12- 1.54)	81.9 (39.7- 124.1)
	Post School - High	333	138.0	238.1	258.7	1.00 -	0.0 -
1996-99	No Qualifications	4,278	452.9	355.0	328.2	1.66 (1.45- 1.91)	131.0 (102.7- 159.4)
	School Low	1,110	262.4	287.8	284.6	1.44 (1.25- 1.67)	87.4 (55.2- 119.6)
	School High	477	177.8	264.1	262.4	1.33 (1.13- 1.57)	65.2 (27.9- 102.5)
	Post School - Low	2,091	233.8	266.4	268.5	1.36 (1.18- 1.57)	71.4 (42.4- 100.4)
	Post School - High	363	110.6	181.8	197.2	1.00 -	0.0 -

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>Age standardised per 100,000 person-years

<sup>‡</sup>age and ethnicity standardised per 100,000 person-years

### 5.2.2.1 *Variation by age in CVD mortality by education*

Figure 5-8 shows CVD mortality by education level, age and sex for each of the four cohorts.

These results show that for 25-44 year olds CVD mortality rates were based on very few deaths in some education categories and periods, especially for females. However rates for cohort members with no educational qualifications are always higher than rates for members with qualifications in every cohort. No further results are presented for this age group.

*Ages 45-59 years:* For females, aged 45-59 years, relative inequality measures were very large in all four cohorts. Considering the SRR for the no qualifications relative to the highest education group SRR for the consecutive cohorts were 4.08, 8.96, 4.84 and 3.88. Confidence intervals were relatively wide as a consequence of the low mortality rates in the most educated group. The RII declined from 2.45 to 2.11 over the first inter-cohort period but subsequently increased to 3.04 in 1991-94 and 4.96 in 1996-99 (Figure 5-9 and Table 5-10). Absolute measures of inequality, the SRD and SII, declined over the period from 1981-84 to 1996-99 although the trend was not consistent in all inter-censal periods. The no qualification – post-school-high SRD declined overall by 46% from 124.9 to 67.4 per 100,000 person-years while the SII declined by 36% from 124 to 79 per 100,000 person-years.

For males, the SRR for no qualifications relative to the highest education group were also highest in 1986-89. The SRR for each consecutive cohorts were 1.40, 2.81, 2.42 and 2.46. The RII however increased consistently over the four cohorts from 1.63 in 1981-84 to 2.56 in 1996-99. In all periods SRR and RII are substantially less for males than for females.

SRD and SII were also highest in 1986-89, for males, but declined in each subsequent cohort. The no qualification – highest education group SRD for the consecutive cohorts were 120.9, 248.8, 183.3 and 182.1 per 100,000 person-years. The SII for the consecutive cohorts were 187, 202, 176 and 165 per 100,000 person-years.

*Ages 60-77 years:* For females aged 60-77 years relative inequality measures are much less than for the 45-59 year age group but RII still reach greater than 2.00 reflecting the strong association between education level and CVD mortality. There is no clear pattern of change

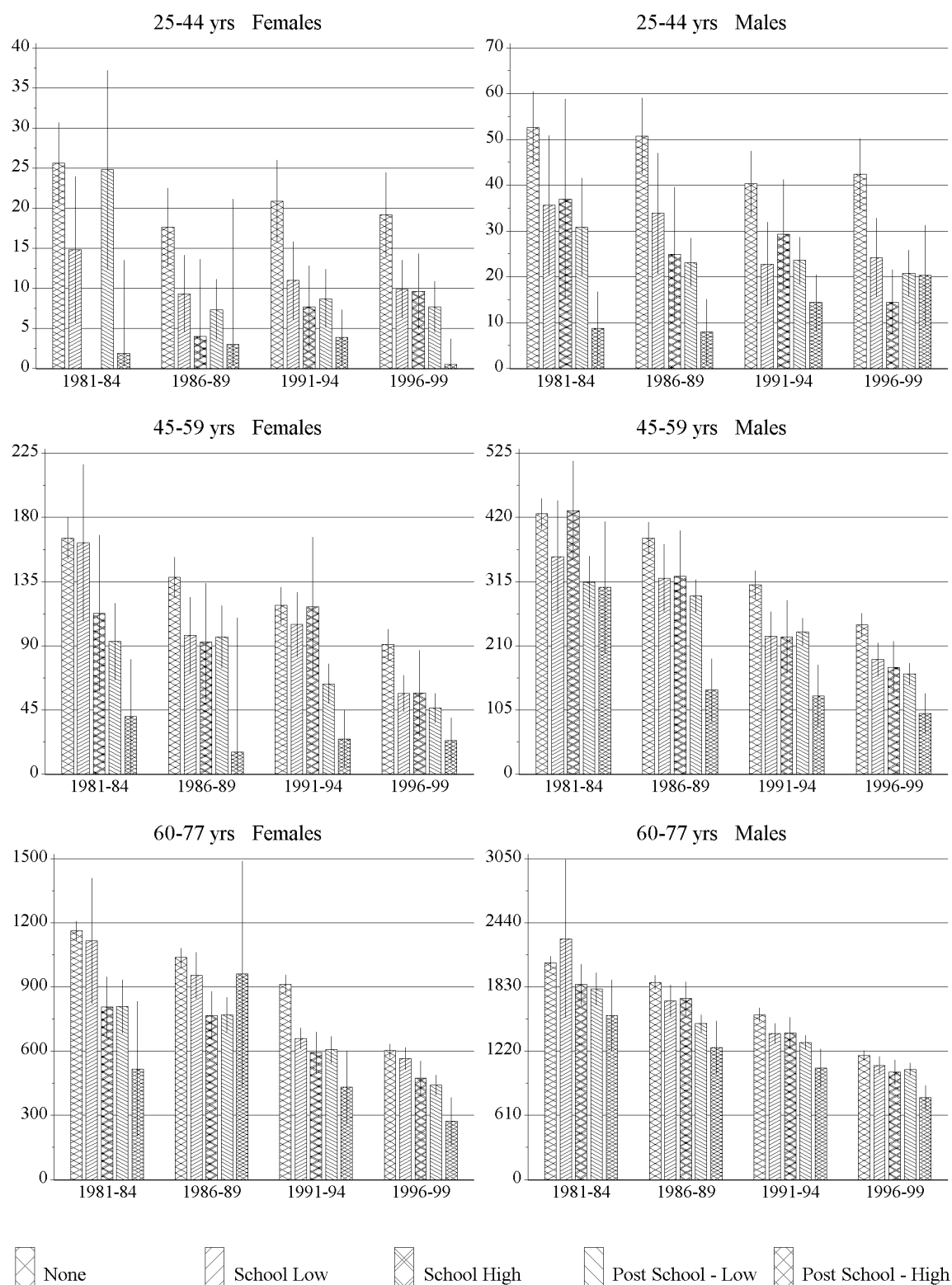


in the relative measures over the four cohorts. Absolute inequality however declined substantially over the four cohorts. The SII declined by 60% from 183 to 104 per 100,000 person-years and the SRD for no qualifications relative to the highest education group halved from 646.1 to 330.6 per 100,000 person-years between 1981-84 and 1996-99.

For males aged 60-77 years relative inequality is also much less than for 45-59 year old. SRR for the no qualifications relative to the highest education group were stable (1.32, 1.49, 1.48 and 1.51 for the consecutive cohorts). The RII were highest in 1986-89 and declined thereafter. RII were 1.29, 1.52, 1.43 and 1.37 for the consecutive cohorts.

Among males aged 60-77 years the SII also peaked in 1986-89 before declining, from 697 (95% CI:553-841) to 338 (95% CI:133-544) in 1996-99.

**Figure 5-8 Cardiovascular Mortality Rates by Education Level Cohort, Sex and Age Group\***



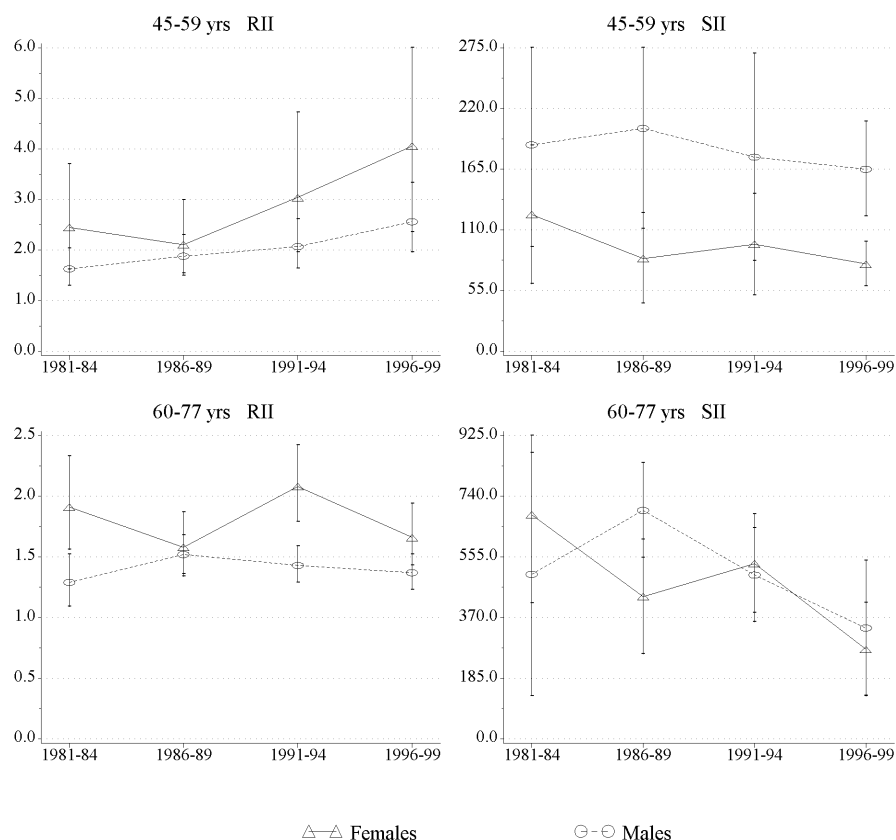
\*age and ethnicity standardised per 100,000 person-years

Tables showing the number of deaths, standardised rates, SRD and SRR are given in the appendix (Table 12-15 and \*\*\*, page 390)

**Table 5-10 CVD Mortality by Education Level - RII and SII, by Cohort and Sex and Age\***

Sex	Age	Period	RII (95% CI)*		P (Trend)	SII (95% CI)*		P (Trend)
Females	45-59 yrs	1981-84	2.45	(1.62- 3.70)	.	124	(61- 186)	.
		1986-89	2.11	(1.50- 2.99)	.	84	(44- 125)	.
		1991-94	3.04	(1.96- 4.72)	.	97	(51- 143)	.
		1996-99	4.06	(2.36- 6.98)	0.21	79	(59- 99)	0.23
	60-77 yrs	1981-84	1.91	(1.56- 2.33)	.	684	(414- 955)	.
		1986-89	1.58	(1.34- 1.87)	.	434	(259- 609)	.
		1991-94	2.08	(1.79- 2.42)	.	535	(385- 685)	.
		1996-99	1.66	(1.43- 1.94)	0.90	273	(131- 415)	0.21
Males	45-59 yrs	1981-84	1.63	(1.30- 2.04)	.	187	(95- 279)	.
		1986-89	1.88	(1.54- 2.30)	.	202	(111- 294)	.
		1991-94	2.07	(1.64- 2.61)	.	176	(82- 270)	.
		1996-99	2.56	(1.96- 3.33)	0.01	165	(122- 208)	0.14
	60-77 yrs	1981-84	1.29	(1.09- 1.52)	.	502	(131- 873)	.
		1986-89	1.52	(1.36- 1.68)	.	697	(553- 841)	.
		1991-94	1.43	(1.29- 1.59)	.	500	(357- 643)	.
		1996-99	1.37	(1.23- 1.52)	0.87	338	(133- 544)	0.18

\*age and ethnicity standardised

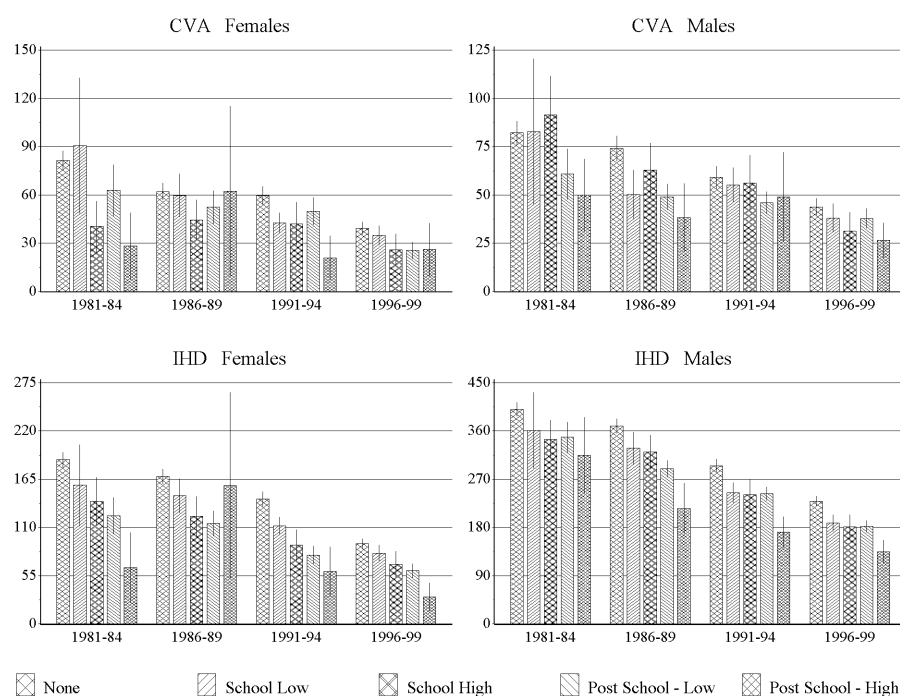
**Figure 5-9 CVD Mortality by Education Level - RII and SII, by Cohort and Sex and Age\***

\*age and ethnicity standardised per 100,000 person-years

### 5.2.2.2 Trends in IHD and Stroke Mortality by Education Level.

Figure 5-10 gives mortality rates by education for IHD and Stroke separately. When all ages are combined, IHD mortality is associated with lower education levels for both females and males. However, although Stroke mortality is similarly patterned by education for males, for females the association between Stroke mortality and education is less evident.

**Figure 5-10 IHD and Stroke Disease Mortality by Education Level and Sex\***



\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices, Table 12-17 and Table 12-18, page 393).

As IHD comprises most of the deaths from CVD, the trends in IHD by education are similar to those for all CVD. Figure 5-11 shows Trends in the RII and SII by cause of death for all CVD and for IHD and Stroke separately. RII are higher for IHD than for Stroke for females, but not for males

Trends in inequality for IHD, and for stroke among males, are similar to those for CVD. For females whereas the RII for total CVD and IHD decreased between the final two cohorts, the RII for Stroke increases. The trend in absolute inequality is however similar for stroke and IHD. As a consequence Stroke mortality contributes a similar proportion (20%) to the CVD SII by education than it did in 1981-84 (22%). For males however the proportional

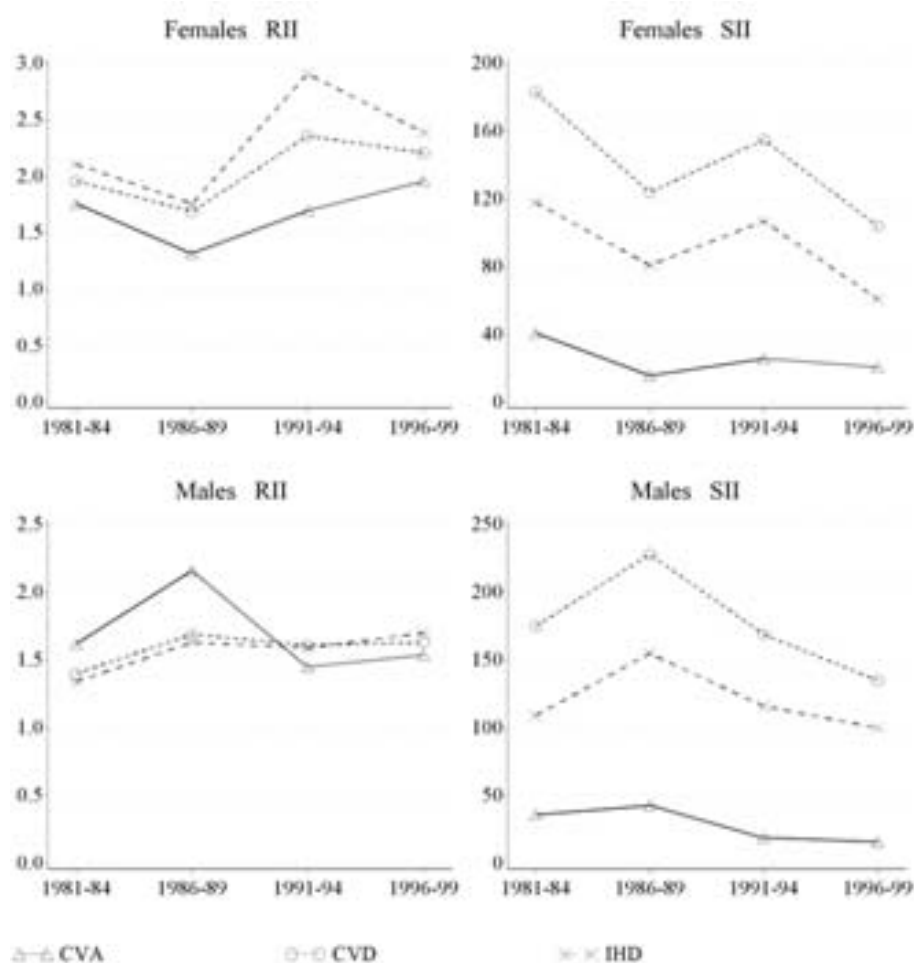
contribution of Stroke to CVD mortality declined from 20% to 13 % of the SII between the first and last cohorts.

**Table 5-11 Stroke and IHD Mortality by Education Level - RII and SII, by Cohort and Sex**

Cause of Death	Sex	Period	RII (95% CI)*		P (Trend)	SII (95% CI)*		P (Trend)
IHD	Females	1981-84	2.11	(1.62- 2.75)	.	118	(78- 158)	.
		1986-89	1.76	(1.36- 2.28)	.	81	(45- 117)	.
		1991-94	2.91	(2.28- 3.72)	.	107	(97- 116)	.
		1996-99	2.39	(1.86- 3.06)	0.47	61	(39- 83)	0.41
	Males	1981-84	1.34	(1.15- 1.56)	.	109	(83- 136)	.
		1986-89	1.63	(1.46- 1.83)	.	155	(118- 192)	.
		1991-94	1.59	(1.42- 1.79)	.	116	(52- 180)	.
		1996-99	1.70	(1.49- 1.93)	0.22	100	(58- 142)	0.89
Stroke	Females	1981-84	1.76	(1.13- 2.72)	.	41	(9- 90)	.
		1986-89	1.32	(0.93- 1.88)	.	16	(1- 31)	.
		1991-94	1.70	(1.28- 2.27)	.	26	(3- 55)	.
		1996-99	1.96	(1.31- 2.94)	0.49	21	(14- 29)	0.88
	Males	1981-84	1.62	(1.13- 2.32)	.	36	(4- 68)	.
		1986-89	2.16	(1.61- 2.90)	.	43	(26- 61)	.
		1991-94	1.45	(1.05- 1.99)	.	19	(10- 29)	.
		1996-99	1.54	(1.16- 2.05)	0.54	16	(3- 29)	0.17

\*age and ethnicity standardised

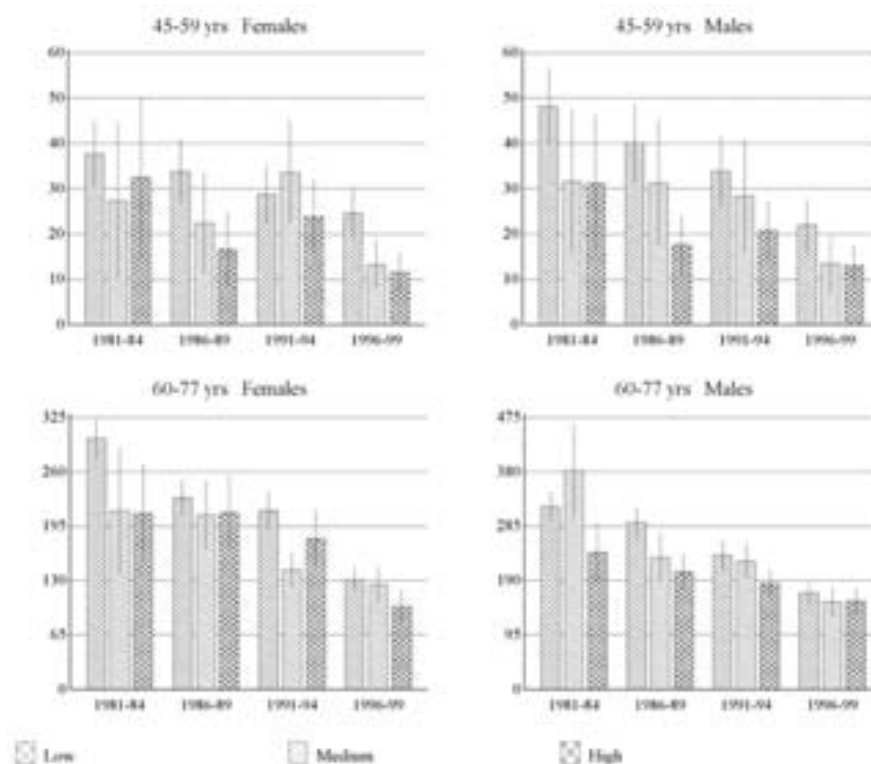
**Figure 5-11 Stroke and IHD Mortality by Education Level - RII and SII, by Cohort and Sex**



\*age and ethnicity standardised

There were too few deaths to analyse Stroke and IHD mortality by five levels of education and age. Instead mortality rates by three levels of education and age are presented in Figure 5-12

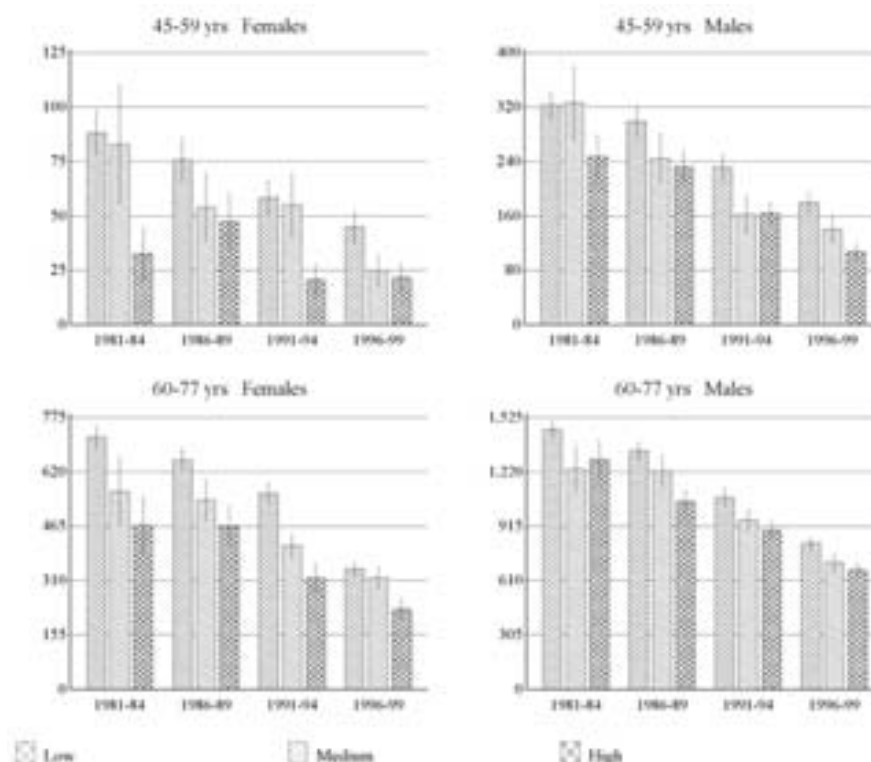
Among 45-59 year olds and 60-77 year olds the associations of education with Stroke mortality varied by age (Table 12-18, appendix page 396). For both males and females the association between Stroke mortality and education is weaker in the 60-77 year age group than for people 45-59 years. Furthermore, for the older age group, there is some evidence that the excess mortality among those with less education has largely disappeared by the latest cohort, especially for males. Cohortees aged 45-59 years in 1981-84 were aged 60-75 by 1996-99. Mortality rate estimates for the 45-59 year groups are relatively unstable.

**Figure 5-12 Stroke Mortality by Education Level, Sex, Age and Cohort**

\*age and ethnicity standardised

Mortality rates and 95% CIs are given in the appendices, Table 12-17 and Table 12-18, page 393ff.)

The association between IHD mortality and education level is more consistent at all ages than the association for Stroke mortality (Figure 5-13, below). Mortality from IHD decreased in all age and education categories for both males and females. Across the four cohorts the SRR for Low – High education halved overall. There was however no consistent trend in relative inequality. SRR were in general higher for females than males and higher for younger cohorts.

**Figure 5-13 IHD Mortality by Education Level , Sex, Age and Cohort\***

\*age and ethnicity standardised per 100,000 person-years

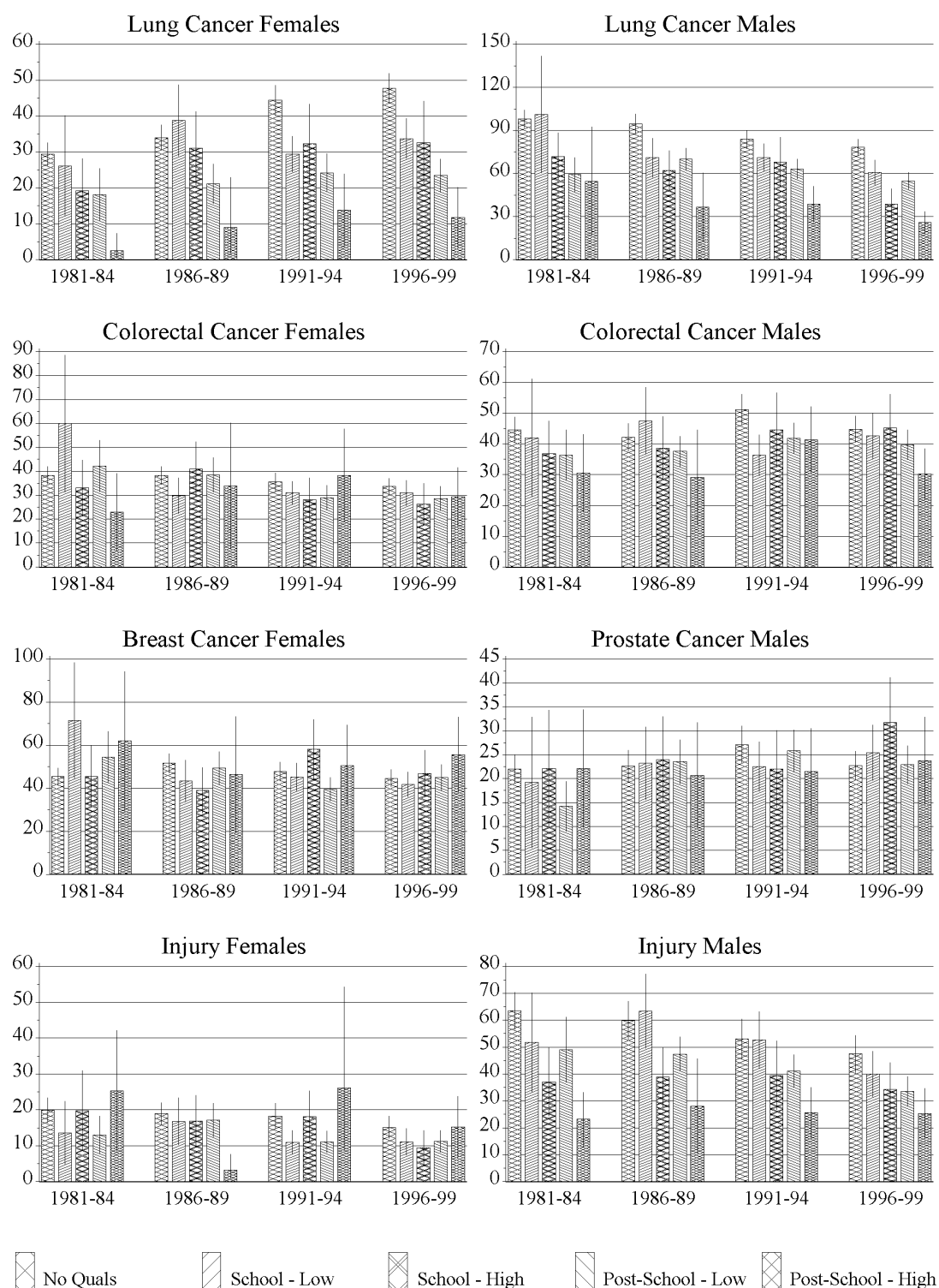
Mortality rates and 95% CIs are given in the appendices, Table 12-17, page 393).

### 5.2.3 Other Selected Causes

Not all causes of death show the pattern of declining mortality at all levels of education observed for CVD mortality. Figure 5-14 shows mortality rates by education level for 25-77 year old cohort members, for lung, colorectal, breast and prostate cancers and for unintentional injury. Corresponding RII and SII measures are shown in Figure 5-15 and Table 5-12.



**Figure 5-14 Mortality Rates for Selected Causes by Education Level, Cohort and Sex – ages 25-77 years.\***



\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices, Table 12-19, page 398.

### 5.2.3.1 *Lung Cancer*

Lung cancer was strongly associated with education level in all four cohorts for both males and females. However for females lung cancer rates increase for all education levels, with greater increases for cohort members with less education. For cohort members with no education the increase in mortality rate across the four cohorts (18.4 per 100,000 person-years) was twice the increase for those with tertiary qualifications (9.2 per 100,000 person-years). The summary measure of absolute inequality also doubled from 22 to 42 per 100,000 person-years. Relative inequality also increased markedly; the RII increased from 2.53 to 4.10 between 1981-84 and 1996-99.

For males lung cancer rates, for all education groups, declined across the four cohorts. The summary measure of absolute inequality, the SII, also declined for the first three cohorts but increased again in the final inter-cohort period. The RII followed a similar trend, but in the last cohort period the increase was substantial so that by 1996-99 the RII had increased to 2.72 compared to 2.28 in 1981-84.

### 5.2.3.2 *Colorectal Cancer*

For females there is little evidence of an association between education and colorectal mortality. Confidence intervals for the RII included 1.0 for all periods and for the SII included 0 for all periods. However both measures did increase across the four cohorts and the test for linear trend was significant in both instances. However for males colorectal cancer mortality was weakly associated with education level. The association was strongest in the first and last censuses.

### 5.2.3.3 *Breast Cancer*

There is no evidence of an association between breast cancer mortality and education level.

### 5.2.3.4 *Prostate Cancer*

There is no evidence of an association between prostate cancer mortality and education level.

### 5.2.3.5 Injury

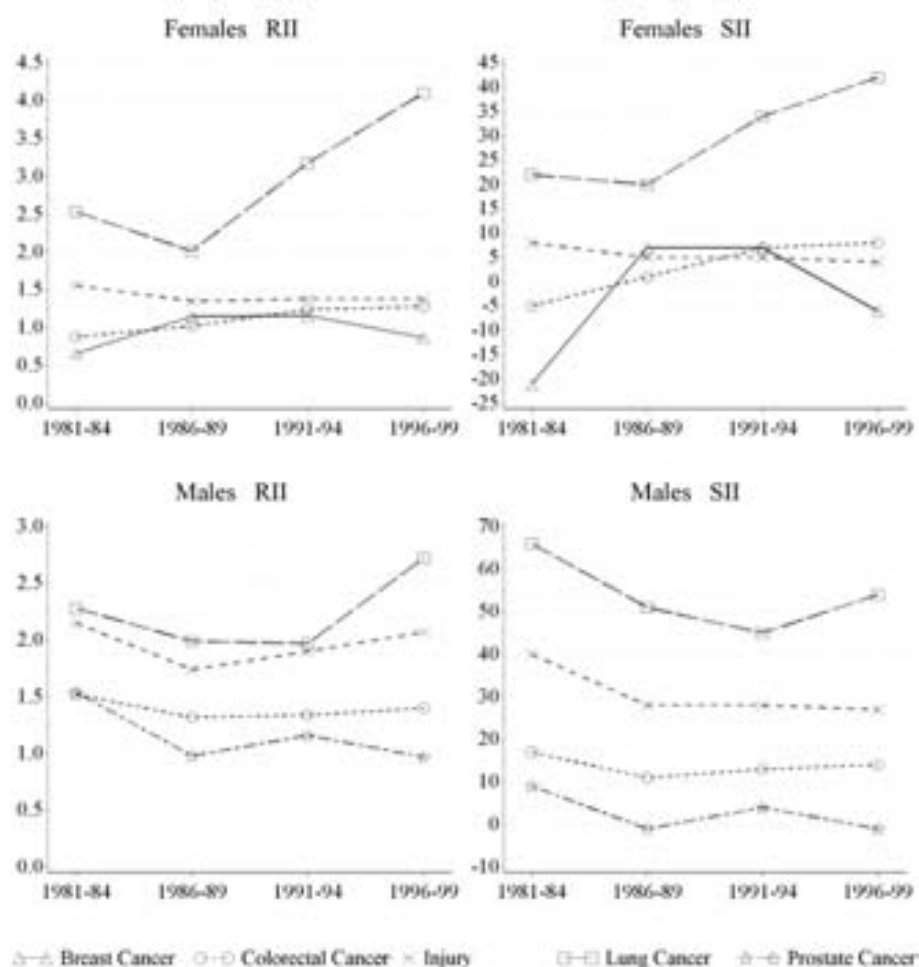
Mortality due to unintentional injury was strongly associated with education in all four cohorts for both males and females. Furthermore injury mortality rates declined over the four cohorts for all education groups, for both males and females. The association was stronger for males than females. However RII measures suggest that relative inequality for injury mortality by education declined in the first inter-cohort period and then remained relatively constant for females but increased for males. Absolute inequality measures declined across the four cohorts for both males and females.

**Table 5-12 RII and SII by Education Level for Selected Causes, by Cohort and Sex.**

Cause of Death	Sex	Period	RII (95% CI)*		P (Trend)	SII (95% CI)*		P (Trend)
Lung Cancer	Females	1981-84	2.53	(1.42- 4.50)	.	22	(10- 34)	.
		1986-89	2.01	(1.34- 2.99)	.	20	(1- 40)	.
		1991-94	3.18	(2.09- 4.84)	.	34	(24- 44)	.
		1996-99	4.10	(2.53- 6.66)	0.18	42	(34- 49)	0.03
	Males	1981-84	2.28	(1.49- 3.48)	.	66	(37- 94)	.
		1986-89	1.99	(1.55- 2.55)	.	51	(21- 81)	.
		1991-94	1.97	(1.55- 2.49)	.	45	(28- 62)	.
		1996-99	2.72	(2.11- 3.51)	0.40	54	(21- 87)	0.31
Colorectal Cancer	Females	1981-84	0.88	(0.53- 1.46)	.	-5	(-39- 28)	.
		1986-89	1.02	(0.73- 1.42)	.	1	(-13- 14)	.
		1991-94	1.24	(0.88- 1.75)	.	7	(-4- 18)	.
		1996-99	1.28	(0.93- 1.77)	0.04	8	(-2- 13)	0.07
	Males	1981-84	1.52	(1.04- 2.21)	.	17	(12- 22)	.
		1986-89	1.32	(0.98- 1.78)	.	11	(0- 22)	.
		1991-94	1.34	(1.04- 1.72)	.	13	(-2- 28)	.
		1996-99	1.40	(1.09- 1.81)	0.75	14	(4- 24)	0.34
Breast Cancer	Females	1981-84	0.66	(0.41- 1.05)	.	-21	(-51- 9)	.
		1986-89	1.15	(0.87- 1.52)	.	7	(-8- 22)	.
		1991-94	1.16	(0.88- 1.53)	.	7	(-13- 27)	.
		1996-99	0.87	(0.66- 1.14)	0.99	-6	(-18- 6)	0.80
Prostate Cancer	Males	1981-84	1.54	(0.83- 2.89)	.	9	(-2- 19)	.
		1986-89	0.98	(0.66- 1.45)	.	-1	(-4- 2)	.
		1991-94	1.16	(0.82- 1.63)	.	4	(-4- 11)	.
		1996-99	0.97	(0.67- 1.41)	0.43	-1	(-11- 10)	0.86
Injury	Females	1981-84	1.56	(0.82- 2.94)	.	8	(-4- 19)	.
		1986-89	1.35	(0.86- 2.12)	.	5	(-3- 13)	.
		1991-94	1.38	(0.59- 3.23)	.	5	(-13- 22)	.
		1996-99	1.38	(0.81- 2.37)	0.46	4	(-4- 12)	0.14
	Males	1981-84	2.15	(1.47- 3.14)	.	40	(15- 64)	.
		1986-89	1.74	(1.28- 2.37)	.	28	(5- 51)	.
		1991-94	1.90	(1.37- 2.65)	.	28	(14- 42)	.
		1996-99	2.07	(1.44- 2.97)	0.95	27	(21- 32)	0.19

\*age and ethnicity standardised.

Figure 5-15 RII and SII by Education Level for Selected Causes by Cohort and Sex\*



\*age and ethnicity standardised

#### 5.2.4 Contribution of CVD and other Causes to Education Inequality

Figure 5-16 shows the RII and SII for all causes and for all CVD, injury, lung cancer non-lung cancers and other causes. Figure 5-17 gives an alternative presentation of the contribution of different causes to the SII for all-cause mortality. The RII for all causes is comprised of a weighted combination of the broad cause of death groups, while the SII for the broad cause of death groups adds to the SII for all causes.

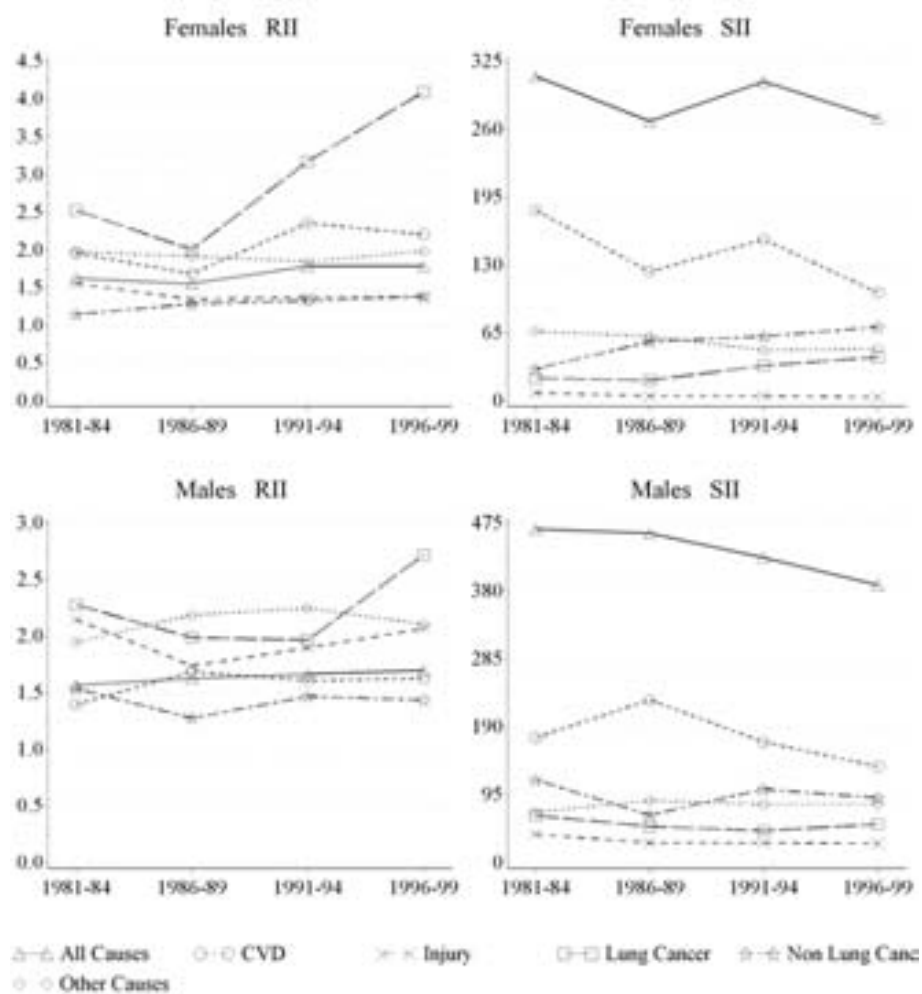
Considering females, lung cancer, CVD and 'other causes' are more strongly associated with education than all-cause mortality or injury or non-lung cancers. Lung cancer in particular has become more strongly patterned by education over time – however increases in relative inequality for CVD and non-lung cancers have also contributed to the increase in relative inequality in the 1990s compared to the 1980s.

Although lung cancer shows by far the strongest pattern of relative inequality by education more common causes of death contribute more to the trends in the all cause SII. Thus although the SII for lung cancer does increase over the period of the four censuses, CVD and non-lung cancers constitute most of the SII for all cause mortality. The decline in the SII due to CVD over time has been counteracted by a rise in the SII for both lung and non-lung cancers, preventing a sustained decline in the SII for all cause mortality.

For males, the trends by cause of death vary from trends for females in several ways. Firstly the increase in the RII for lung cancer was not as pronounced as for females. In the middle two cohorts the RII for other causes is higher than that for lung cancer. The RII for unintentional mortality by education are higher than for CVD or all-cause mortality.

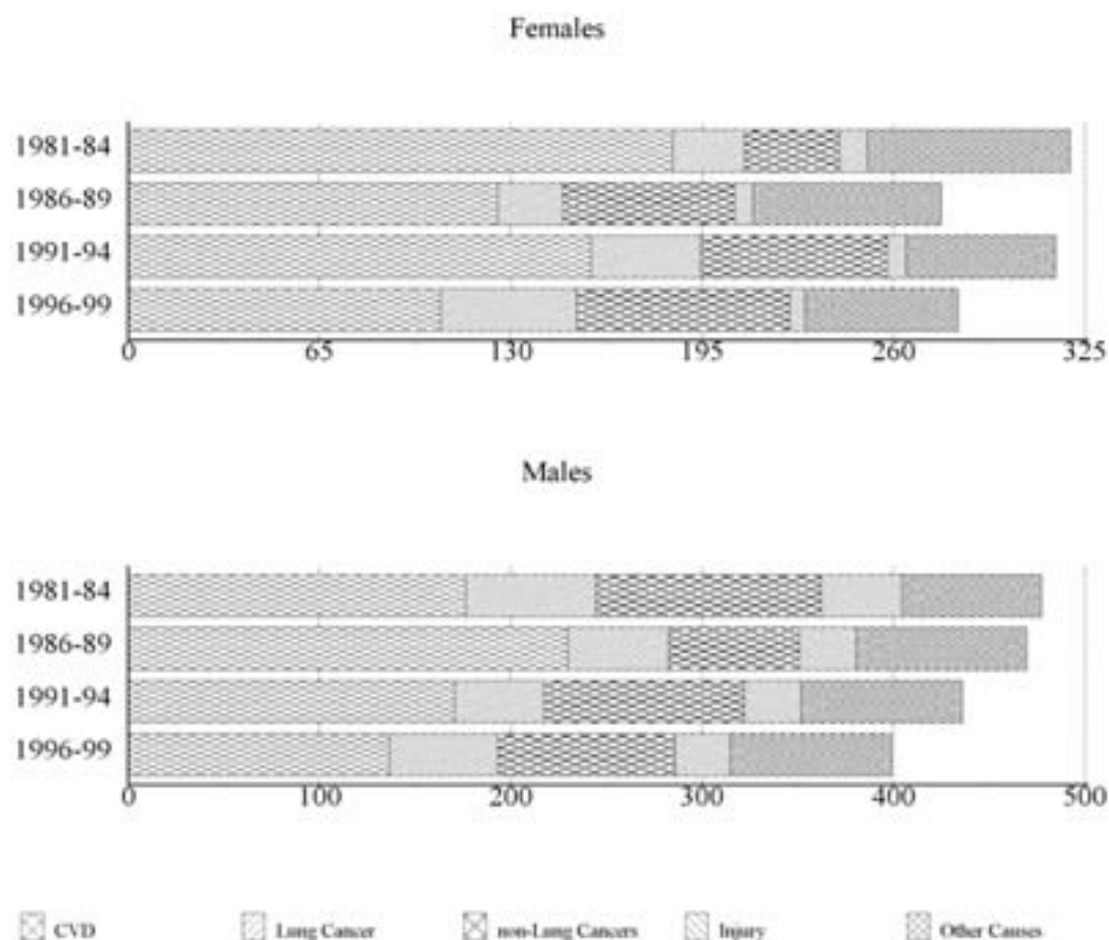
In general there is little evidence of changing impact of absolute inequality by education for any broad cause apart from CVD, for which the SII declines after 1986-89. It is the decline in SII for CVD that accounts for the decline in SII for all-cause mortality. The trend in the SII for all-cause mortality is primarily driven by the decline in the SII for CVD. Unlike females, there is little no evidence of an increase in the contribution of cancers to the SII for all-cause mortality.

**Figure 5-16 Comparison of Inequality by Education by Cause of Death, All-Causes and major Cause of Death groups, by Cohort and Sex.\***



\*age and ethnicity standardised

**Figure 5-17 Contribution of Major Cause of Death Groupings to the SII\* for All-Cause Mortality by Income, by Cohort and Sex.**



\*age and ethnicity standardised

### 5.3. Sensitivity Analyses and Assessment of Bias

#### 5.3.1 Sensitivity to the Educational grouping

Throughout these analyses the RII is calculated wherever possible based on the 5-way classification of education (section 3.3.1.2, page 95). However due to small numbers in the highest educated group this was not always possible: in this case the RII is based on the three way grouping for all four cohorts. Table 5-13 compares the RII obtained using the 3-way and 5-way education classifications. These results suggest that for most analyses the RII is relatively insensitive to the educational classification. However for the both males and

females aged 25-44 years the RII measure does vary according to the educational grouping. Trends in the RII are similar for both classifications.

**Table 5-13 Comparison of RII\* using 3 and 5 way groupings of the educational variable– All Cause Mortality**

Sex	Age	Cohort	Education Grouping	
			3-way RII (95% CI)*	5-way RII (95% CI)*
Females	25-44 yrs	1981-84	1.58 (1.13- 2.19)	1.73 (1.28- 2.36)
		1986-89	1.78 (1.31- 2.43)	1.79 (1.25- 2.58)
		1991-94	2.50 (1.80- 3.46)	2.51 (1.84- 3.43)
		1996-99	2.47 (1.79- 3.41)	2.37 (1.73- 3.25)
	45-59 yrs	1981-84	1.77 (1.44- 2.17)	1.69 (1.32- 2.17)
		1986-89	1.69 (1.42- 2.03)	1.74 (1.47- 2.05)
		1991-94	1.78 (1.50- 2.11)	1.77 (1.49- 2.10)
		1996-99	1.77 (1.51- 2.07)	1.86 (1.58- 2.18)
	60-77 yrs	1981-84	1.59 (1.38- 1.83)	1.59 (1.39- 1.83)
		1986-89	1.47 (1.33- 1.63)	1.47 (1.32- 1.63)
		1991-94	1.68 (1.53- 1.85)	1.67 (1.52- 1.83)
		1996-99	1.57 (1.44- 1.72)	1.60 (1.46- 1.74)
	Total	1981-84	1.65 (1.46- 1.86)	1.63 (1.43- 1.86)
		1986-89	1.55 (1.42- 1.70)	1.56 (1.41- 1.73)
		1991-94	1.79 (1.64- 1.95)	1.79 (1.63- 1.96)
		1996-99	1.70 (1.57- 1.84)	1.79 (1.63- 1.96)
Males	25-44 yrs	1981-84	2.56 (1.87- 3.50)	2.49 (1.76- 3.51)
		1986-89	2.37 (1.81- 3.11)	2.69 (2.07- 3.49)
		1991-94	2.10 (1.63- 2.70)	2.25 (1.77- 2.87)
		1996-99	2.77 (2.07- 3.71)	2.99 (2.26- 3.96)
	45-59 yrs	1981-84	1.73 (1.48- 2.03)	1.69 (1.40- 2.02)
		1986-89	1.69 (1.47- 1.95)	1.75 (1.52- 2.00)
		1991-94	1.73 (1.50- 2.00)	1.86 (1.61- 2.14)
		1996-99	2.07 (1.79- 2.41)	2.27 (1.96- 2.64)
	60-77 yrs	1981-84	1.47 (1.34- 1.61)	1.45 (1.30- 1.62)
		1986-89	1.47 (1.36- 1.58)	1.48 (1.38- 1.59)
		1991-94	1.47 (1.36- 1.57)	1.49 (1.39- 1.60)
		1996-99	1.40 (1.30- 1.50)	1.42 (1.32- 1.52)
	Total	1981-84	1.60 (1.48- 1.74)	1.57 (1.41- 1.76)
		1986-89	1.58 (1.48- 1.68)	1.63 (1.52- 1.74)
		1991-94	1.57 (1.47- 1.67)	1.67 (1.56- 1.78)
		1996-99	1.60 (1.50- 1.70)	1.70 (1.59- 1.82)

\*age and ethnicity standardised



### 5.3.2 Assessment of Bias

#### 5.3.2.1 Selection Bias

Selection into the education-restricted cohorts is dependent (conditioned) on a valid educational qualification value from the census. If mortality is also conditioned on factors that influence the presence of a valid educational variable then selection bias is likely to occur (Hernán et al. 2004). As discussed earlier (page 131) there was a proportion of census respondents in each cohort with missing information about educational qualifications. The proportion of cohort members excluded because of missing data was highest in 1981 for older respondents, females and Māori. The potential for selection biases to affect the population measures of inequality by education was greatest for the 1981-84 cohort.

For 1981 only, level of educational attendance as well as qualifications gained were collected in the census. To test whether the relationship between educational level and mortality was different for those included and excluded into the education-restricted cohort, the mortality rate by educational attendance was calculated for cohort members selected and not selected into the cohort.

For the 1981 cohort only, the highest level of educational attendance was compared with the highest level of educational qualifications. Table 5-14 gives, for those with an educational qualification, the percentage of cohort members in each educational qualification category for each level of attendance. On the basis of the distribution in Table 5-14 educational attendance was grouped into three hierarchical education categories, on the basis of the likely qualification level associated with that level of attendance, according to the following scheme.

Level of Attendance	5-way grouping	3-way grouping
no secondary schooling	No Qualifications	Low
Secondary to 5 <sup>th</sup> Form	School Low	Medium
Still attending school, 6 <sup>th</sup> Form, 7 <sup>th</sup> Form	School High	
Teachers Training College, Polytechnic/Technical Institute/ Community College, University and Polytechnic/ Technical or Community College	Post-School Low	High
University, University and Teachers College	Post School High	

The percentage of cohortees assigned an educational level based on their level of educational attendance was 99% for cohortees selected into the cohort and 84% for those excluded from the cohort.

Table 5-15 shows the mortality rates and rate ratios by level of educational attendance by Educational Level, and sex for cohortees selected into and excluded from the education-restricted cohort. There is considerable overlap in the confidence intervals for the SRR and SRD. The interpretation of these results is limited by wide confidence intervals. However both SRR and SRD were less for men excluded from the cohort than for those selected into the education restricted cohorts. For females, All-Cause and CVD SRR and SRD were similar for females excluded from and selected into the education restricted cohorts but for cancer those excluded had higher SRR and SRD.

It is not possible to repeat this exercise for other cohorts, however as the proportion of cohortees excluded from the analyses was very small in 1991-94 and 1996-99 even if there was an extreme degree of selection results for these years would not be greatly affected by any selection bias.

**Table 5-14 Cross Classification of years of schooling by highest qualification 1981 – Percentage of cohortes with Level of Qualification at each level of attendance – for those with qualifications.**

Highest Level of Educational Attendance	No qualifications	School Qualifications – Low	School Qualifications - High	Post-School Qualifications - Low	Post-School Qualifications - High
Still Attending	21	51	26	2	0
No Secondary	98	0	0	2	0
Secondary to 5th Form	79	13	1	7	0
6th Form	13	25	50	12	0
7th Form	12	5	67	14	2
University	4	2	21	20	53
Teachers Training College	2	3	13	82	0
Polytech/Tech Inst./Com. Coll.	21	10	9	60	0
University & Teachers College	1	0	6	42	50
Univ. & Polytech/Tech/Com. Coll.	5	3	20	50	23
Other Tertiary	17	8	8	64	4
Not Specified	77	6	9	7	0

**Table 5-15 1981-84 SRR and SRD\* by Educational Attendance Level and Selection Status, by sex and age – Low attendance compared to high.**

Cause of Death	Sex	SRR (95% CI)						SRD (95% CI)					
		Selected			Excluded			Selected			Excluded		
All Causes	Females	1.35	(1.26-	1.46)	1.32	(1.09-	1.61)	183	(144-	223)	168	(64-	271)
	Males	1.32	(1.25-	1.38)	1.16	(0.97-	1.39)	277	(231-	322)	166	(-27-	360)
CVD	Females	1.39	(1.23-	1.58)	1.37	(1.01-	1.85)	89	(59-	118)	78	(11-	146)
	Males	1.20	(1.12-	1.29)	1.05	(0.82-	1.35)	93	(60-	126)	29	(-108-	166)
All Cancers	Females	1.12	(1.01-	1.24)	1.40	(1.02-	1.92)	24	(3-	45)	68	(11-	124)
	Males	1.36	(1.24-	1.49)	1.28	(0.91-	1.80)	79	(57-	101)	73	(-17-	162)

\*age and ethnicity standardised

The RII and SII are affected not only by mortality rates but also the size of the educational categories. It is evident from Table 5-14 that those excluded from the education-restricted cohort are more likely to have lower levels of educational attendance. For example of those with an educational attendance value, 62% of those selected into the cohort who either had no secondary schooling or attended only to 5<sup>th</sup> form but of the cohortes excluded from the cohort 77% were in these categories of educational attendance. To investigate the impact on the RII of the change in the size of the education category the RII was calculated with the original educational qualification grouping and then adjusting the size of the educational categories to the likely distribution in the population based on the educational attendance variable. Despite the difference in the distribution of the included and excluded cohortes by educational attendance, the adjustment of the category sizes was very small – the category sizes required multiplication by 1.004, 0.996, 1.003, 0.992, and 0.988 for lowest to highest educational groupings.

Table 5-16 shows that the RII and SII were unaffected by adjusting the category sizes to take account of selection bias.

**Table 5-16 RII and SII for All Cause Mortality by Education Level – adjustment for category size**

Sex	Educational level	Std Rate	X <sub>1</sub>	RII <sub>1</sub>	X <sub>2</sub>	RII <sub>2</sub>
Females	No quals	701.5	0.308		0.309	
	School-Low	685.2	0.669		0.671	
	School –High	599.4	0.758		0.760	
	Post School Low	507.2	0.882		0.883	
	Post School – High	396.5	0.985	1.63	0.985	1.63
Males	No quals	1,156.6	0.268		0.269	
	School-Low	1,047.4	0.575		0.577	
	School –High	984.9	0.656		0.658	
	Post School Low	885.9	0.816		0.817	
	Post School – High	855.1	0.967	1.57	0.967	1.57

### 5.3.2.2 *Misclassification Bias*

Qualifications are generally gained in early adulthood and so the distribution by educational qualifications of an age-cohort should remain relatively constant as the cohort ages – with a small shift towards higher qualifications as a small proportion of cohortes gain additional qualifications in later life. Thus if the inter-censal classification of qualifications was constant over the four cohorts the distribution of the age cohorts should show a small shift

towards higher qualifications. However given that the instrument used to collect information about educational qualifications changed over the four cohorts (page 94) this could also produce shifts in the distribution of the cohort due to misclassification of educational qualifications in different cohorts. Table 5-17 shows the proportion of the cohorts with low, medium and high qualifications by age in 1981. The decline in those with no qualifications (Low Education level) is much greater between 1981 and 1986 than would be expected. For example among males aged 50-54 in 1981, 61% had no qualifications in 1981, but five years later in 1986 when these cohortes were aged 55-59 years 45% had no qualifications. It seems unlikely that the 16% difference in the proportion of the cohort with no qualifications is due to men in this age group- gaining extra qualifications, or due to selective migration out. Instead this difference is most likely due to the differences in the collection instrument between the two cohorts. This pattern of a substantial decline in those with no qualifications is most evident for older age cohorts.

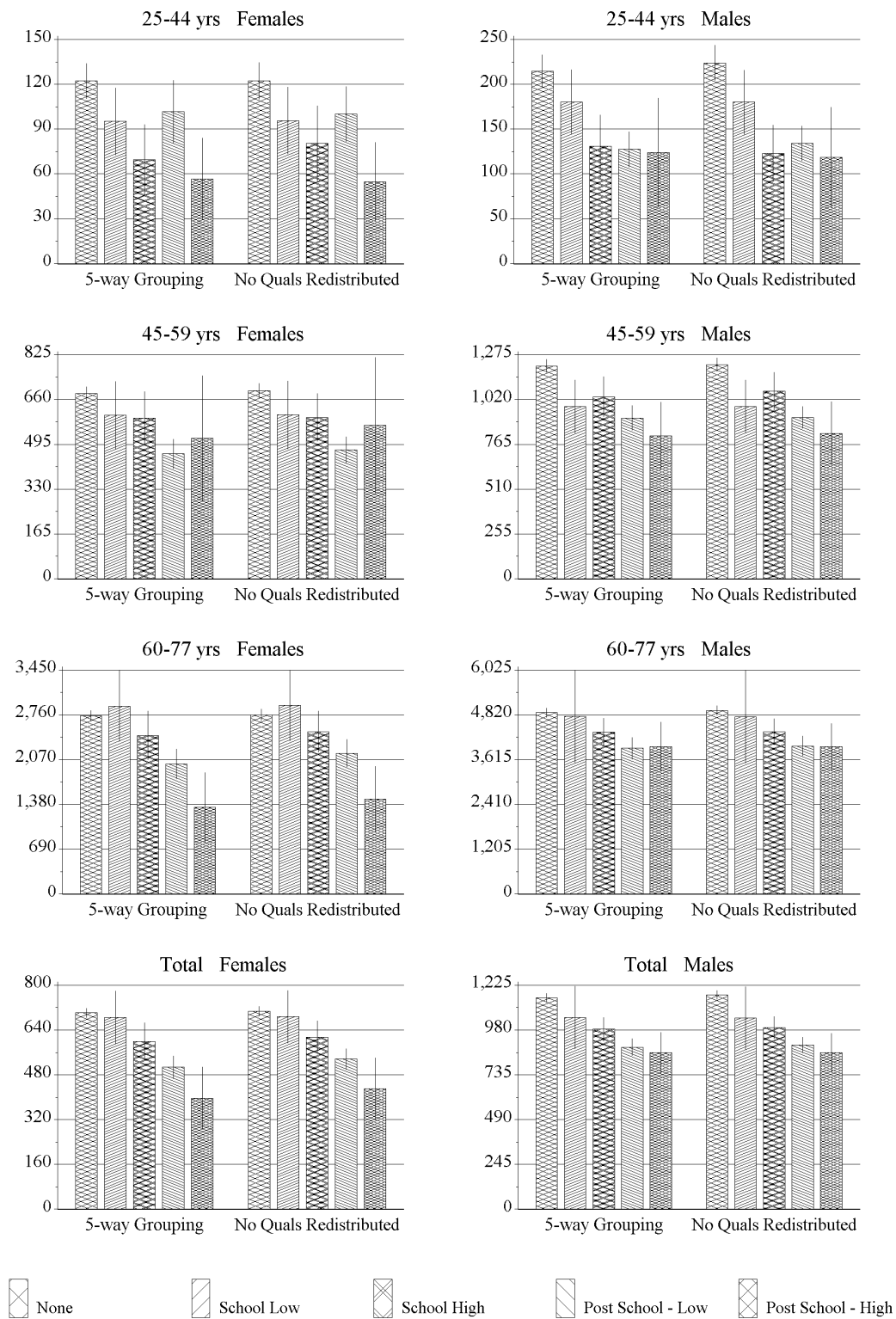
**Table 5-17 Proportions of Cohorts in each Education Level by Age in 1981, by sex and Cohort**

Age in 1981	Education Level	Females				Males			
		1981	1986	1991	1996	1981	1986	1991	1996
25-29 yrs	Low	39%	34%	30%	29%	36%	29%	27%	28%
	Medium	33%	30%	28%	32%	27%	22%	21%	25%
	High	28%	36%	42%	38%	37%	49%	52%	47%
30-34 yrs	Low	49%	44%	39%	38%	42%	34%	32%	33%
	Medium	24%	22%	22%	27%	21%	17%	17%	22%
	High	26%	34%	39%	35%	38%	49%	51%	45%
35-39 yrs	Low	56%	49%	44%	43%	47%	39%	37%	38%
	Medium	20%	19%	20%	26%	17%	14%	15%	21%
	High	24%	32%	36%	31%	36%	47%	48%	42%
40-44 yrs	Low	61%	53%	48%	48%	53%	42%	40%	41%
	Medium	17%	18%	20%	24%	14%	13%	14%	20%
	High	23%	29%	32%	28%	33%	45%	46%	39%
45-49 yrs	Low	65%	57%	51%	52%	57%	44%	42%	44%
	Medium	14%	17%	21%	23%	13%	14%	15%	19%
	High	21%	26%	28%	25%	30%	42%	43%	36%
50-54 yrs	Low	70%	59%	52%	56%	61%	45%	43%	48%
	Medium	11%	18%	26%	24%	12%	15%	19%	21%
	High	18%	24%	24%	23%	28%	43%	43%	38%
55-59 yrs	Low	74%	60%	46%	56%	65%	45%	39%	48%
	Medium	11%	19%	34%	26%	11%	17%	23%	21%
	High	15%	20%	21%	18%	24%	38%	38%	32%

To test the effect of likely misclassification of educational qualifications for cohort members with no qualifications I reassigned the level of educational qualifications for those with no qualifications by level of attendance, on the same basis as described on page 169. I then recalculated mortality rates, SRR and SRD and the RII and SII. Figure 5-18 and Figure 5-19 compare mortality rates by education for the original 5-way education grouping with the results of using the redistributed 'no qualification' group. The recalculated RII and SII are given in Table 5-18, page 173. These results show that the association between educational level and mortality remains relatively unchanged by the redistribution of those with no qualifications.

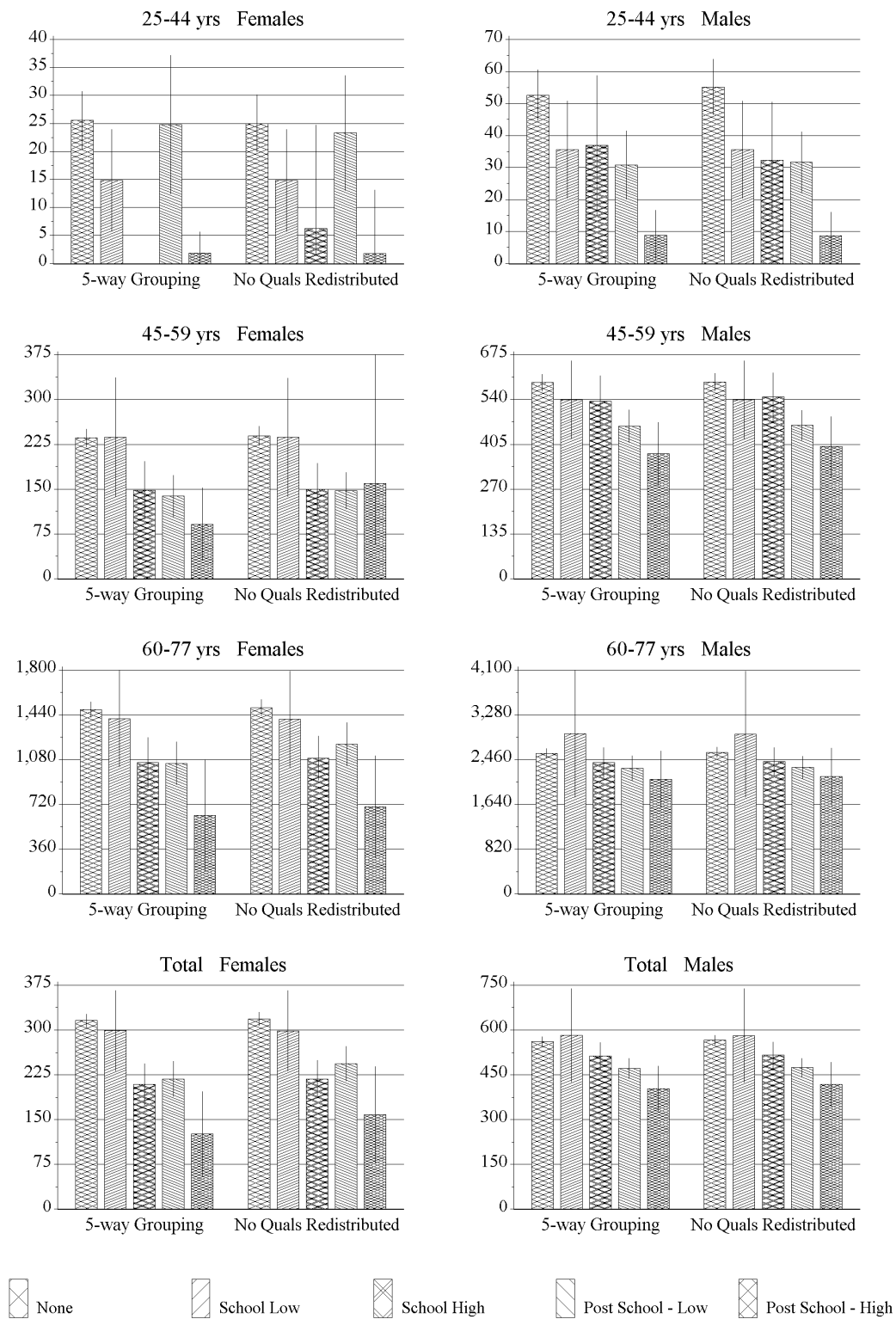
The RII and SII also remain relatively unchanged, except for CVD among females only. In this case the RII and SII are both reduced when the no qualifications group is redistributed- although confidence limits do overlap with those for the original grouping. These results suggest that, for females only, the trend towards increasing effect of relative inequalities on CVD mortality may be underestimated in the results while the trend to a decreasing effect of absolute inequality may be overstated. Nevertheless the direction of the trends are unaffected.

**Figure 5-18 Standardised Mortality Rates\* for All Cause Mortality by Education – Comparison of results for redistributing ‘no qualifications’ by level of attendance with the original 5-way education grouping, 1981, by sex and age**



\*age and ethnicity standardised

**Figure 5-19 Standardised Mortality Rates\* for CVD Mortality by Education – Comparison of results for redistributing ‘no qualifications’ by level of attendance with the original 5-way education grouping, 1981, by sex and age**



\*age and ethnicity standardised



**Table 5-18 Comparison of RII and SII\* where ‘no qualifications’ redistributed by level of attendance with the original 5-way education grouping, 1981, by sex and age**

Cause of Death	Sex	Imputation		Age											
				25-44 yrs			45-59 yrs			60-77 yrs			Total		
All Causes	Females	5-way grouping	RII	1.73	(1.28-	2.36)	1.69	(1.32-	2.17)	1.59	(1.39-	1.83)	1.63	(1.43-	1.86)
		No-Quals Redistributed	RII	1.69	(1.25-	2.29)	1.72	(1.34-	2.22)	1.52	(1.34-	1.72)	1.57	(1.38-	1.78)
		5-way grouping	SII	57	(8-	106)	253	(109-	397)	986	(432-	1541)	311	(146-	477)
		No-Quals Redistributed	SII	54	(12-	97)	262	(124-	399)	889	(460-	1318)	289	(163-	415)
	Males	5-way grouping	RII	2.49	(1.76-	3.51)	1.69	(1.40-	2.02)	1.45	(1.30-	1.62)	1.57	(1.41-	1.76)
		No-Quals Redistributed	RII	2.62	(1.86-	3.70)	1.66	(1.39-	1.98)	1.47	(1.33-	1.63)	1.59	(1.42-	1.77)
		5-way grouping	SII	146	(102-	190)	412	(282-	542)	1,386	(1031-	1741)	467	(408-	526)
		No-Quals Redistributed	SII	153	(93-	213)	399	(239-	560)	1,435	(1190-	1680)	475	(432-	517)
CVD	Females	5-way grouping	RII				2.45	(1.62-	3.70)	1.91	(1.56-	2.33)	1.96	(1.57-	2.43)
		No-Quals Redistributed	RII				2.09	(1.20-	3.62)	1.70	(1.42-	2.04)	1.72	(1.40-	2.13)
		5-way grouping	SII				124	(61-	186)	684	(414-	955)	183	(90-	277)
		No-Quals Redistributed	SII				105	(57-	154)	569	(296-	842)	152	(74-	232)
	Males	5-way grouping	RII				1.63	(1.30-	2.04)	1.29	(1.09-	1.52)	1.40	(1.17-	1.67)
		No-Quals Redistributed	RII				1.62	(1.30-	2.02)	1.28	(1.09-	1.50)	1.40	(1.18-	1.67)
		5-way grouping	SII				187	(95-	279)	502	(131-	873)	175	(78-	272)
		No-Quals Redistributed	SII				184	(87-	280)	492	(182-	802)	176	(98-	254)

\*age and ethnicity standardised

## Chapter 6 Trends in Mortality By Income

### **Text Box 5. Summary of Trends in Mortality By Income**

The distribution of income widened over the four cohorts. Between 1981-84 and 1996-99 there was a tendency for the proportion of the cohort in the highest (\$52,800-\$300,000) and lowest income (\$0-\$21,100) groups to increase, while the proportion in the three middle income groups decreased.

#### ***All Cause Mortality***

*Mortality trends:* There was a consistent monotonic association of increasing income with declining mortality rates in all cohort periods. Over time the proportional decline in mortality rates was greatest for high-income groups and least for low-income groups.

*Trends in Relative Inequality:* relative inequality increased substantially across all four cohorts; for females the RII increased from 1.50 to 2.16 – a 132% increase; for males the RII increased from 1.74 to 2.61 – a 117% increase.

*Trends in Absolute Inequality:* Absolute measures of inequality also increased across the four cohorts for females but remained fairly constant for males.

*Variation by Age:* In 1981-84 there was no consistent association between income and mortality level for females aged 25-44 years. However over the succeeding cohorts a pattern of decreasing mortality with increasing income emerges. At this age there is no improvement in mortality rates over the four cohorts among the lowest income group. Both relative and absolute inequality increased between the 1980s cohorts and the 1990s cohorts although the trend is not consistent for all inter-cohort periods.

Both 45-59 and 60-77 year age groups show consistent declines in mortality at all levels of income. Relative inequality increased in both age groups, but particularly so for 45-59 year olds. Absolute inequality was relatively stable across all four cohorts, except among 60-77 year old men where the SII fell by 14% between 1981-84 and 1996-99.

#### ***CVD Mortality***

There was a consistent association of low-income levels with high rates of CVD mortality, except among 25-44 year old females.

*Mortality Trends:* Substantial declines in CVD mortality rates occurred at all income groups between 1981-84 and 1996-99. By 1991-94 the mortality rates of the lowest income group had declined to rates lower than the rates of the highest income group in 1981-84, for both males and females.

*Trends in Relative Inequality:* Relative Inequality increased substantially across the four

cohorts, for both males and females.

*Trends in Absolute Inequality:* Absolute inequality measures remained relatively stable across the four cohorts.

***Variation by Age:*** When trends by age are considered, for females an increase in relative inequality was only evident among the 45-59 year age group for whom the RII increased substantially from 1.79 to 8.39. Absolute inequality was however stable for 45-59 year olds but halved among 60-77 year olds.

For males, the RII increased in all age groups, but both the increase over time and the magnitude of the inequality measure were greatest in the 45-59 year old age group. Absolute inequality increased for 25-44 year olds, was stable for 45-59 year olds but decreased for 60-77 year old males.

*IHD and Stroke Mortality:* For IHD mortality the trends in relative and absolute inequality largely mirror those for all CVD. However the association between income and stroke mortality was different for male and females. Whereas for males the pattern for stroke was similar to the pattern for IHD, for females, aged 60-77 years there was no association between income and stroke mortality.

*Contribution of Causes to Inequality by Income* The contribution of different causes to the change in overall inequality was assessed by examining the changing contribution of broad cause of death groups to the SII for all causes. For females, the contribution of CVD to the all cause SII has declined over the four cohorts while at the same time cancers, both lung and non-lung, have become increasingly important. By 1996-99 non-lung cancers accounted for a greater proportion of the total SII than CVD. The contribution of other causes also increases, this is largely due to increasing inequality due to respiratory diseases and COPD in particular. In contrast, the contribution of CVD to the SII for males, was similar in the first and last cohorts. The increase in absolute inequality for males between the 1980s and 1990s is mainly due to the increased SII for cancers, particularly non-lung cancers, and other causes.

### **Assessment of Bias**

*Selection bias* was assessed by considering comparing the SRR and SRD for education level, of those included in the income-restricted cohort and those excluded from the cohort.

Assuming that any unobservable selection bias for income would be mirrored by education gradients for those with and without an income value, the income results presented in this thesis might slightly overestimate the increases in relative inequality for young adults. On the other hand the increase in relative inequality among older adults may have been slightly underestimated.

*Drift health selection* was assessed by comparing results for the full three years of follow-up with results excluding the first year of follow-up. The results suggest some drift selection among males aged 25-44 and 45-59 years in the last cohort only. The impact of this possible drift selection would be to slightly overestimate the trend towards increasing relative inequality.

## 6.1. Description and Assessment of Data

### 6.1.1.1 Counts of Deaths and Person-Time

Weighted person-years of follow-up for the income-restricted cohort are given Table 6-1 and raw and weighted counts of deaths in Table 12-21 (appendix, page 406). Deaths by sex, age group and broad cause of death categories are given in the appendix (Table 12-22 page 406).

**Table 6-1 Person-Years (1000s) by Sex, and Age and Cohort for Income Restricted Cohorts**

Sex	Age	Cohort			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	1,179	1,336	1,458	1,589
	45-59 yrs	659	695	764	923
	60-77 yrs	572	607	624	644
	Total	2,410	2,639	2,846	3,155
Males	25-44 yrs	1,177	1,324	1,412	1,505
	45-59 yrs	679	707	764	915
	60-77 yrs	485	528	561	594
	Total	2,341	2,559	2,737	3,015

### 6.1.1.2 Cohort restriction

The cohort was restricted to persons aged 25-74 years on census night with a non-missing equivalised household income value. This restriction meant that between 10.3% and 21.7%, depending on age and sex, of the total person-years for the cohorts were excluded from the income analyses, because of missing data (see Table 6-2, below). Potential biases arising from this missing information are explored in section 6.3.2, page 213).

**Table 6-2 Percentage of Cohort with Missing Equivalised Income data by Sex and Age Group**

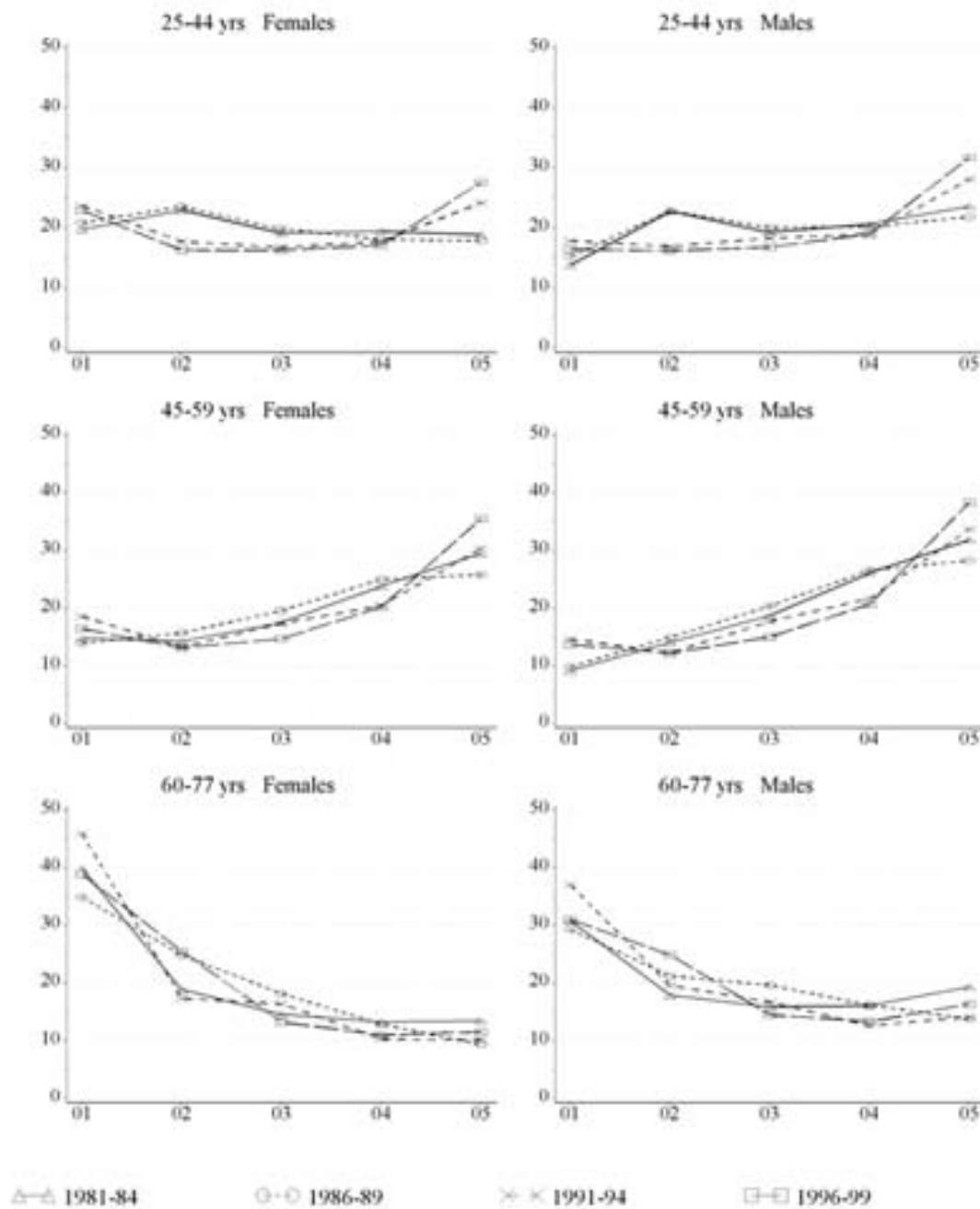
Sex	Age	Cohort			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	17	17	17	19
	45-59 yrs	21	16	15	19
	60-77 yrs	20	11	10	17
	Total	19	15	15	18
Males	25-44 yrs	20	18	18	20
	45-59 yrs	22	17	16	19
	60-77 yrs	21	13	12	18
	Total	21	17	16	19

### *6.1.1.3 Income Distribution*

The distribution of the cohort by five-way income level is given in Figure 6-1. The distribution of the cohorts by income varied according to age, sex, ethnicity and cohort. In particular for cohortes of all ages females were distributed more towards lower incomes than males. Māori and Pacific cohortes were also over-represented at low incomes (Table 12-20, appendix page 405). Between 1981-84 and 1996-99 there was a tendency for the proportion of the cohort in the highest (\$52,800-\$300,000) and lowest income (\$0-\$21,100) groups to increase, while the proportion in the three middle income groups decreased.

Throughout this chapter SRD and SRR are presented using the highest income group as the reference group. For cohortes aged 60-77 years this age group is relatively small. The use of this reference group means that the confidence intervals of the SRD and SRR are wider than would have been the case if the lowest income group was the reference group.

**Figure 6-1 Percentages of person-years in each income-level category by age, sex and cohort**



Key

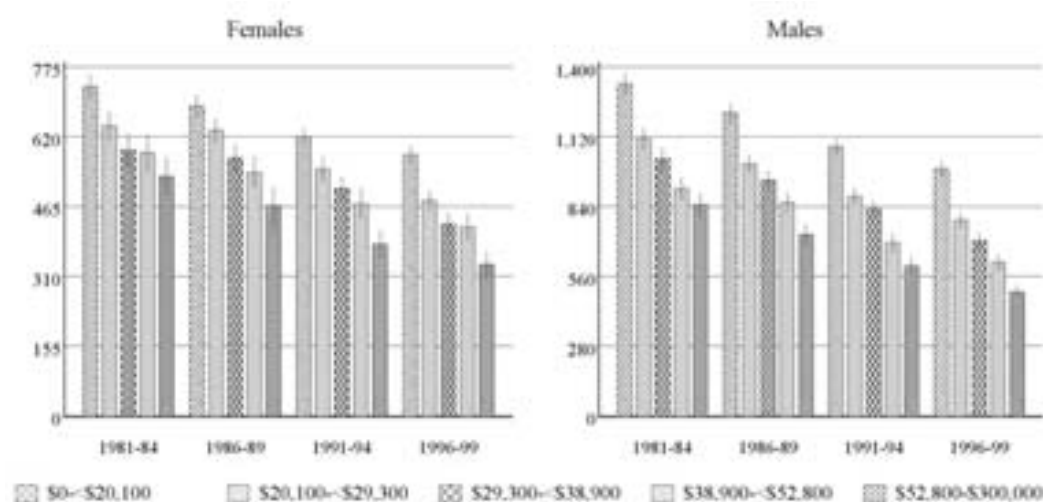
01=Low - <\$20,100      02=\$20,100 - <\$29,300      03=\$29,300 - <\$38,900      04=\$38,900- <\$52,800      05=\$52,800 - \$300,000

## 6.2. Mortality Trends by Income

### 6.2.1 All Cause Mortality

Table 6-4 and Table 6-5 give crude, age-standardised, and age and ethnicity standardised mortality rates, and age and ethnicity standardised mortality SRR and SRD by income level and sex for each cohort. Figure 6-2 summarises the age and ethnicity standardised mortality rates by sex, cohort and income level.

**Figure 6-2 All-Cause Mortality Rates\* by Income Level, Cohort and Sex**



\*age and ethnicity standardised, per 100,000 person-years

Figure 6-2 shows a consistent monotonic association of increasing income and declining mortality rates. Mortality rates declined at each level of income between 1981-84 and 1996-99. However the rate of the mortality decline varied by income level. For females, the mortality rate of the lowest income level (\$0-\$20,100) declined by 21% compared to 37% for the highest income group (\$52,800-\$300,000). For males the corresponding rates of decline were 26% and 41%.

Note however that for males the absolute levels of mortality decline for high and low income groups were similar for all income levels: 340.7 and 350.0 per 100,000 person-years for the lowest and highest income groups respectively. For females the absolute level of declines was 30% higher for the highest income group compared to the lowest: 151.8 compared to a 195.7 per 100,000 person-years.



The differential patterns of mortality decline by income level translate into increasing relative inequality. SRR for the highest to lowest income groups increased, between 1981-84 and 1996-99, from 1.38 (95% CI:1.26 -1.50) to 1.72 (95% CI:1.57-1.89) for females – a 90% increase in relative excess mortality in the lowest income group; for males the corresponding increase was from 1.57 (95% CI:1.48 -1.68) to 1.99 (95% CI:1.87-2.13) – a 110% increase in relative excess mortality for the lowest income group. The RII, which captures the pattern of inequality across all income levels, shows even more pronounced increases (Table 6-3 and Figure 6-3); for females the RII increased from 1.50 (95% CI:1.36 -1.65) to 2.16 (95% CI:1.94 –2.40) – a 132% increase in relative excess; for males the RII increased from 1.74 (95% CI:1.61 -1.88) to 2.61 (95% CI:2.38 –2.86) – a 117% increase in relative excess. Greater increases in the RII than the SRR are a function of the widening income disparities over time.

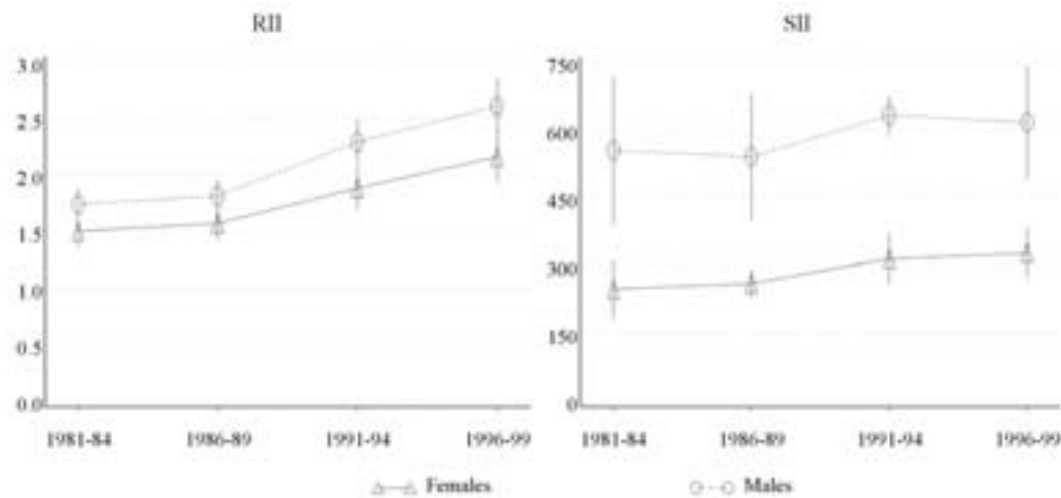
Absolute measures of inequality also increased across the four cohorts for females but remained fairly constant for males. Low-High Income SRD increased from 199.7 to 243.6 per 100,000 person-years for females, and from 486.4 to 493.0 per 100,000 person-years for males. For females the SII also increased substantially over the period, from 247 to 327 per 100,000 person-years, a 32% increase. For males the SII did not show a consistent pattern of increase although the SII was higher for the 1990s cohorts than for the 1980s cohorts.

**Table 6-3 All Cause Mortality by Income - RII and SII, by Cohort and Sex.**

Sex	Period	RII (95% CI)*			P (Trend)	SII (95% CI) *			P (Trend)
Females	1981-84	1.50	(1.36-	1.65)	.	247	(184-	310)	.
	1986-89	1.57	(1.43-	1.72)	.	260	(229-	290)	.
	1991-94	1.88	(1.71-	2.07)	.	314	(260-	369)	.
	1996-99	2.16	(1.94-	2.40)	0.03	327	(275-	380)	0.05
Males	1981-84	1.74	(1.61-	1.88)	.	554	(391-	716)	.
	1986-89	1.81	(1.68-	1.95)	.	540	(400-	679)	.
	1991-94	2.29	(2.11-	2.49)	.	632	(591-	673)	.
	1996-99	2.61	(2.38-	2.86)	0.04	616	(491-	741)	0.28

\*age and ethnicity standardised

**Figure 6-3 All Cause Mortality by Income, RII and SII by Income, Cohort and Sex \***



\*age and ethnicity standardised

*Confounding by Ethnicity.* Differences in the pattern of income distribution by ethnicity are evident from the differential effect of standardisation on the mortality rates. For example, the 1996-99 cohort, the *age and ethnicity* standardised rate for low income males (989.3 per 100,000 person-years) was 5 % less than the *age standardised* rate (1046.3 per 100,000 person-years). In comparison the, *age and ethnicity* standardised mortality rate for high income males (496.3 per 100,000 person-years) was 2 % higher than the age standardised rate (486.0 per 100,000 person-years). This reflects the distribution of Māori males towards lower incomes, compared to the overall cohort. Because ethnicity is associated with mortality independent of income (section 4.4, page 127), the difference in distribution of different ethnic groups by income, confounds the income mortality association. *Age and ethnicity* standardised rates are therefore presented throughout these results to control for confounding by ethnicity.

**Table 6-4 Summary of Mortality Rates per 100,000 person-years, SRR and SRD by Income - Females**

Period	Income	Deaths (n)*	Crude Rate	Age Std Rate	Age & Eth Std Rate <sup>†</sup>	SRR (95% CI) <sup>†</sup>			SRD (95% CI) <sup>†</sup>		
1981-84	\$0-<\$20,100	5,031	1114.2	745.1	731.8	1.38	(1.26-	1.50)	199.7	(149.8-	249.6)
	\$20,100-<\$29,300	2,283	594.6	636.5	643.4	1.21	(1.10-	1.33)	111.3	(57.8-	164.8)
	\$29,300-<\$38,900	1,710	497.0	572.9	589.9	1.11	(1.00-	1.23)	57.8	(2.3-	113.3)
	\$38,900-<\$52,800	1,635	437.8	565.7	583.7	1.10	(0.99-	1.22)	51.6	(6.8-	110.0)
	\$52,800-\$300,000	1,530	383.8	517.7	532.1	1.00	-	.	0.0	-	-
1986-89	\$0-<\$20,100	4,884	975.3	698.7	688.0	1.47	(1.34-	1.62)	220.9	(172.4-	269.4)
	\$20,100-<\$29,300	3,417	701.4	632.1	633.6	1.36	(1.23-	1.50)	166.5	(117.5-	215.5)
	\$29,300-<\$38,900	2,343	543.0	564.3	573.2	1.23	(1.11-	1.36)	106.1	(55.5-	156.7)
	\$38,900-<\$52,800	1,716	412.9	529.5	541.1	1.16	(1.04-	1.29)	74.0	(19.5-	128.5)
	\$52,800-\$300,000	1,140	285.7	446.8	467.1	1.00	-	.	0.0	-	-
1991-94	\$0-<\$20,100	6,093	917.1	642.6	620.7	1.63	(1.49-	1.78)	240.3	(203.6-	277.0)
	\$20,100-<\$29,300	2,190	551.4	556.4	548.1	1.44	(1.31-	1.59)	167.7	(126.3-	209.1)
	\$29,300-<\$38,900	1,968	482.7	496.1	504.1	1.33	(1.20-	1.46)	123.7	(83.0-	164.4)
	\$38,900-<\$52,800	1,320	325.8	461.7	471.3	1.24	(1.11-	1.38)	90.9	(45.3-	136.5)
	\$52,800-\$300,000	1,248	228.2	367.5	380.4	1.00	-	.	0.0	-	-
1996-99	\$0-<\$20,100	4,923	786.6	610.1	580.0	1.72	(1.57-	1.89)	243.6	(209.2-	278.0)
	\$20,100-<\$29,300	2,685	603.5	488.9	478.5	1.42	(1.29-	1.56)	142.1	(106.8-	177.4)
	\$29,300-<\$38,900	1,482	379.3	429.3	426.1	1.27	(1.14-	1.40)	89.7	(51.8-	127.6)
	\$38,900-<\$52,800	1,308	304.3	421.3	419.8	1.25	(1.12-	1.39)	83.4	(43.0-	123.8)
	\$52,800-\$300,000	1,284	188.1	322.2	336.4	1.00	-	.	0.0	-	-

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>age and ethnicity standardised

**Table 6-5 Summary of Mortality Rates per 100,000 person-years, SRR and SRD by Income - Males**

Period	Income	Deaths (n)*	Crude Rate	Age Std Rate	Age & Eth Std Rate <sup>†</sup>	SRR (95% CI) <sup>†</sup>			SRD (95% CI) <sup>†</sup>		
1981-84	\$0-<\$20,100	6,456	2,183.7	1,368.8	1,333.0	1.57	(1.48-	1.68)	486.4	(422.2-	550.6)
	\$20,100-<\$29,300	3,702	1,035.5	1,112.1	1,111.7	1.31	(1.23-	1.40)	265.1	(202.0-	328.2)
	\$29,300-<\$38,900	3,123	915.4	1,014.5	1,029.8	1.22	(1.13-	1.30)	183.2	(118.8-	247.6)
	\$38,900-<\$52,800	2,976	753.7	897.7	911.3	1.08	(1.00-	1.16)	64.7	(1.2-	128.2)
	\$52,800-\$300,000	3,045	654.0	825.8	846.6	1.00	-	.	0.0	-	-
1986-89	\$0-<\$20,100	6,795	1,901.5	1,232.0	1,214.5	1.67	(1.56-	1.79)	487.9	(428.3-	547.5)
	\$20,100-<\$29,300	4,575	1,056.9	1,012.7	1,011.1	1.39	(1.30-	1.49)	284.5	(227.4-	341.6)
	\$29,300-<\$38,900	3,969	929.9	938.3	945.9	1.30	(1.21-	1.40)	219.3	(162.0-	276.6)
	\$38,900-<\$52,800	3,201	712.7	841.8	855.6	1.18	(1.09-	1.27)	129.0	(69.5-	188.5)
	\$52,800-\$300,000	2,355	506.7	701.8	726.6	1.00	-	.	0.0	-	-
1991-94	\$0-<\$20,100	8,121	1,684.1	1,114.3	1,081.1	1.80	(1.68-	1.93)	480.3	(432.3-	528.3)
	\$20,100-<\$29,300	3,774	1,018.5	892.2	879.9	1.46	(1.36-	1.57)	279.1	(229.0-	329.2)
	\$29,300-<\$38,900	3,231	794.1	824.5	830.8	1.38	(1.28-	1.49)	230.0	(179.8-	280.2)
	\$38,900-<\$52,800	2,247	535.4	681.2	694.7	1.16	(1.07-	1.25)	93.9	(41.9-	145.9)
	\$52,800-\$300,000	2,316	379.8	576.5	600.8	1.00	-	.	0.0	-	-
1996-99	\$0-<\$20,100	6,585	1,464.5	1,046.3	989.3	1.99	(1.87-	2.13)	493.0	(451.0-	535.0)
	\$20,100-<\$29,300	4,311	1,063.7	808.4	784.5	1.58	(1.48-	1.69)	288.2	(247.5-	328.9)
	\$29,300-<\$38,900	2,559	668.0	710.1	701.1	1.41	(1.31-	1.52)	204.8	(162.3-	247.3)
	\$38,900-<\$52,800	2,187	490.7	612.2	615.1	1.24	(1.15-	1.34)	118.8	(76.3-	161.3)
	\$52,800-\$300,000	2,406	323.4	486.0	496.3	1.00	-	.	0.0	-	-

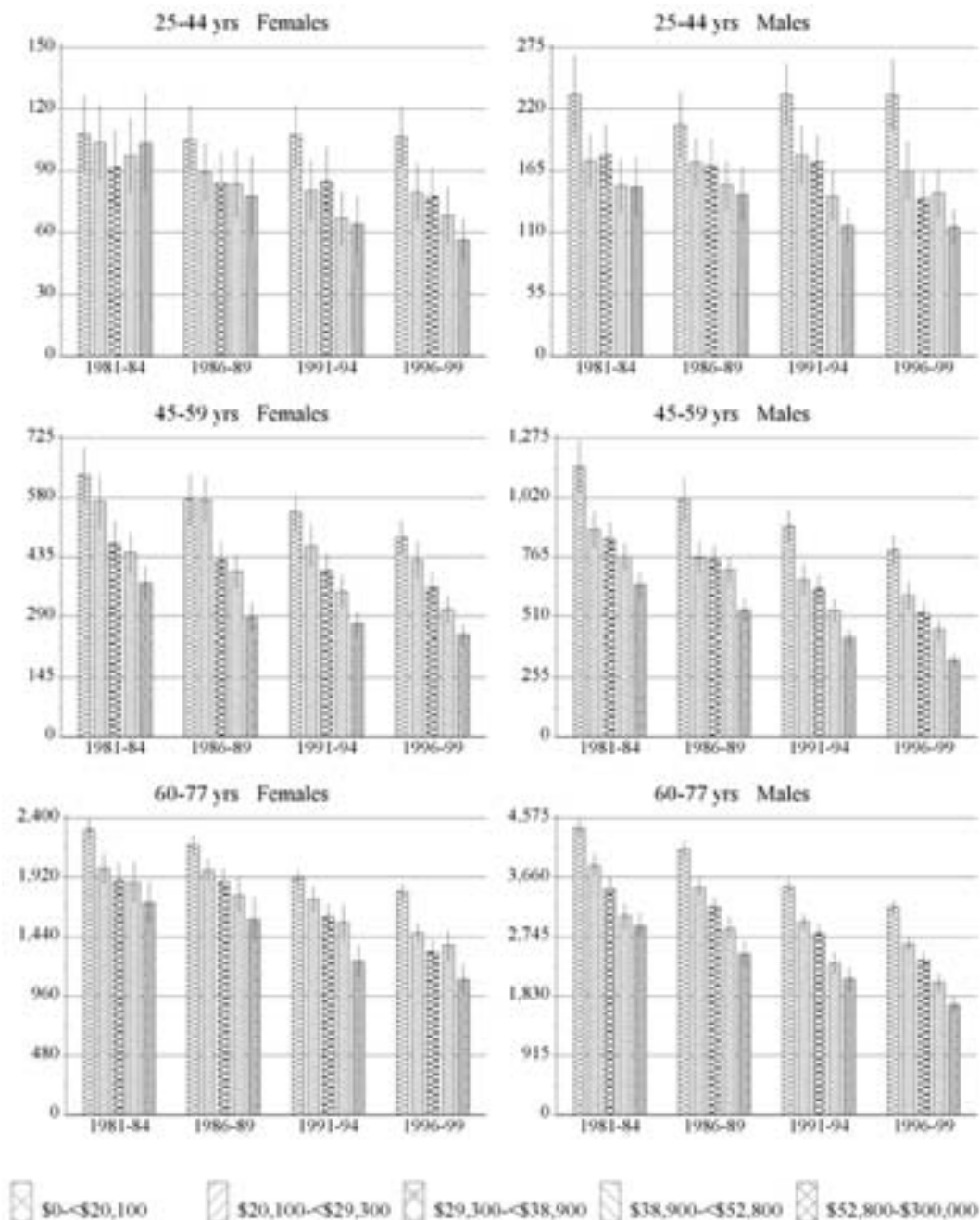
\*Random rounded to base three according to SNZ protocol

<sup>†</sup>age and ethnicity standardised

### 6.2.1.1 Variations by Age in Trends in All-Cause Mortality by Income

Trends in mortality varied by age (Figure 6-4).

**Figure 6-4 All-Cause Mortality Rates per 100,000 person-years by Income Level, Cohort, Sex and Age Group\***



\* age and ethnicity standardised

Mortality rates and 95% CIs are given in the appendices, Table 12-23 and Table 12-24, page 407).

In 1981-84 there was no consistent association between income and mortality level for females aged 25-44 years. However over the succeeding cohorts a pattern of decreasing mortality with increasing income emerges. This is a consequence of greater declines in mortality at higher income levels, 46% for the highest income group but not the lowest income group. The consequence of this differential decline in mortality is a substantial rise in both relative and absolute measures of inequality. Low-high income SRD increase from 4.4 to 50 per 100,000 person-years while the SII from 5 to 59 per 100,000 person-years. Low:high SRR increase from 1.04 to 1.89 and the RII from 1.05 to 2.23.

Unlike females of the same age, 25-44 year old males show a consistent pattern of lower mortality at higher income levels for all four cohorts. However like their female counterparts 25-44 year old males in the lowest income groups show no improvement in mortality over the inter-cohort periods. At this age both relative and absolute measures show an increase between the 1980s cohorts and the 1990s cohorts although the trend is not consistent for all inter-cohort periods. There was a particularly large increase in the total inequality measures between the 1986-89 and 1991-94 cohorts, where the excess RII increased by 145% from 1.62 to 2.52 and the SII by 61% from 82 to 132 per 100,000 person-years.

Both females and males aged 45-59 and 60-77 years show a consistent inverse association between income and low mortality in all cohorts together with substantial declines in mortality at all income levels.

For females aged 45-59 low-high income rate differences remained relatively constant, but increased by 20% from 589.3 to 706.1 per 100,000 person-years among 60-77 year olds. There was no consistent change in the SII in either age group. Relative inequality did however increase for both the 45-59 and 60-77 year old females. Low:high income SRR increased from 1.71 to 1.97 per 100,000 person-years and 1.34 to 1.64 per 100,000 person-years for the two age groups respectively. RII levels increased for both the 45-59 year and 60-77 year age groups, although the trend was not consistent in all inter-cohort periods.

For males aged 45-59 years the proportional decline in mortality rates between 1981-84 and 1996-99 for the five income levels, from low to high, were 31%, 32%, 38%, 41% and 49%. As a consequence of these differential rates of decline the Low:High SRR and the RII increase in each inter-cohort period. The RII increased consistently over the four cohorts

from 1.81 to 3.30, a 62% increase in relative excess. In comparison the absolute decline in mortality rates was greatest in the lowest income group (358.2 per 100,000 person-years) and similar for all other income levels. The SII trend was not consistent – the SII increased during the 1986-89 to 1991-94 inter-cohort period but declined during the first and last inter-cohort periods.

For 60-77 year old males the rate of decline in mortality rates for the five income groups, from low to high, was 28%, 32%, 31%, 34% and 42%. RII and low:high income SRR increased consistently over the four cohorts. The RII increased from 1.73 to 1.99, an increase in relative excess of 15% which is substantially less than the 62% increase seen for the 45-59 year old group. Absolute declines were however greater for 60-77 year old cohorts. Mortality rates declined by 1,219, 1,211, 1,095, 1,030 and 1,212.1 per 100,000 person-years for the five income groups from low to high respectively. In this case, the absolute level of decline was lowest among those in the 3<sup>rd</sup> and 4<sup>th</sup> highest income groups (\$29,300-\$38,900 and \$38,900-\$52,800). The low-high income SRD remained relatively stable over the inter-cohort periods but the summary SII showed a consistent decline from 1953 to 1980 (14%) over the four cohorts.

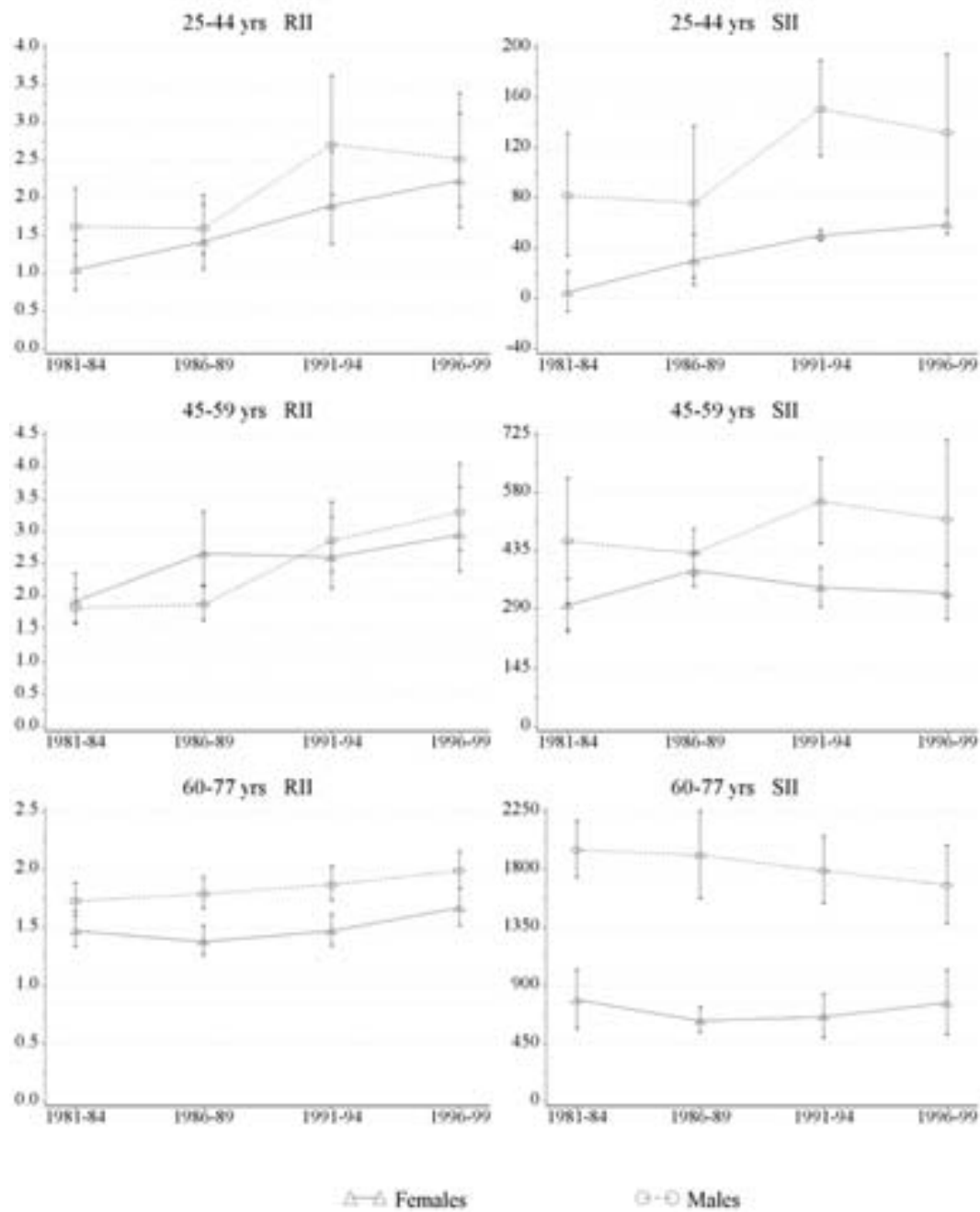
**Table 6-6 All Cause Mortality by Income - RII and SII, by Cohort and Sex and Age Group**

Sex	Age	Period	RII (95% CI)*			P (Trend)	SII (95% CI)*			P (Trend)
Females	25-44 yrs	1981-84	1.05	(0.77-	1.43)	.	5	(11-	21)	.
		1986-89	1.42	(1.05-	1.91)	.	30	(11-	50)	.
		1991-94	1.90	(1.38-	2.61)	.	50	(46-	54)	.
		1996-99	2.23	(1.60-	3.11)	0.008	59	(51-	68)	0.054
	45-59 yrs	1981-84	1.92	(1.58-	2.34)	.	299	(235-	362)	.
		1986-89	2.66	(2.14-	3.30)	.	386	(344-	427)	.
		1991-94	2.60	(2.11-	3.21)	.	343	(294-	392)	.
		1996-99	2.95	(2.37-	3.67)	0.106	330	(263-	398)	0.988
	60-77 yrs	1981-84	1.47	(1.33-	1.63)	.	788	(564-	1012)	.
		1986-89	1.38	(1.26-	1.51)	.	627	(530-	724)	.
		1991-94	1.47	(1.34-	1.61)	.	660	(490-	830)	.
		1996-99	1.67	(1.51-	1.83)	0.293	764	(514-	1014)	0.926
Males	25-44 yrs	1981-84	1.62	(1.24-	2.12)	.	82	(33-	131)	.
		1986-89	1.60	(1.25-	2.03)	.	76	(16-	137)	.
		1991-94	2.71	(2.04-	3.61)	.	151	(113-	189)	.
		1996-99	2.52	(1.88-	3.38)	0.156	132	(70-	194)	0.205
	45-59 yrs	1981-84	1.81	(1.56-	2.10)	.	459	(304-	615)	.
		1986-89	1.87	(1.61-	2.16)	.	429	(371-	488)	.
		1991-94	2.86	(2.37-	3.45)	.	558	(451-	664)	.
		1996-99	3.30	(2.70-	4.04)	0.063	514	(317-	710)	0.293
	60-77 yrs	1981-84	1.73	(1.59-	1.88)	.	1953	(1737-	2169)	.
		1986-89	1.79	(1.66-	1.93)	.	1911	(1574-	2248)	.
		1991-94	1.87	(1.73-	2.02)	.	1791	(1532-	2051)	.
		1996-99	1.99	(1.83-	2.15)	0.008	1680	(1377-	1983)	0.014

\*age and ethnicity standardised



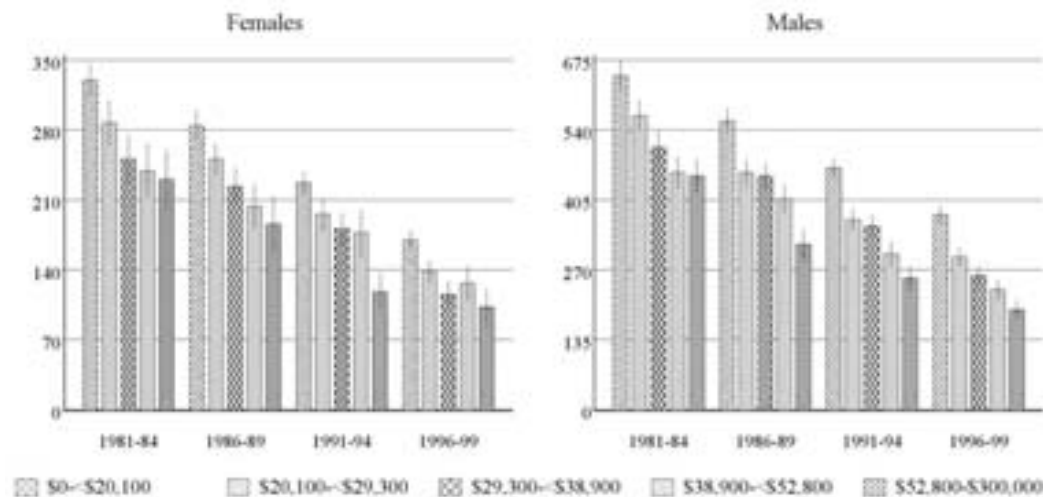
**Figure 6-5 All Cause Mortality by Income - RII and SII, by Cohort, Sex and Age Group\***



\*age and ethnicity standardised

## 6.2.2 Trends in Cardiovascular Mortality by Income

**Figure 6-6 CVD Mortality Rates per 100,000 person-years by Income Level, Cohort and Sex**



\*age and ethnicity standardised

Figure 6-6 illustrates the consistent association of low income levels with high rates of CVD mortality. However substantial declines in CVD mortality rates occurred at all income groups between 1981-84 and 1996-99. By 1991-94 the mortality rates of the lowest income group had declined to rates lower than the rates of the highest income group in 1981-84, for both males and females. Mortality rates, SRR and SRD are given in Table 6-8 and Table 6-9. RII and SII are given in Table 6-10.

For females mortality rates declined by 49%, 52%, 54%, 47% and 55% for the five income groups, from lowest to highest. Thus there was tendency for greater proportional declines in mortality rates at higher income levels. These differential patterns of decline translate into increases in the RII between from 1.67 to 2.14 over the first two inter-cohort periods after which it remains stable.

The decline in absolute mortality rates was greater for low-income groups; 160.1, 149.1, 135.4, 112.3 and 127.9 per 100,000 person-years for lowest to highest income groups respectively (Table 6-8). The SII was lower in 1996-99 than the previous three cohorts but the decline was not consistent.

The pattern of mortality decline was similar for males (Table 6-9); mortality declined by 42%, 48%, 49%, 49% and 57% for the low to high income groups respectively. Low:High SRR increased in each inter-cohort period . The RII increased from 1.58 in 1981-84 to 2.65 in 1996-99, a 43% increase in relative inequality.

For males the decline in absolute mortality was similar at all income levels: 267.8, 271.9, 247.6, 226.4 and 258.7 per 100,000 person-years for low to high income levels respectively. The SII was also relatively stable over the four cohorts.

**Table 6-7 RII and SII for Income by Sex and Cohort, Cardiovascular Mortality**

Sex	Period	RII (95% CI)*		P (Trend)	SII (95% CI) *		P (Trend)
Females	1981-84	1.67	(1.43- 1.94)	.	135	(97- 174)	.
	1986-89	1.68	(1.45- 1.95)	.	118	(104- 132)	.
	1991-94	2.14	(1.81- 2.54)	.	133	(81- 184)	.
	1996-99	2.13	(1.73- 2.62)	0.11	93	(65- 122)	0.14
Males	1981-84	1.58	(1.42- 1.75)	.	231	(150- 312)	.
	1986-89	1.84	(1.65- 2.04)	.	255	(190- 320)	.
	1991-94	2.32	(2.05- 2.62)	.	273	(246- 300)	.
	1996-99	2.65	(2.28- 3.08)	0.01	237	(182- 293)	0.88

\*age and ethnicity standardised

**Table 6-8 Summary of CVD Mortality Rates per 100,000 person-years, SRR and SRD by Income - Females**

Period	Income	Deaths (n)*	Crude Rate	Age Std Rate	Age & Eth Std Rate <sup>†</sup>	SRR (95% CI) <sup>†</sup>			SRD (95% CI) <sup>†</sup>		
1981-84	\$0-<\$20,100	2,445	541.0	332.3	329.8	1.43	(1.25-	1.64)	99.3	(65.2-	133.4)
	\$20,100-<\$29,300	999	260.2	282.4	287.1	1.25	(1.07-	1.45)	56.6	(19.4-	93.8)
	\$29,300-<\$38,900	684	198.5	242.6	250.7	1.09	(0.93-	1.28)	20.2	(18.1-	58.5)
	\$38,900-<\$52,800	588	157.2	230.6	238.9	1.04	(0.87-	1.23)	8.4	(31.9-	48.7)
	\$52,800-\$300,000	549	137.4	223.5	230.5	1.00	-	.	0.0	-	-
1986-89	\$0-<\$20,100	2,169	433.1	289.1	284.3	1.53	(1.30-	1.81)	98.8	(66.3-	131.3)
	\$20,100-<\$29,300	1,395	286.4	250.2	250.7	1.35	(1.14-	1.60)	65.2	(32.2-	98.2)
	\$29,300-<\$38,900	870	201.3	219.2	223.5	1.20	(1.01-	1.44)	38.0	(3.7-	72.3)
	\$38,900-<\$52,800	567	136.6	197.4	203.7	1.10	(0.91-	1.33)	18.2	(18.4-	54.8)
	\$52,800-\$300,000	333	83.6	176.3	185.5	1.00	-	.	0.0	-	-
1991-94	\$0-<\$20,100	2,382	358.5	236.5	227.1	1.93	(1.63-	2.27)	109.2	(87.6-	130.8)
	\$20,100-<\$29,300	777	195.0	200.1	195.7	1.66	(1.39-	1.98)	77.8	(52.9-	102.7)
	\$29,300-<\$38,900	669	163.7	176.6	181.2	1.54	(1.28-	1.84)	63.3	(38.6-	88.0)
	\$38,900-<\$52,800	396	98.0	171.4	176.9	1.50	(1.23-	1.84)	59.0	(29.7-	88.3)
	\$52,800-\$300,000	297	54.4	114.1	117.9	1.00	-	.	0.0	-	-
1996-99	\$0-<\$20,100	1,533	245.0	180.9	169.7	1.65	(1.36-	2.00)	67.1	(45.9-	88.3)
	\$20,100-<\$29,300	801	180.4	141.8	138.0	1.35	(1.10-	1.64)	35.4	(13.6-	57.2)
	\$29,300-<\$38,900	396	101.3	117.0	115.3	1.12	(0.91-	1.39)	12.7	(10.2-	35.6)
	\$38,900-<\$52,800	324	75.6	126.7	126.6	1.23	(0.98-	1.55)	24.0	(1.3-	49.3)
	\$52,800-\$300,000	258	37.7	95.0	102.6	1.00	-	.	0.0	-	-

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>age and ethnicity standardised

**Table 6-9 Summary of CVD Mortality Rates per 100,000 person-years, SRR and SRD by Income – Males**

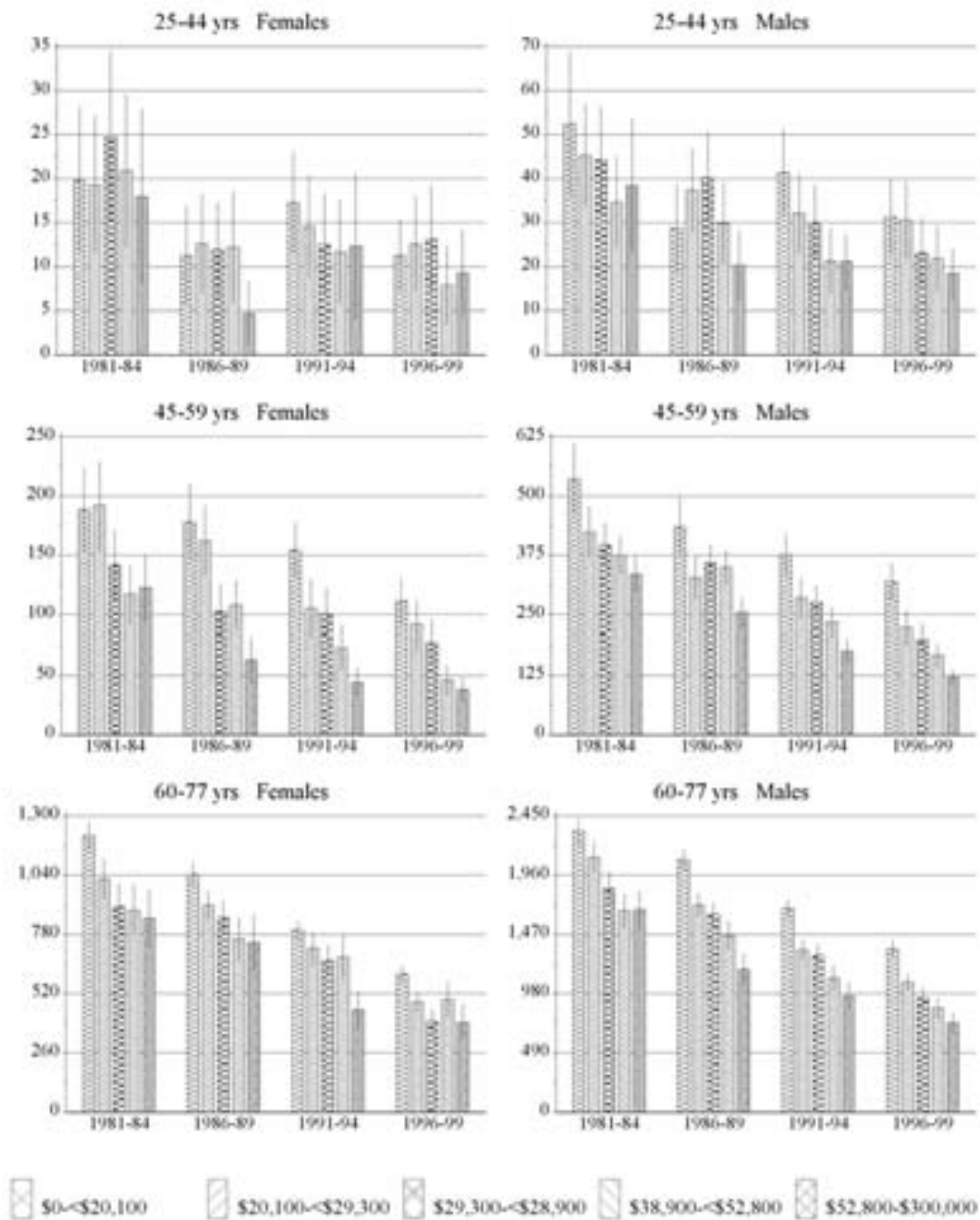
Period	Income	Deaths (n)*	Crude Rate	Age Std Rate	Age & Eth Std Rate <sup>†</sup>	SRR (95% CI) <sup>†</sup>			SRD (95% CI) <sup>†</sup>		
1981-84	\$0-<\$20,100	3,276	1,108.1	661.4	644.5	1.43	(1.31-	1.56)	193.1	(147.6-	238.6)
	\$20,100-<\$29,300	1,887	527.8	567.0	567.1	1.26	(1.14-	1.38)	115.7	(69.6-	161.8)
	\$29,300-<\$38,900	1,530	448.4	501.5	506.5	1.12	(1.02-	1.24)	55.1	(8.8-	101.4)
	\$38,900-<\$52,800	1,473	372.5	455.8	458.1	1.01	(0.92-	1.12)	6.7	(39.6-	53.0)
	\$52,800-\$300,000	1,533	329.1	440.1	451.4	1.00	-	.	0.0	-	-
1986-89	\$0-<\$20,100	3,303	924.0	567.2	556.3	1.74	(1.57-	1.93)	237.3	(198.6-	276.0)
	\$20,100-<\$29,300	2,100	485.3	457.6	457.4	1.43	(1.29-	1.59)	138.4	(100.8-	176.0)
	\$29,300-<\$38,900	1,896	444.7	448.5	450.7	1.41	(1.27-	1.57)	131.7	(93.5-	169.9)
	\$38,900-<\$52,800	1,494	333.2	397.7	406.3	1.27	(1.14-	1.43)	87.3	(47.2-	127.4)
	\$52,800-\$300,000	1,014	218.4	310.8	319.0	1.00	-	.	0.0	-	-
1991-94	\$0-<\$20,100	3,681	763.5	480.2	466.4	1.84	(1.66-	2.03)	212.3	(181.8-	242.8)
	\$20,100-<\$29,300	1,605	432.8	371.2	366.7	1.44	(1.29-	1.61)	112.6	(80.6-	144.6)
	\$29,300-<\$38,900	1,380	338.9	350.6	354.5	1.40	(1.25-	1.56)	100.4	(68.0-	132.8)
	\$38,900-<\$52,800	927	220.5	292.0	299.8	1.18	(1.04-	1.34)	45.7	(11.7-	79.7)
	\$52,800-\$300,000	894	146.9	241.4	254.1	1.00	-	.	0.0	-	-
1996-99	\$0-<\$20,100	2,649	589.2	401.1	376.7	1.95	(1.76-	2.17)	184.0	(158.7-	209.3)
	\$20,100-<\$29,300	1,701	419.6	306.3	295.2	1.53	(1.37-	1.71)	102.5	(77.6-	127.4)
	\$29,300-<\$38,900	948	247.0	262.8	258.9	1.34	(1.19-	1.52)	66.2	(39.8-	92.6)
	\$38,900-<\$52,800	792	177.9	229.8	231.7	1.20	(1.06-	1.37)	39.0	(12.1-	65.9)
	\$52,800-\$300,000	852	114.3	188.6	192.7	1.00	-	.	0.0	-	-

\*Random rounded to base three according to SNZ protocol

<sup>†</sup>age and ethnicity standardised

### 6.2.2.1 Variation by age in CVD mortality by income

**Figure 6-7 Cardiovascular Mortality Rates per 100,000 person-years by Income Level, Cohort, Sex and Age Group\***



\*age and ethnicity standardised

Mortality rates and 95% CIs are given in the appendices, Table 12-25 and Table 12-26, page 405)

Considering age-specific mortality rates, cardiovascular mortality rates showed a consistent largely monotonic relationship to income, for males and females aged 44-59 and 60-77 years (Figure 6-7, above). However for females aged 25-44 years there was no evidence of systematic relationship of income with cardiovascular mortality rates. For males aged 25-44 years the pattern of decreasing mortality rates with higher incomes was present in three of the four cohorts but not in 1986-89.

CVD RII and SII by income are presented by age and sex in Table 6-10 and Figure 6-8. For females aged 25-44 years the confidence intervals of the RII include 1.0 in all four censuses. However for male aged 25-44 years the RII increases substantially across the four cohorts from 1.43 to 2.52 – suggesting a 2.5 fold increase in relative disadvantage by income. Males also show an increase in the SII between the 1980s and 1990s although the confidence intervals for all periods overlap.

For both males and females RII are highest for the 45-59 year age group. At this age the RII increases across every inter-cohort period; for females the RII increases five fold from 1.79 in 1981-84 to 8.39 in 1996-99; for males the RII increases 2.5 fold from 1.55 to 3.84. The large increases in relative inequalities were not however matched by similar levels of increase in the SII. The SII did increase for males from 1981-84 through to 1991-94 but declined again in the last inter-cohort period, while for females an increase in the first inter-cohort period was followed by a 28% decline from 1986-89 to 1996-99.

For female cohortees aged 60-77 years the RII fell from 1.69 in 1981-84 to 1.49 in 1991-94 only to increase again to 1.62 in 1996-99, although 95% confidence intervals all overlap. The SII remained relatively constant in the first three cohorts but declined by 30% in the final inter-cohort period. For males aged 60-77 years the RII increased steadily from 1.59 to 1.98 between 1981-84 to 1996-99, but at the same time the SII declined by 22% from 898 to 699 per 100,000 person-years.

**Table 6-10 RII for Income by Age and Sex and Cohort, Cardiovascular Mortality**

Sex	Age	Period	RII (95% CI)*	P (Trend)	SII (95% CI) *	P (Trend)
Females	25-44 yrs	1981-84	1.03 (0.52- 2.04)	.	1 (-5- 6)	.
		1986-89	2.11 (0.82- 5.43)	.	8 (2- 18)	.
		1991-94	1.88 (0.83- 4.24)	.	8 (2- 15)	.
		1996-99	1.38 (0.64- 2.96)	0.56	3 (-5- 11)	0.53
	45-59 yrs	1981-84	1.79 (1.23- 2.59)	.	82 (13- 151)	.
		1986-89	4.27 (2.41- 7.57)	.	140 (102- 179)	.
		1991-94	6.90 (2.97- 16.05)	.	131 (93- 170)	.
		1996-99	8.39 (2.91- 24.16)	0.03	100 (74- 127)	0.58
	60-77 yrs	1981-84	1.69 (1.46- 1.96)	.	535 (472- 598)	.
		1986-89	1.55 (1.35- 1.78)	.	393 (337- 450)	.
		1991-94	1.49 (1.29- 1.72)	.	283 (165- 400)	.
		1996-99	1.62 (1.37- 1.92)	0.57	242 (110- 375)	0.02
Males	25-44 yrs	1981-84	1.43 (0.85- 2.41)	.	15 (10- 21)	.
		1986-89	1.74 (1.04- 2.91)	.	17 (1- 33)	.
		1991-94	2.47 (1.39- 4.39)	.	24 (16- 32)	.
		1996-99	2.52 (1.35- 4.72)	0.04	21 (15- 27)	0.16
	45-59 yrs	1981-84	1.55 (1.27- 1.90)	.	168 (100- 237)	.
		1986-89	1.64 (1.33- 2.02)	.	160 (133- 188)	.
		1991-94	2.94 (2.19- 3.94)	.	244 (199- 290)	.
		1996-99	3.84 (2.67- 5.51)	0.07	213 (152- 275)	0.26
	60-77 yrs	1981-84	1.59 (1.42- 1.77)	.	898 (735- 1061)	.
		1986-89	1.81 (1.63- 2.02)	.	980 (706- 1254)	.
		1991-94	1.95 (1.73- 2.19)	.	891 (789- 994)	.
		1996-99	1.98 (1.75- 2.25)	0.05	699 (549- 848)	0.31

\*age and ethnicity standardised

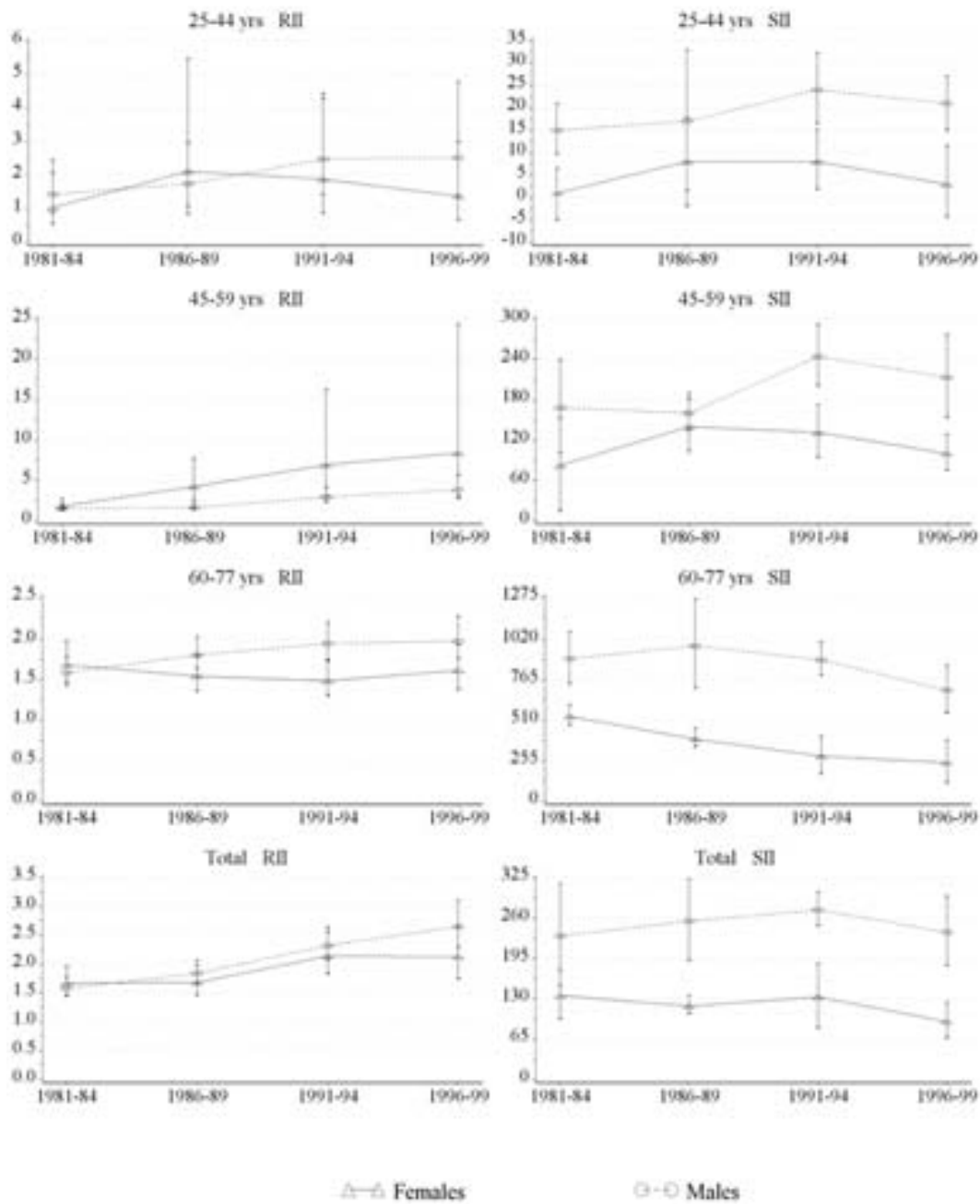
Statistical imprecision makes it difficult to make definitive statements about trends in the RII and SII over time. The general trends are summarised in Table 6-11,below.

**Table 6-11 Summary of Trends in RII and SII – CVD Mortality**

Age	Females		Males	
	RII	SII	RII	SII
25-44 years		--	↑↑	↑
45-59 years	↑↑↑	--	↑↑	--
60-77 years	--	↓↓	↑	↓



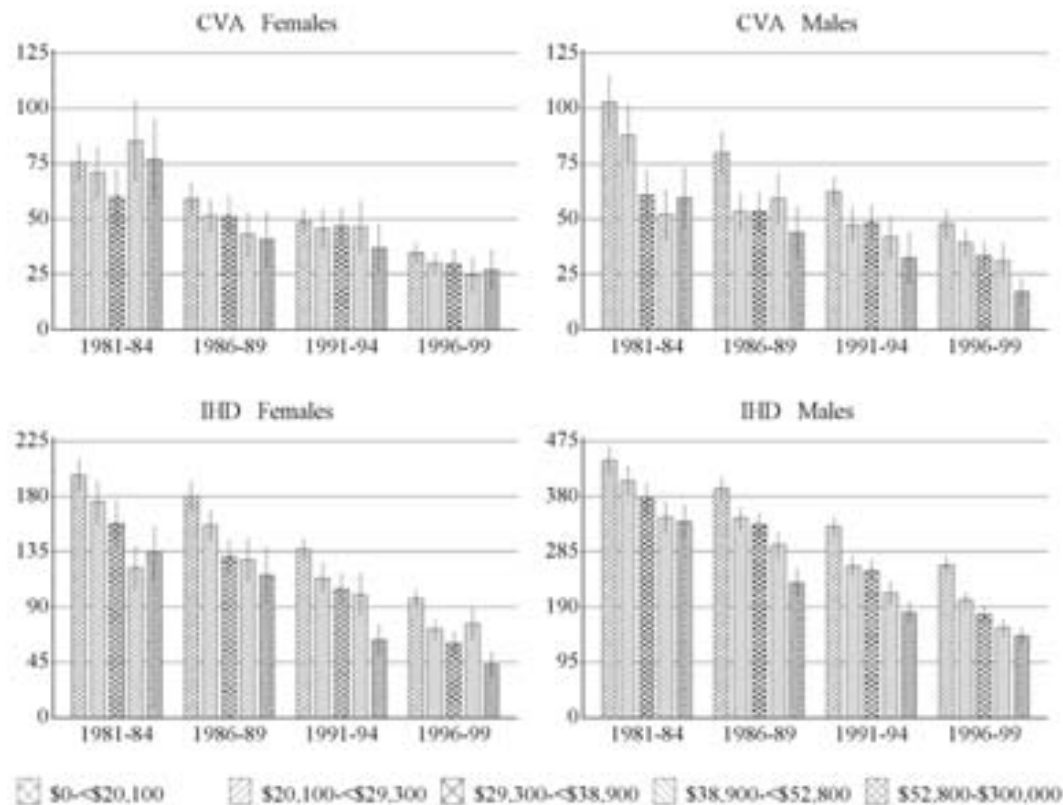
**Figure 6-8 CVD Mortality by Income, RII and SII for Income by Cohort, Sex and Age\***



\*age and ethnicity standardised

### 6.2.2.2 Trends in Ischaemic Heart Disease and Stroke Mortality by Income

**Figure 6-9 IHD and Stroke Mortality Rates per 100,000 person-years by Income Level and Sex**



\*age and ethnicity standardised

Mortality rates and 95% CIs are given in the appendices, Table 12-28, page 417.

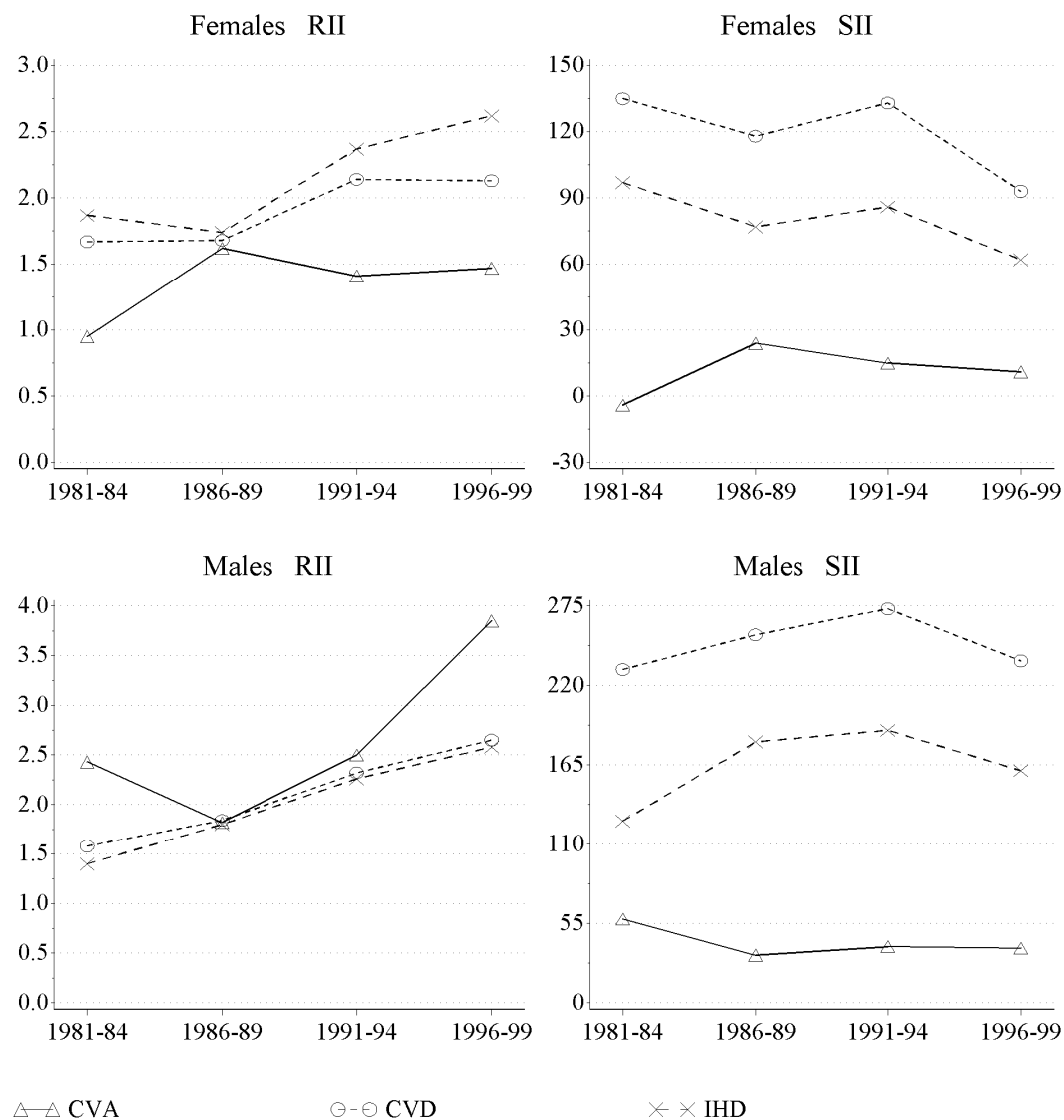
Figure 6-9 gives mortality rates by income for IHD and stroke separately. When all ages are combined, IHD mortality is associated with lower income levels for both females and males. However, although stroke mortality is similarly patterned by income for males, for females the association between stroke mortality and income is less evident (Figure 6-10). As a consequence RII are higher for IHD than for stroke for females, but not for males (Table 6-12).

For IHD relative inequality by income increased consistently over the all inter-cohort periods for males: the RII increased from 1.40 to 2.58 – a quadrupling of the total effect of income on mortality. Absolute inequality, measured by the SII, was highest for males for the middle two cohorts. For female IHD RII in the first two cohorts were similar, then increased in the subsequent periods Overall the RII increased from 1.87 to 2.62 – an 87% increase in

relative excess. At the same time absolute inequality, measured by the SII, declined overall from 97 to 62 per 100,000 person-years, a 37% decline.

The additive properties of the SII, as an absolute measure, mean it is possible to consider the proportional contributions of IHD and stroke to the total SII for CVD. The proportional contribution of IHD to the overall SII for CVD changed over the four cohorts. For females IHD contributed 72% (97/135) of the SII for CVD in 1981-84 but by 1996-99 this had declined to 67% (62/93). For males the contribution of IHD to the SII for CVD increased from 53% (126/231) to 67% (161/237).

**Figure 6-10 IHD and Stroke Mortality by Income - RII and SII, by Cohort and Sex\*.**



\*age and ethnicity standardised

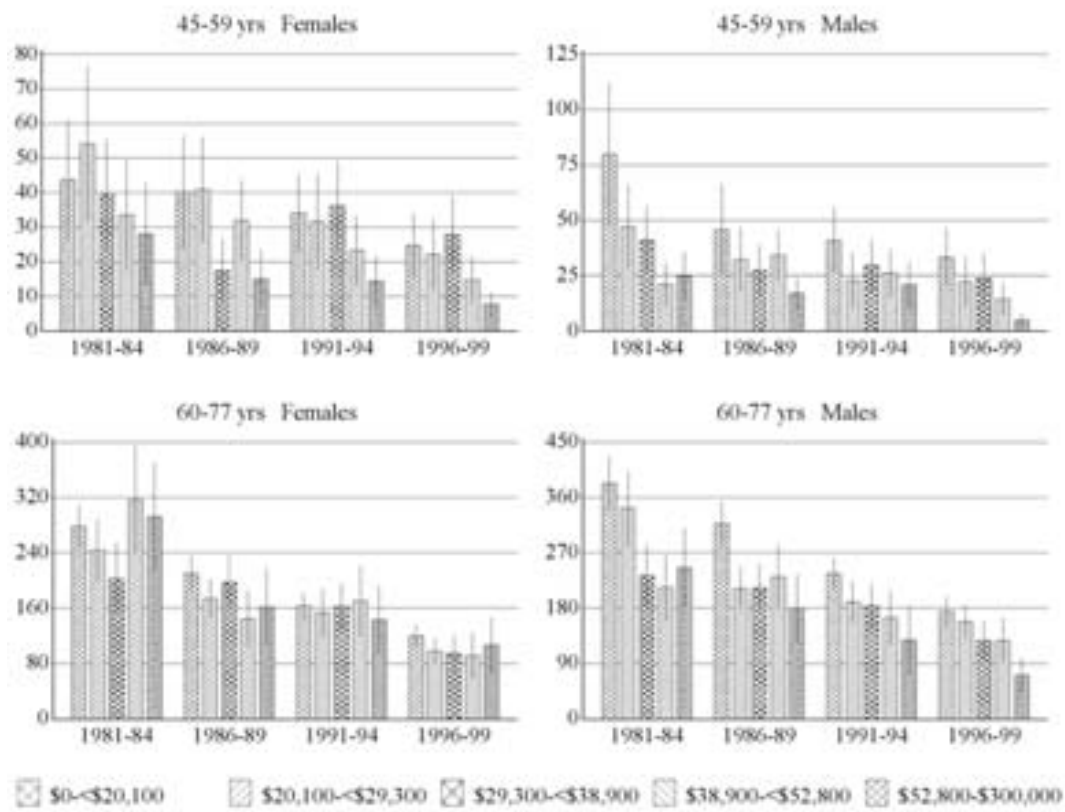
**Table 6-12 Stroke and IHD Mortality by Income - RII and SII, by Cohort and Sex.**

Cause	Sex	Period	RII (95%CI)*	P (Trend)	SII (95%CI)*	P (Trend)
Stroke	Females	1981-84	0.95 (0.70- 1.29)	.	-4 (-35- 28)	.
		1986-89	1.62 (1.18- 2.22)	.	24 (14- 33)	.
		1991-94	1.41 (1.02- 1.95)	.	15 (4- 26)	.
		1996-99	1.47 (0.96- 2.26)	0.33	11 (5- 18)	0.36
	Males	1981-84	2.43 (1.70- 3.46)	.	58 (24- 92)	.
		1986-89	1.82 (1.34- 2.48)	.	33 (5- 61)	.
		1991-94	2.50 (1.71- 3.66)	.	39 (29- 49)	.
		1996-99	3.85 (2.23- 6.65)	0.45	38 (30- 45)	0.49
IHD	Females	1981-84	1.87 (1.53- 2.29)	.	97 (58- 136)	.
		1986-89	1.74 (1.44- 2.10)	.	77 (55- 100)	.
		1991-94	2.37 (1.88- 2.98)	.	86 (56- 116)	.
		1996-99	2.62 (1.95- 3.53)	0.18	62 (44- 80)	0.15
	Males	1981-84	1.40 (1.24- 1.58)	.	126 (64- 188)	.
		1986-89	1.80 (1.59- 2.03)	.	181 (144- 218)	.
		1991-94	2.26 (1.96- 2.62)	.	189 (166- 213)	.
		1996-99	2.58 (2.17- 3.08)	0.01	161 (116- 205)	0.66

\*age and ethnicity standardised

There were too few deaths to analyse stroke and IHD mortality by five levels of income for 25-44 year olds. However, among 45-59 year olds and 60-77 year olds the associations of income with stroke mortality varied by age (Figure 6-11 and appendices Table 12-28, page 417). There was an association between low income and high mortality for females aged 45-59 years but this pattern is not present for 60-77 year old females. Cohortees aged 45-59 years in 1981-84 were aged 60-77 years in 1996-99. Hence these results suggest that, for females, the association of stroke mortality which was present for this age cohort when they were 45-59 years old had disappeared by the time they reached 60-77 years. This was not the case for males, for whom an association between low income and high stroke mortality was observed for both age groups.

**Figure 6-11 Stroke Mortality Rates\* by Income, Cohort, Sex and Age Group**

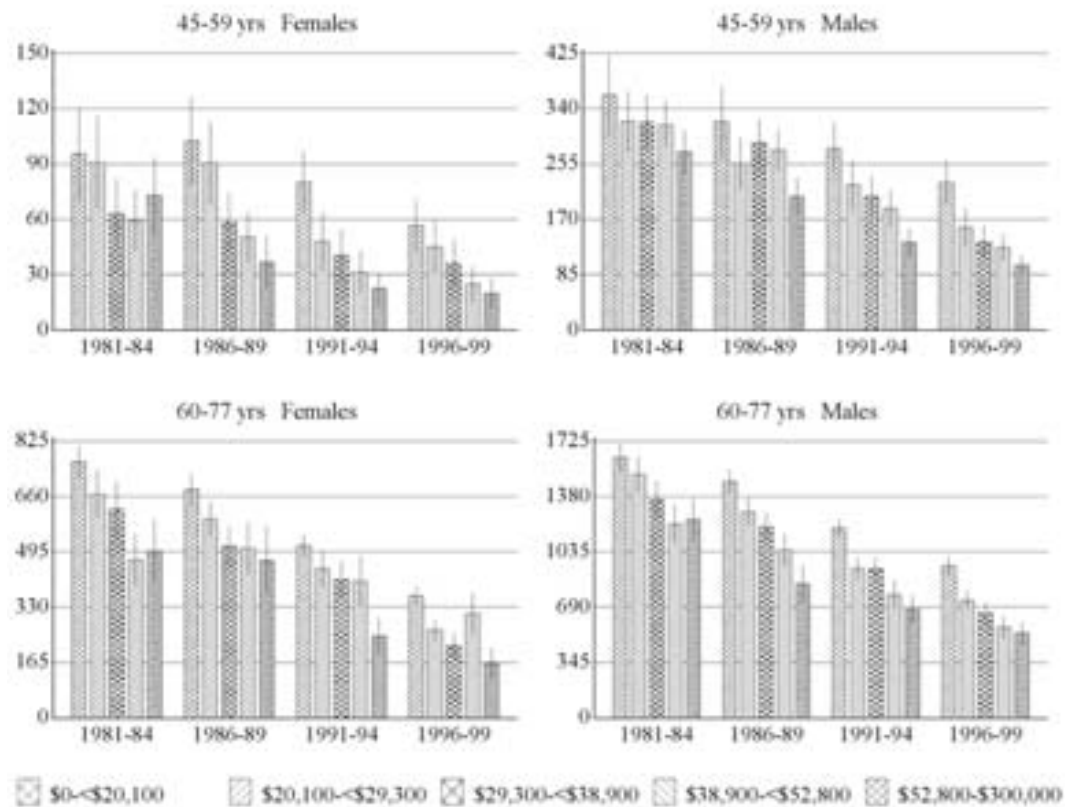


\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices, Table 12-28, page 417.

Figure 6-12 shows IHD mortality rates by income level and age. The pattern is very similar to that for all CVD reflecting the high proportion of CVD deaths due to IHD at older ages.

**Figure 6-12 IHD Disease Mortality Rates per 100,000 person-years\* by Income, Cohort, Sex and Age Group**



\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices, Table 12-28, page 417.

### 6.2.3 Other Causes of Death

The focus of this PhD is all-cause and CVD mortality, however it useful to briefly consider other causes of death, both as a point of comparison and also to inform interpretation of trends in mortality by income.

The pattern of declining mortality at all income levels observed for CVD mortality was not present for other causes of death. Figure 6-13, below, shows mortality rates by income level for all ages combined (25-77 years) for lung, colorectal, breast and prostate cancers and for unintentional injury. Corresponding RII and SII measures are given in Figure 6-14 and Table 6-13.

#### 6.2.3.1 *Lung Cancer*

Lung cancer was strongly associated with income level in all four cohorts for males and in the last three cohorts for females. However for females lung cancer mortality rates increase differentially by income, There was no increase in mortality rates at high incomes while mortality rates for the lowest income group almost doubled. In comparison, male lung cancer mortality declined between 1981-84 and 1996-99; first for the highest income group but by the 1996-99 cohort mortality rates had declined for all income groups. These differential patterns of change in mortality rates by income result in substantial increases in RII for lung cancer between the 1981-84 and 1991-96 cohorts for both males and females. For females there was a consistent increase from 1.16 to 4.20 while for males the RII increased from 1.81 to 5.06. The SII for females also increased substantially from 4 to 41 per 100,000 person-years. For males the inter-cohort change in SII followed no consistent pattern, although the SII was lower for the first cohort than in all subsequent cohorts.

#### 6.2.3.2 *Colorectal Cancer*

Overall colorectal cancer mortality rates declined for women but increased for men between 1981-86 and 1996-99. Although not strongly patterned by income level, colorectal mortality declined further for high-income females and did not increase for high-income males. Both RII and SII were higher for males than females. For females the RII increased consistently across the inter-cohort periods while for males the RII decreased in the first inter-cohort period but increased thereafter.

#### 6.2.3.3 *Breast Cancer*

Breast cancer mortality shows no consistent association with income level. However rates do decline in the highest income category in 1996-99. The RII and SII fail to reach statistical significance in the first three cohorts but by 1996-99 the RII is 1.47 (95% CI: 1.12-1.93) and the SII is 16 (95% CI: 3-36). Taken together these results suggest an increasing burden of inequality for breast cancer. When mortality by age is considered there is some suggestion of a stronger association between income and breast cancer mortality for 45-59 year old cohortes, compared those aged 60-77 years (results not shown).

#### 6.2.3.4 *Prostate Cancer*

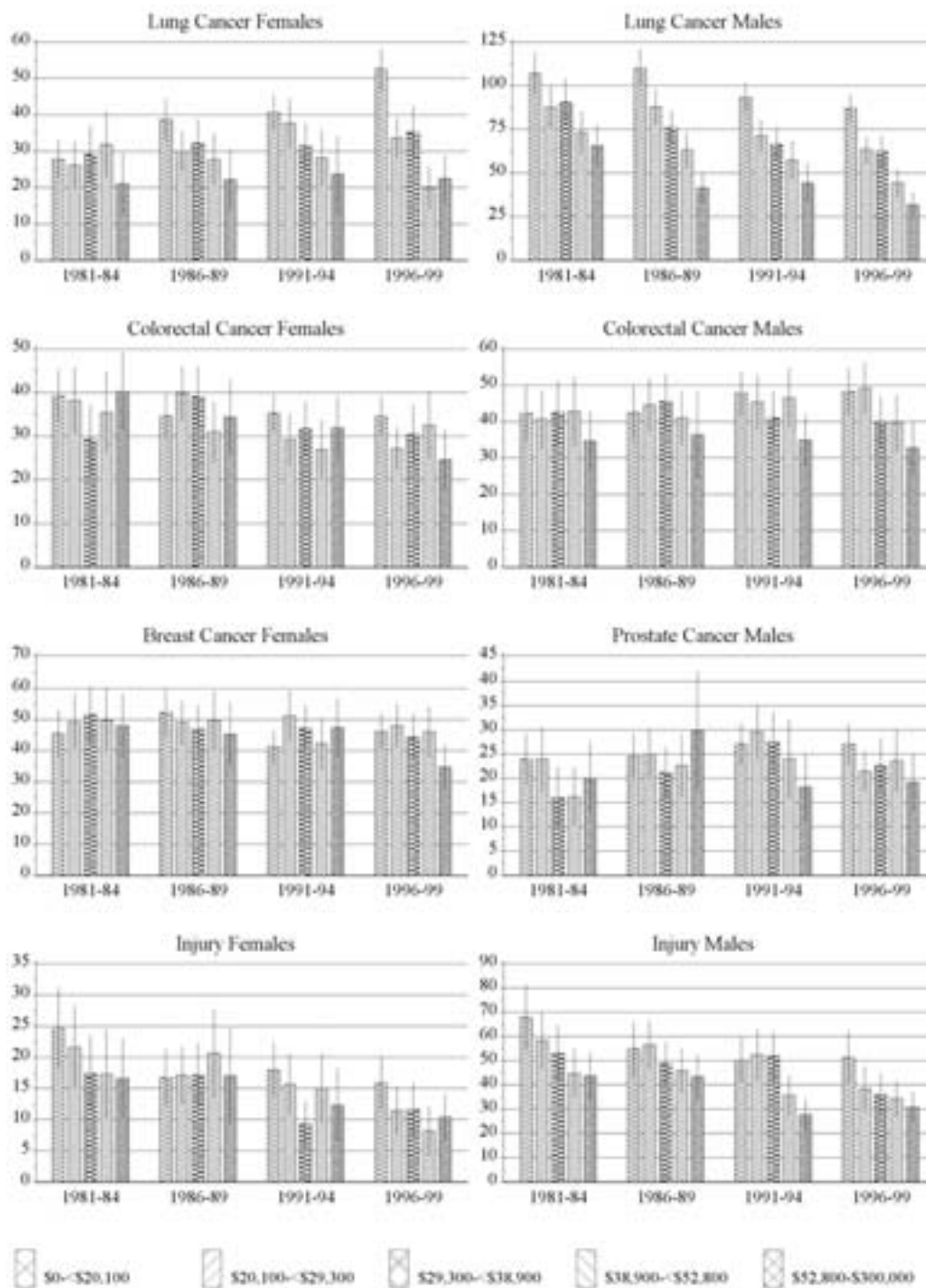
Figure 6-13 shows a pattern of higher prostate mortality at low income levels for all cohorts except 1986-89. The RII and SII show no consistent trend towards either increasing or decreasing inequality. However both are highest in 1991-94.

#### 6.2.3.5 *Injury*

Mortality due to unintentional injury declined for both males and females over the period from 1981-84 to 1996-99. For females, injury mortality rates were inversely associated with income in three of the four cohorts but in 1986-89 there was no observed association. For males, the association is observed in all four cohort-periods. There was no clear trend towards decreasing or increasing inequality for males. The RII and SII were highest for males in 1991-94. For females however, the RII and SII show a decline over the first inter-cohort period with increases in the subsequent two inter-cohort periods.



**Figure 6-13 Mortality Rates per 100,000 person-years\* for Selected Causes by Income Level, Cohort and Sex – ages 25-77 years**



\*age and ethnicity standardised

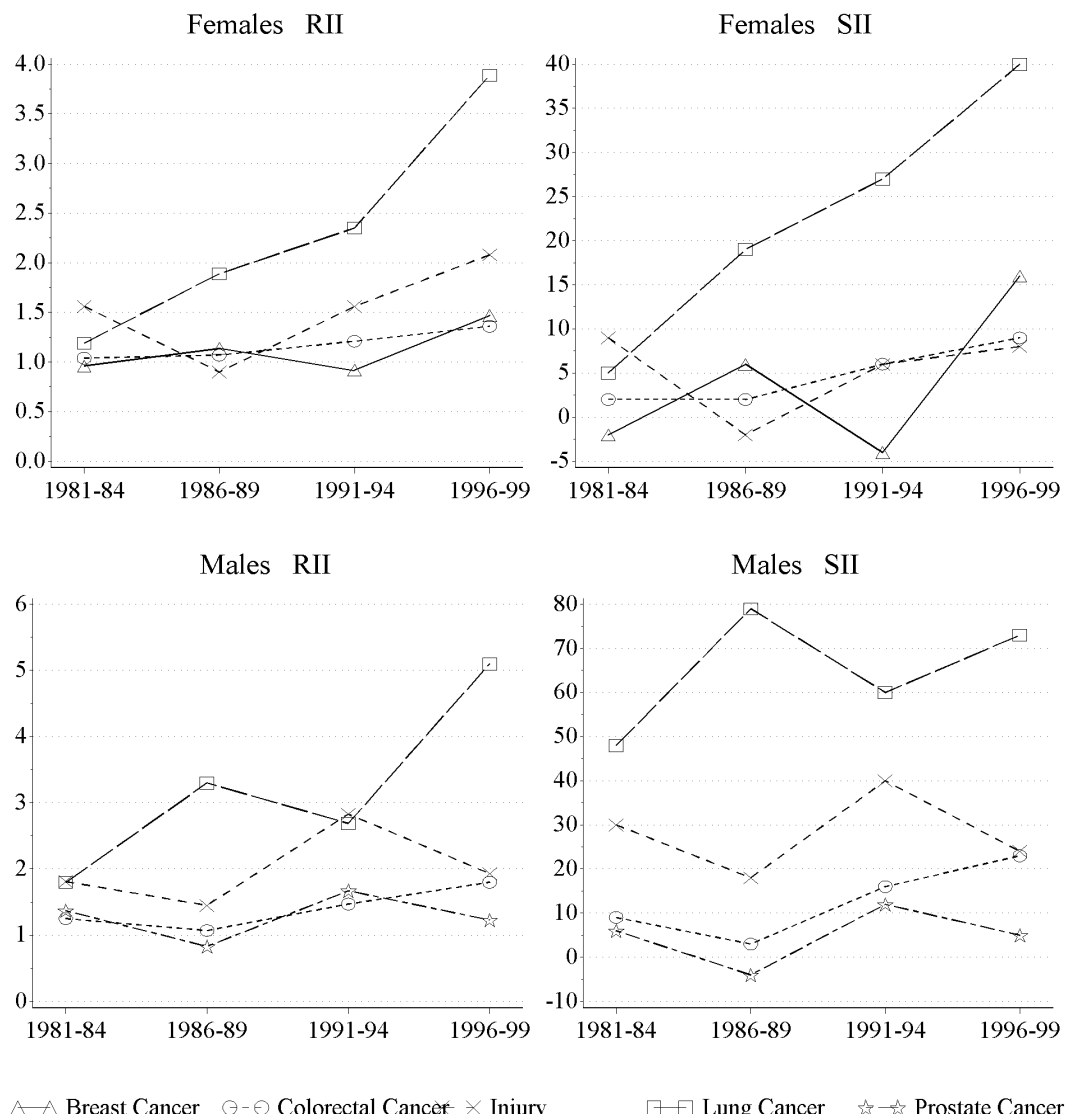
Mortality rates and 95% CIs are given in the appendices, Table 12-28, page 417.

**Table 6-13 Mortality by Income for Selected Causes - RII and SII, by Cohort and Sex.**

Cancer Type	Sex	Period	RII (95% CI)*	P (Trend)	SII (95% CI)*	P (Trend)
Lung Cancer	Females	1981-84	1.19 (0.77- 1.83)	.	5 (-7- 16)	.
		1986-89	1.89 (1.29- 2.78)	.	19 (7- 30)	.
		1991-94	2.35 (1.50- 3.67)	.	27 (23- 30)	.
		1996-99	3.89 (2.39- 6.32)	0.012	40 (30- 49)	0.008
	Males	1981-84	1.80 (1.38- 2.34)	.	48 (42- 53)	.
		1986-89	3.30 (2.41- 4.51)	.	79 (59- 98)	.
		1991-94	2.69 (1.88- 3.85)	.	60 (49- 72)	.
		1996-99	5.10 (3.25- 8.00)	0.138	73 (62- 84)	0.142
Colorectal Cancer	Females	1981-84	1.04 (0.74- 1.47)	.	2 (-15- 18)	.
		1986-89	1.07 (0.79- 1.44)	.	2 (-8- 12)	.
		1991-94	1.21 (0.89- 1.65)	.	6 (-1- 13)	.
		1996-99	1.36 (0.96- 1.93)	0.034	9 (2- 17)	0.031
	Males	1981-84	1.25 (0.89- 1.78)	.	9 (-9- 27)	.
		1986-89	1.07 (0.71- 1.61)	.	3 (-4- 10)	.
		1991-94	1.47 (1.12- 1.93)	.	16 (-2- 34)	.
		1996-99	1.80 (1.32- 2.45)	0.154	23 (14- 32)	0.100
Breast Cancer	Females	1981-84	0.96 (0.71- 1.29)	.	-2 (-10- 6)	.
		1986-89	1.14 (0.86- 1.50)	.	6 (3- 10)	.
		1991-94	0.92 (0.70- 1.20)	.	-4 (-17- 9)	.
		1996-99	1.47 (1.12- 1.93)	0.369	16 (3- 36)	0.510
Prostate Cancer	Males	1981-84	1.37 (0.78- 2.40)	.	6 (-2- 14)	.
		1986-89	0.83 (0.51- 1.35)	.	-4 (-12- 4)	.
		1991-94	1.67 (1.05- 2.67)	.	12 (3- 22)	.
		1996-99	1.23 (0.81- 1.85)	0.804	5 (-4- 14)	0.766
Injury	Females	1981-84	1.56 (0.89- 2.74)	.	9 (1- 16)	.
		1986-89	0.90 (0.54- 1.51)	.	-2 (-7- 3)	.
		1991-94	1.56 (0.87- 2.79)	.	6 (-1- 14)	.
		1996-99	2.08 (1.10- 3.93)	0.529	8 (5- 12)	0.536
	Males	1981-84	1.81 (1.25- 2.62)	.	30 (23- 37)	.
		1986-89	1.45 (1.05- 1.98)	.	18 (9- 28)	.
		1991-94	2.83 (1.82- 4.38)	.	40 (13- 67)	.
		1996-99	1.93 (1.29- 2.87)	0.592	24 (16- 31)	0.615

\*age and ethnicity standardised

**Figure 6-14 Mortality by Income for Selected Causes - RII and SII, by Cohort and Sex\*.**

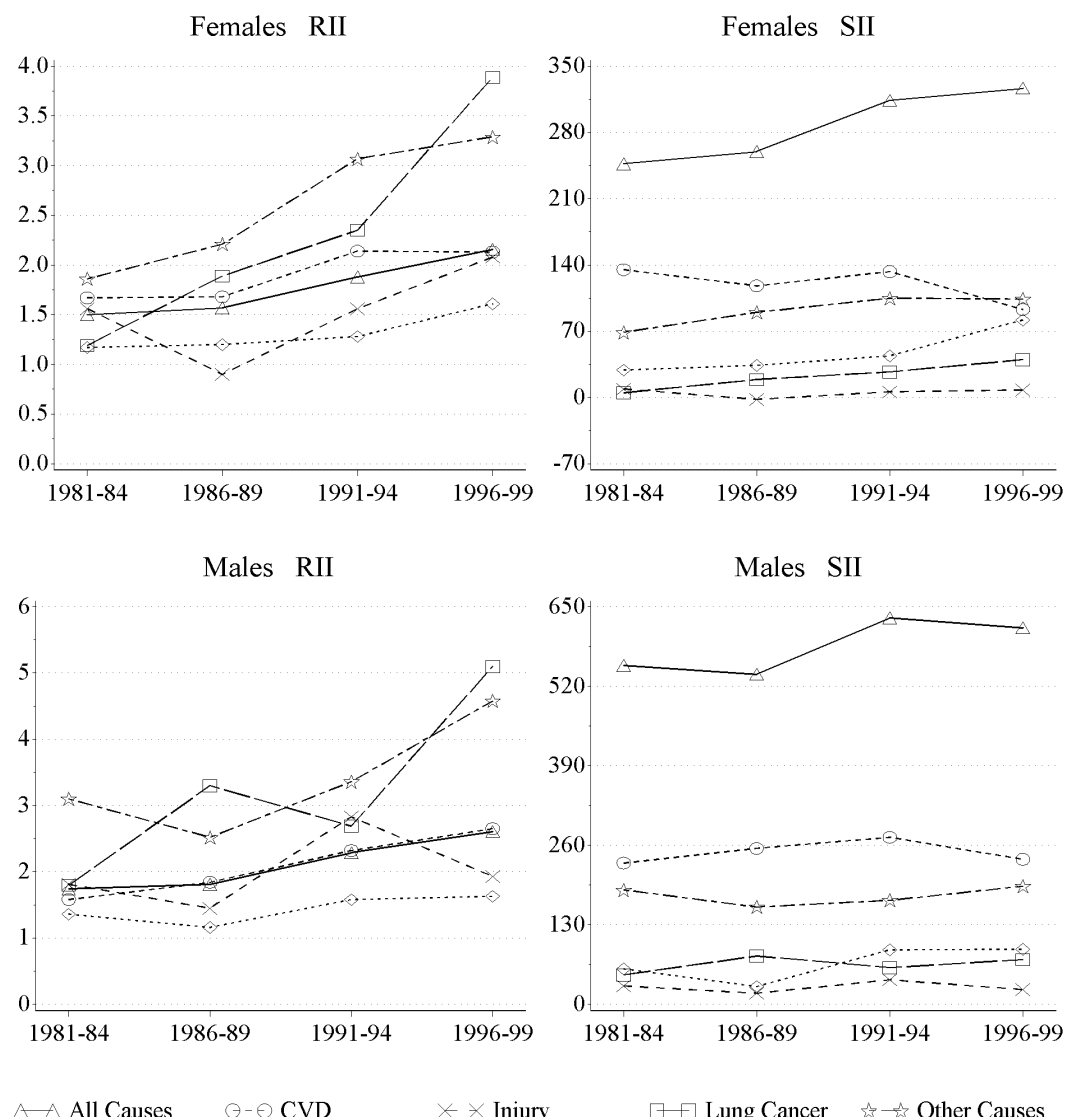


\*age and ethnicity standardised

#### 6.2.4 The contributions of CVD and other causes to all-cause inequality by income

Figure 6-15 shows the RII and SII for all cause mortality and for CVD, Injury, Lung Cancer, non-lung cancers and other causes. There is a clear trend towards increasing relative inequality, measured by the RII, for all cause of death groups for females and all cause of death groups except injury in males. However the RII has particularly increased for lung cancer and other causes. The major contributor to the increase in the RII for other causes was respiratory disease, and in particular chronic obstructive pulmonary disease (COPD).

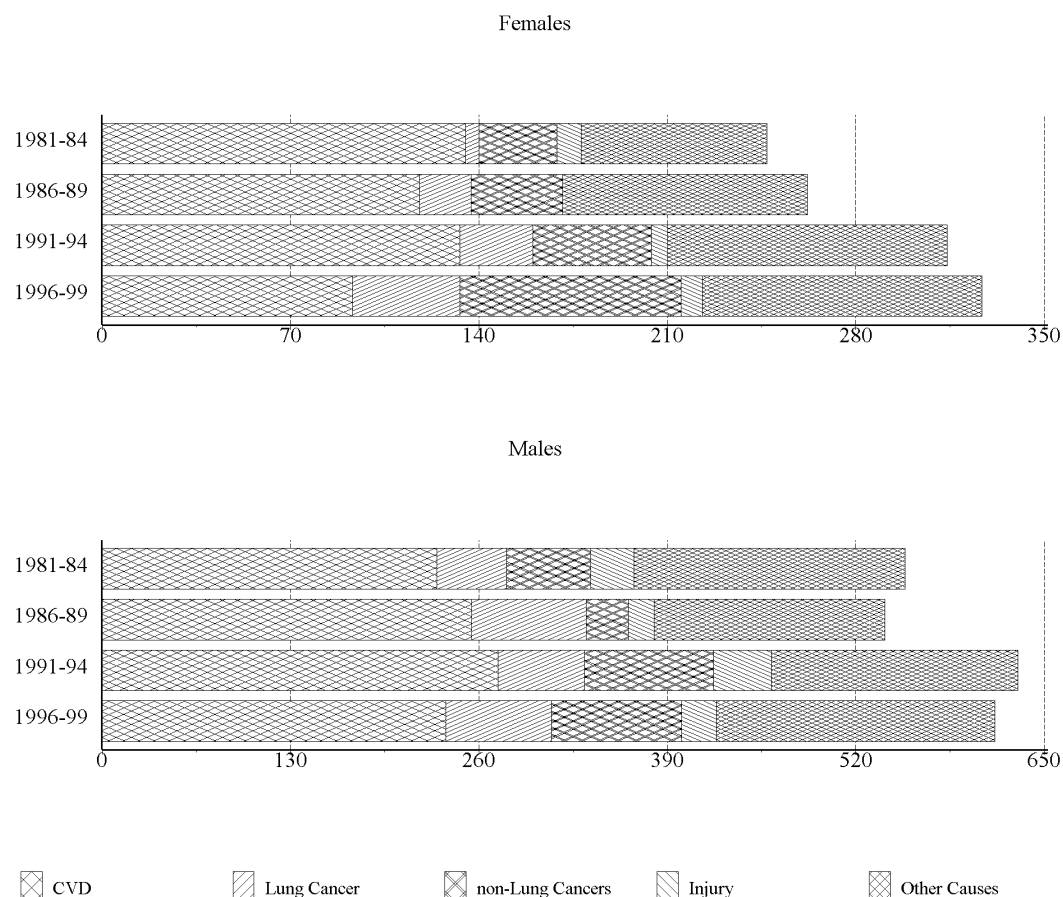
**Figure 6-15 Comparison of RII for Income by Cause of Death: all-causes and major cause of death groups, by cohort and sex. \***



\*age and ethnicity standardised

The additive properties of the SII make it possible to consider the contribution of different causes to total absolute inequality. Figure 6-16 shows that for females, the contribution of CVD to the all cause SII has declined over the four cohorts while at the same time cancers, both lung and non-lung have become increasingly important. By 1996-99 non-lung cancers accounted for a greater proportion of the total SII than CVD. The contribution of other causes also increases, this is largely due to increasing inequality due to respiratory diseases and COPD in particular. In contrast, the contribution of CVD to the SII for males was similar in the first and last cohorts. The increase in the all cause SII for males between the 1990s and 1980s is due to the increased SII for cancers, particularly non-lung cancers, and other causes.

**Figure 6-16 Contribution of Major Cause of Death Groupings to the SII for All-Cause Mortality by Income, by Cohort and Sex.\***



\*age and ethnicity standardised

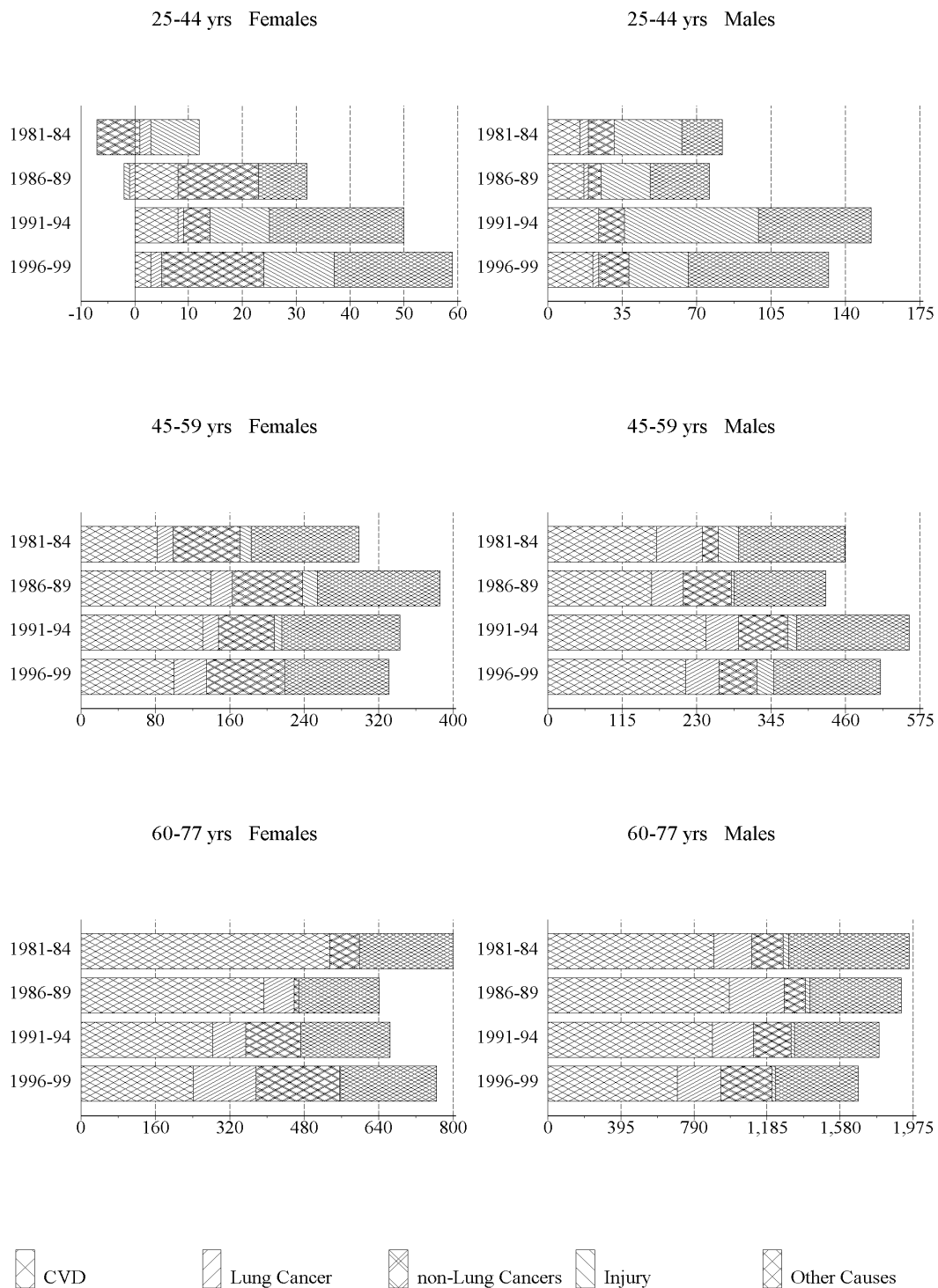
Figure 6-17 shows that the contribution of various causes to the SII, and changes in the SII over time, were different at different ages. For ages 25-44 years the contribution of the “*other causes of death*” grouping grew over the four cohorts for both males and females. This was a result of growing inequalities in the distribution of suicide deaths over the 1990s.

Among 45-59 year old men CVD remains the largest contributor to the SII. In this age group CVD was more important in the 1990s than the 1980s, which reflects the growing inequalities in CVD mortality in this age group, despite the halving of the overall CVD mortality rates over the four cohorts. The growing importance of cancer as a contributor to income inequality is only evident in the last cohort period for females aged 45–59 years.

In comparison among females aged 60-77 years the increase in the contribution of cancers to the SII occurs across the four cohorts and is substantial and contrasts markedly with the consistent decline in the contribution of CVD to the total SII across all four cohorts. The increase in cancer SII occurs for both lung and non-lung cancers. Had the SII for cancer remained constant the SII for overall mortality would have tracked downward, in line with the decline in the SII for CVD mortality

For males aged 60-77 years the contribution of CVD to the overall SII has been the main contributor to the overall decline in the SII for all cause mortality. The contribution of all cancers combined remained relatively constant after 1991-94. However the contribution of lung cancer declined over this period while the contribution of other cancers increased.

**Figure 6-17 Contribution of Major Cause of Death Groupings to the SII for All-Cause Mortality by Income, by Sex, Age and Cohort\*.**



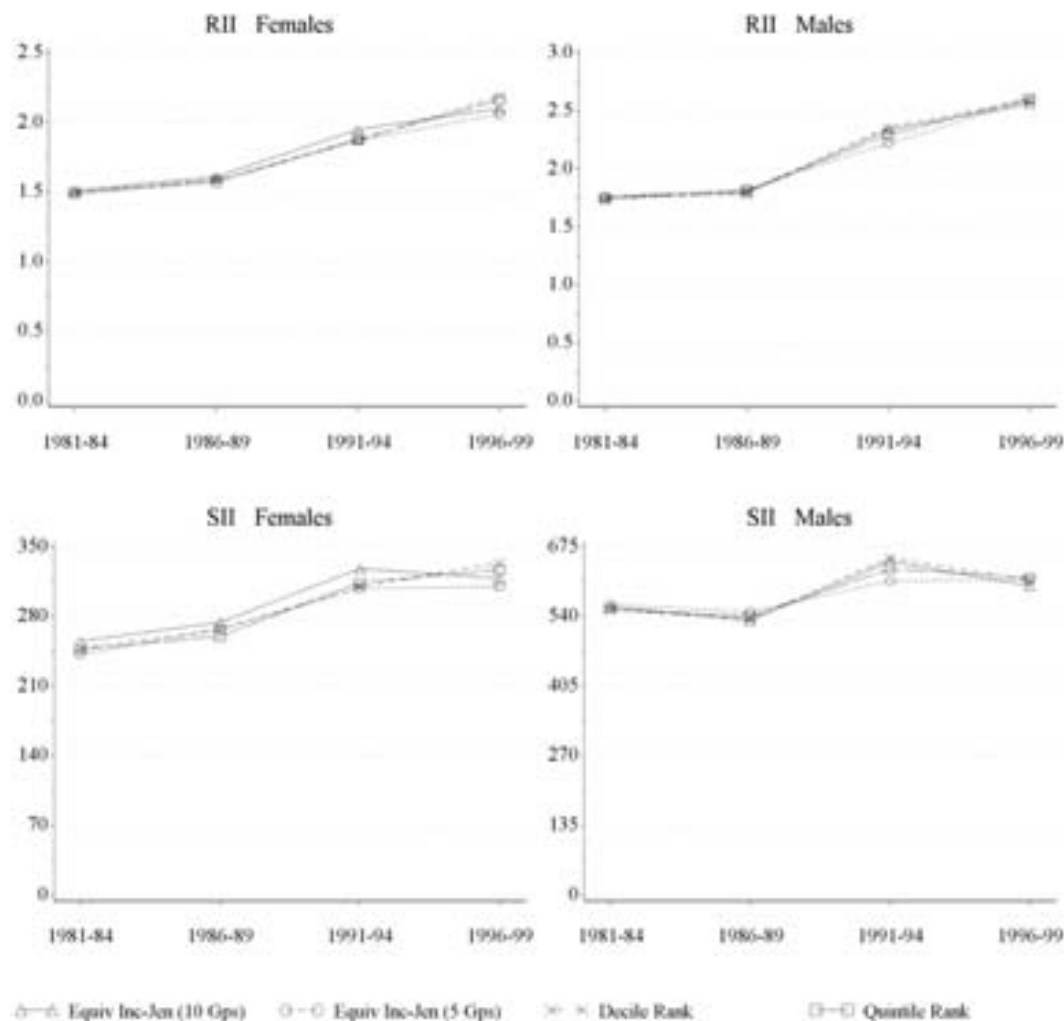
\*age and ethnicity standardised

### 6.3. Sensitivity Analyses and Assessment of Systematic Error

#### 6.3.1 Sensitivity of the RII and SII to the income variable

The sensitivity of the RII to the categorisation of the income variable was investigated by comparing the results obtained with four different classifications of the Jensen household equivalised income; income in 10 levels, income in five levels; quintile ranks of income, and decile ranking of income. Figure 6-18 shows the RII and SII obtained for all cause mortality for ages 25-77 years. The RII was generally insensitive to the RII grouping for all cause and CVD mortality (Figure 6-19).

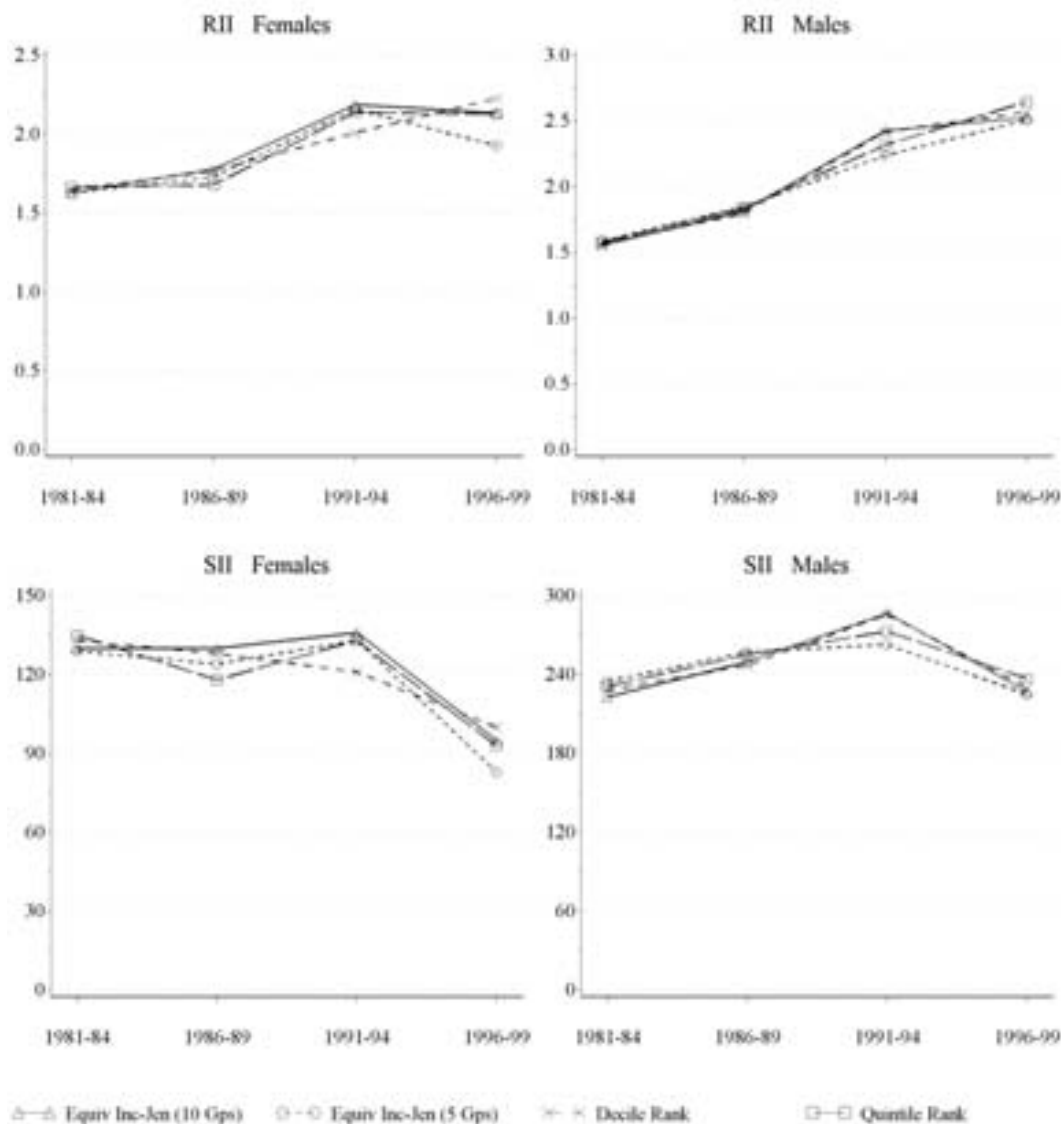
**Figure 6-18 All Cause Mortality by Income - RII and SII using Four Classifications of Income.\***



\*age and ethnicity standardised



**Figure 6-19 CVD Mortality by Income - RII and SII for Income by Four Classifications of Income\*.**



\*age and ethnicity standardised

## 6.3.2 Assessment of Bias

### 6.3.2.1 Assessment of Selection Bias

Selection into the income-restricted cohorts is dependent (conditioned) on each member of a cohort's household aged 18 and over having a valid income value from the census. If mortality is also conditioned on factors that influence the presence of a valid income variable then selection bias is likely (Hernán et al. 2004). As discussed earlier (page 177), in each cohort there was a proportion of census respondents with missing income variables.

**Figure 6-20 Directed Acyclic Graph (DAG) Depicting Conditions for Selection Bias in the Income-Restricted Cohort**

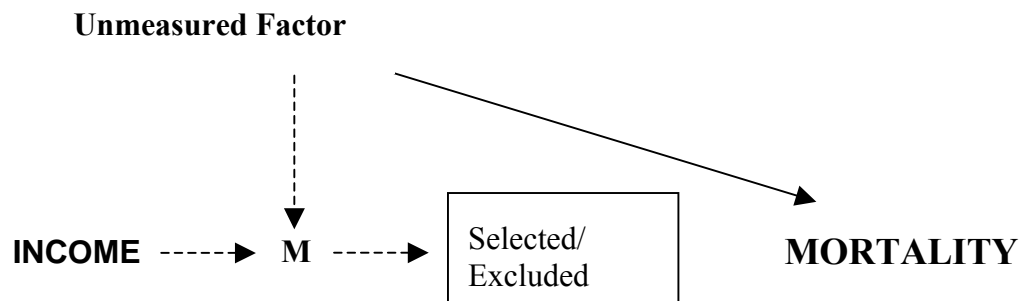


Figure 6-20 is a diagrammatic representation of how selection bias might arise in the income-restricted cohort. By this schema an unmeasured factor is directly associated with mortality but also another variable, M, that is associated with income and also with selection into the cohort..

Differences between cohorts in the proportion of cohorttees with missing income variables mean that the potential influence of selection bias on the measured income differentials is different for each cohort. The proportion of each cohort with missing equivalised income data was higher for males than females, at all ages, for all four cohorts (Table 6-2, page 177). The proportion with missing data was least in 1991-94 and highest in 1981-84 for most age by sex strata. Furthermore, the proportion with missing data was lowest for the for the 45-59 year age group.

Table 6-14 shows the standardised mortality ratio for cohorttees with missing equivalised income values compared to cohorttees with valid equivalised income values. These results suggest that those included in the analyses had lower mortality rates than those excluded from the analyses. The excess mortality among those excluded is higher for females and declines over time for all age and sex groups so that by 1996-99 there is no difference between the two groups for males and for younger females. These results suggest that excluded cohorttees experienced worse health than those included in the income-restricted cohorts. What is not known from this analysis is whether or not the chance of being

excluded from the analyses varied by income level, or whether the SRR by income is different according to selection status.

**Table 6-14 SRR for Selected:Excluded Cohortees by Sex, Age and Cohort – All Cause Mortality**

Sex	Age	SRR (95% CI)* by Cohort			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	1.49 (1.27- 1.76)	1.27 (1.07- 1.50)	1.49 (1.27- 1.74)	1.08 (0.92- 1.27)
	45-59 yrs	1.19 (1.09- 1.31)	1.34 (1.22- 1.48)	1.18 (1.06- 1.31)	1.10 (1.00- 1.20)
	60-77 yrs	1.26 (1.19- 1.33)	1.54 (1.45- 1.64)	1.46 (1.37- 1.56)	1.23 (1.16- 1.30)
	Total	1.26 (1.21- 1.32)	1.49 (1.41- 1.56)	1.41 (1.34- 1.49)	1.19 (1.13- 1.25)
Males	25-44 yrs	1.08 (0.94- 1.24)	1.28 (1.13- 1.46)	1.06 (0.92- 1.22)	0.95 (0.83- 1.10)
	45-59 yrs	1.19 (1.11- 1.28)	1.15 (1.06- 1.25)	1.17 (1.07- 1.28)	1.09 (1.00- 1.18)
	60-77 yrs	1.15 (1.10- 1.20)	1.25 (1.19- 1.32)	1.19 (1.13- 1.25)	1.00 (0.95- 1.05)
	Total	1.15 (1.11- 1.19)	1.24 (1.19- 1.29)	1.17 (1.12- 1.22)	1.01 (0.97- 1.05)

\*age and ethnicity standardised

High education is associated with high income. As an indirect measure of whether the association of income with mortality is likely to be biased by selection into the cohort I considered the relationship of education and mortality in cohortees selected into and excluded from the income-restricted cohort.

Table 6-17 gives the SRR for Low- to High-education for cohortees included in and excluded from the income-restricted cohort. These results show that in most instances the all-cause SRR is higher for those excluded from the cohort than for those selected into the cohort. For 25-44 year old cohortees the differential is greatest in the early cohorts and disappears by the later cohorts, and is greater for females than males. For females ages 45-59 years the differential is greatest in 1986-89 but has disappeared by the later two cohorts but there is little evidence of a differential in the SRR for males aged 45-59 years in any cohort. Among 60-77 year olds, the differential is highest in 1986-89 and 1996-99 for females, but for males is only evident in 1986-89. In most instances the confidence intervals of the selected and excluded SRR overlap. Taken together these results suggest some evidence of selection bias that was greatest for the 1986-89 cohort and least in the later cohorts. However the proportion of cohortees excluded from the cohorts was less in 1986-89 than in the first and last cohorts and so the effect of this bias on the overall SRR estimates for the population will be relatively small. The estimated effect on trends in relative inequality by income reported previously in this PhD is summarised in Table 6-15, below.

**Table 6-15 Effect of Selection Bias on trends in relative inequality by income**

Sex	Age Group			
	25-44 years	45-59 years	60-77 years	25-77 years
Females	Overestimate ↑	Overestimate ↑	Underestimate ↑	Underestimate ↑
Males	Overestimate ↑	Overestimate ↑	Underestimate ↑	Underestimate ↑

Table 6-18 shows the SRD for Low-High education for those selected into and excluded from the income-restricted cohort. In almost all cases, the SRD by education is greater for excluded cohortes than in cohortes in the income-restricted cohorts. The exceptions were females aged 60-77 years in 1981-84, females aged 25-44 in 1996-99 and males aged 25-44 years in 1991-94.

The estimated effect on trends in relative inequality by income is summarised in Table 6-16, below.

**Table 6-16 Effect of Selection Bias on trends in Absolute Inequality by Income**

Sex	Age Group			
	25-44 years	45-59 years	60-77 years	25-77 years
Females	Overestimate ↑	Underestimate ↓	Overestimate ↓	Overestimate ↓
Males	Overestimate ↑	Overestimate ↓	Underestimate ↓	Underestimate ↓

**Table 6-17 SRR (95% CI) for Low:High Educational Level for Cohortees Selected Into and Excluded from the Income Restricted Cohort, by Age, Sex and Cohort.**

Sex	Age	Selected/ Excluded	1981-84	1986-89	1991-94	1996-99	% change in SRR 84- 84 to 96-99
Females	25-44 yrs	Selected	1.13 (0.88- 1.45)	1.32 (1.07- 1.63)	1.55 (1.28- 1.86)	1.76 (1.44- 2.16)	485%
		Excluded	1.67 (1.08- 2.59)	1.70 (1.10- 2.64)	2.29 (1.62- 3.23)	1.98 (1.39- 2.81)	46%
	45-59 yrs	Selected	1.44 (1.23- 1.68)	1.31 (1.15- 1.48)	1.41 (1.26- 1.58)	1.47 (1.32- 1.64)	7%
		Excluded	1.88 (1.38- 2.56)	1.78 (1.35- 2.34)	1.41 (1.10- 1.81)	1.19 (0.97- 1.47)	-78%
	60-77 yrs	Selected	1.46 (1.31- 1.64)	1.25 (1.16- 1.35)	1.39 (1.29- 1.50)	1.33 (1.24- 1.42)	-28%
		Excluded	1.25 (0.98- 1.60)	1.50 (1.22- 1.84)	1.45 (1.21- 1.74)	1.60 (1.37- 1.88)	140%
	Total	Selected	1.42 (1.30- 1.55)	1.27 (1.19- 1.35)	1.41 (1.32- 1.49)	1.39 (1.31- 1.47)	-7%
		Excluded	1.36 (1.12- 1.67)	1.55 (1.31- 1.84)	1.50 (1.30- 1.75)	1.55 (1.37- 1.76)	53%
Males	25-44 yrs	Selected	1.69 (1.42- 2.03)	1.55 (1.34- 1.79)	1.58 (1.37- 1.82)	1.86 (1.60- 2.17)	25%
		Excluded	2.09 (1.35- 3.24)	1.91 (1.44- 2.55)	1.42 (1.05- 1.93)	1.87 (1.37- 2.54)	-20%
	45-59 yrs	Selected	1.38 (1.23- 1.55)	1.32 (1.21- 1.44)	1.33 (1.22- 1.45)	1.52 (1.39- 1.66)	37%
		Excluded	1.35 (1.10- 1.67)	1.35 (1.13- 1.61)	1.50 (1.25- 1.79)	1.57 (1.32- 1.87)	63%
	60-77 yrs	Selected	1.25 (1.17- 1.33)	1.22 (1.16- 1.28)	1.24 (1.18- 1.30)	1.22 (1.16- 1.28)	-12%
		Excluded	1.39 (1.20- 1.61)	1.50 (1.32- 1.71)	1.32 (1.16- 1.49)	1.24 (1.11- 1.38)	-38%
	Total	Selected	1.31 (1.24- 1.38)	1.27 (1.22- 1.32)	1.29 (1.24- 1.34)	1.33 (1.28- 1.39)	6%
		Excluded	1.43 (1.27- 1.61)	1.51 (1.36- 1.67)	1.36 (1.23- 1.50)	1.35 (1.24- 1.48)	-19%

\* age and ethnicity standardised

**Table 6-18 SRD (95% CI) for Low:High Educational Level for Cohortees Selected Into and Excluded from the Income Restricted Cohort, by Age, Sex and Cohort.**

Sex	Age	Selected/ Excluded	1981-84			1986-89			1991-94			1996-99			% change in SRD 84- 84 to 96-99
Females	25-44 yrs	Selected	12	(-13-	38)	26	(7-	44)	38	(22-	55)	44	(28-	60)	267%
		Excluded	71	(17-	126)	63	(16-	110)	107	(61-	153)	84	(38-	130)	18%
	45-59 yrs	Selected	157	(97-	218)	110	(61-	160)	132	(92-	173)	132	(96-	168)	-16%
		Excluded	271	(16-	380)	292	(168-	416)	154	(46-	261)	80	(-14-	174)	-70%
	60-77 yrs	Selected	689	(518-	860)	420	(282-	558)	546	(432-	660)	411	(315-	506)	-40%
		Excluded	531	(-6-	1,067)	1,162	(641-	1,684)	1,014	(562-	1,466)	1,011	(706-	1,315)	90%
	Total	Selected	200	(157-	244)	135	(100-	170)	176	(147-	204)	148	(123-	173)	-26%
		Excluded	224	(97-	350)	366	(243-	490)	322	(214-	430)	292	(215-	368)	30%
Males	25-44 yrs	Selected	87	(59-	115)	71	(46-	95)	81	(54-	108)	102	(75-	129)	17%
		Excluded	125	(63-	187)	142	(78-	205)	69	(7-	130)	127	(62-	193)	2%
	45-59 yrs	Selected	238	(162-	314)	197	(137-	257)	172	(121-	223)	206	(163-	249)	-13%
		Excluded	263	(96-	429)	243	(101-	384)	294	(163-	426)	287	(175-	398)	9%
	60-77 yrs	Selected	763	(547-	980)	662	(507-	818)	637	(499-	775)	503	(387-	619)	-34%
		Excluded	1,221	(730-	1,711)	1,626	(1,143-	2,109)	1,064	(600-	1,528)	692	(355-	1,028)	-43%
	Total	Selected	265	(214-	316)	225	(187-	263)	219	(184-	253)	211	(181-	241)	-20%
		Excluded	386	(271-	501)	473	(362-	585)	332	(225-	438)	285	(202-	367)	-26%

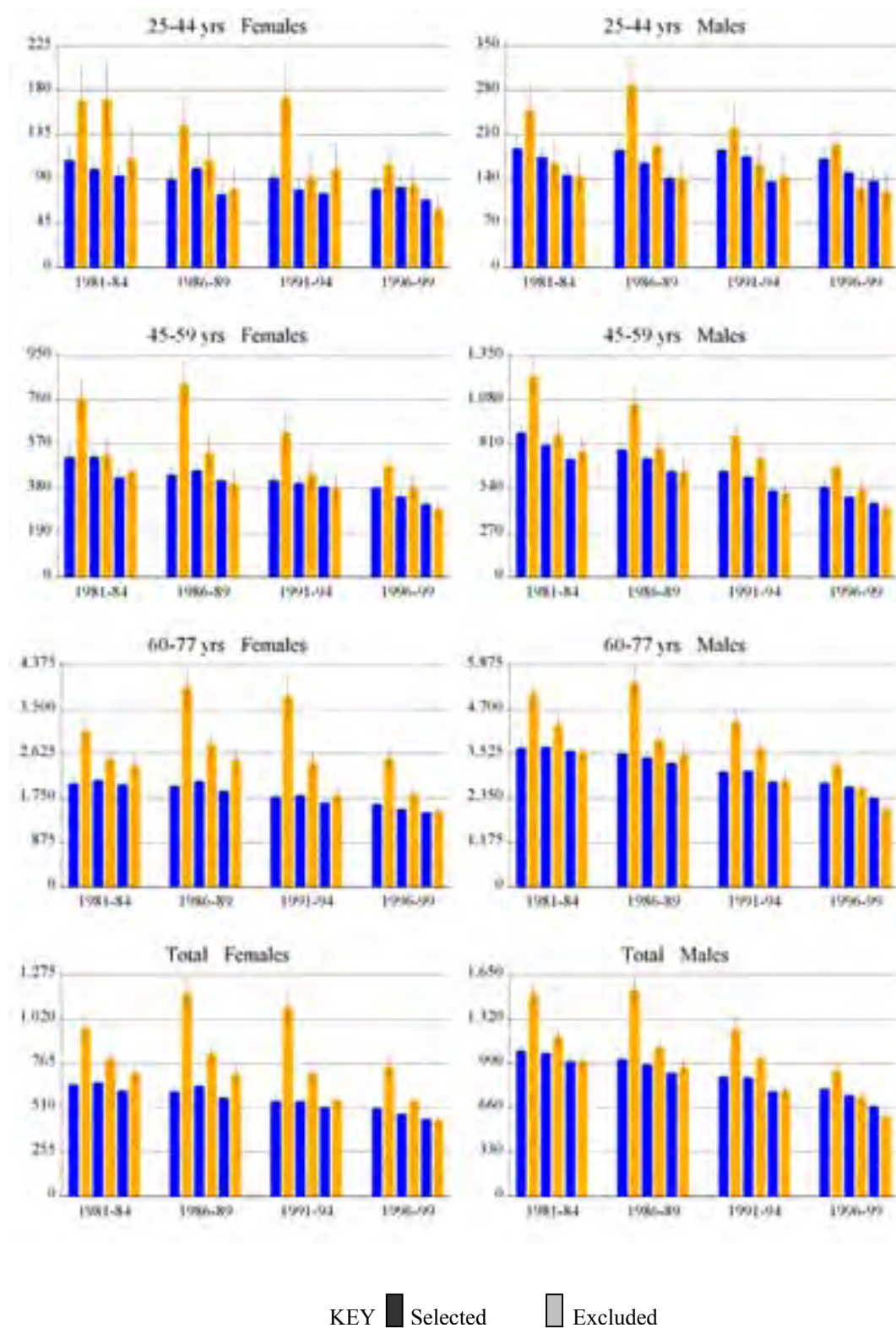
\* age and ethnicity standardised

#### 6.3.2.2 *Health Selection by Period of Follow-Up.*

To further explore potential health selection, variations in mortality rates by follow-up period after the census were investigated. Figure 6-21 shows that excess mortality in cohortees excluded from the income analyses is greatest in the first year after the census and declines in subsequent years so that by the third year of follow-up the excess mortality in cohortees without an income variable has generally disappeared. Although for females aged 60-77 years the excess mortality in those excluded from analyses still persists after three years, for the first three cohorts. The first-year excess mortality is greatest during the middle two cohorts, when the proportion with missing income data is also least. These results are consistent with a degree of selection out of the income-restricted cohort, as a result of illness prior to death. This could arise as a disruption of normal income due to illness could make the estimation of annual income, asked for in the census, problematic.

The weights used adjust for linkage bias did not adjust for time since census, however if this is the explanation for the observed decline in excess mortality among those excluded from the analyses there would need to be a large differential by whether household income was missing in the effect of time from census to explain these results. Analyses without the linkage weights gave similar results (not shown).

**Figure 6-21 All Cause Mortality for People Selected into and Excluded from the Income-Restricted Cohort - by Period Following Each Census, by Sex and Age.**





### 6.3.2.3 *Differential misclassification bias due to income drift (Drift Health Selection).*

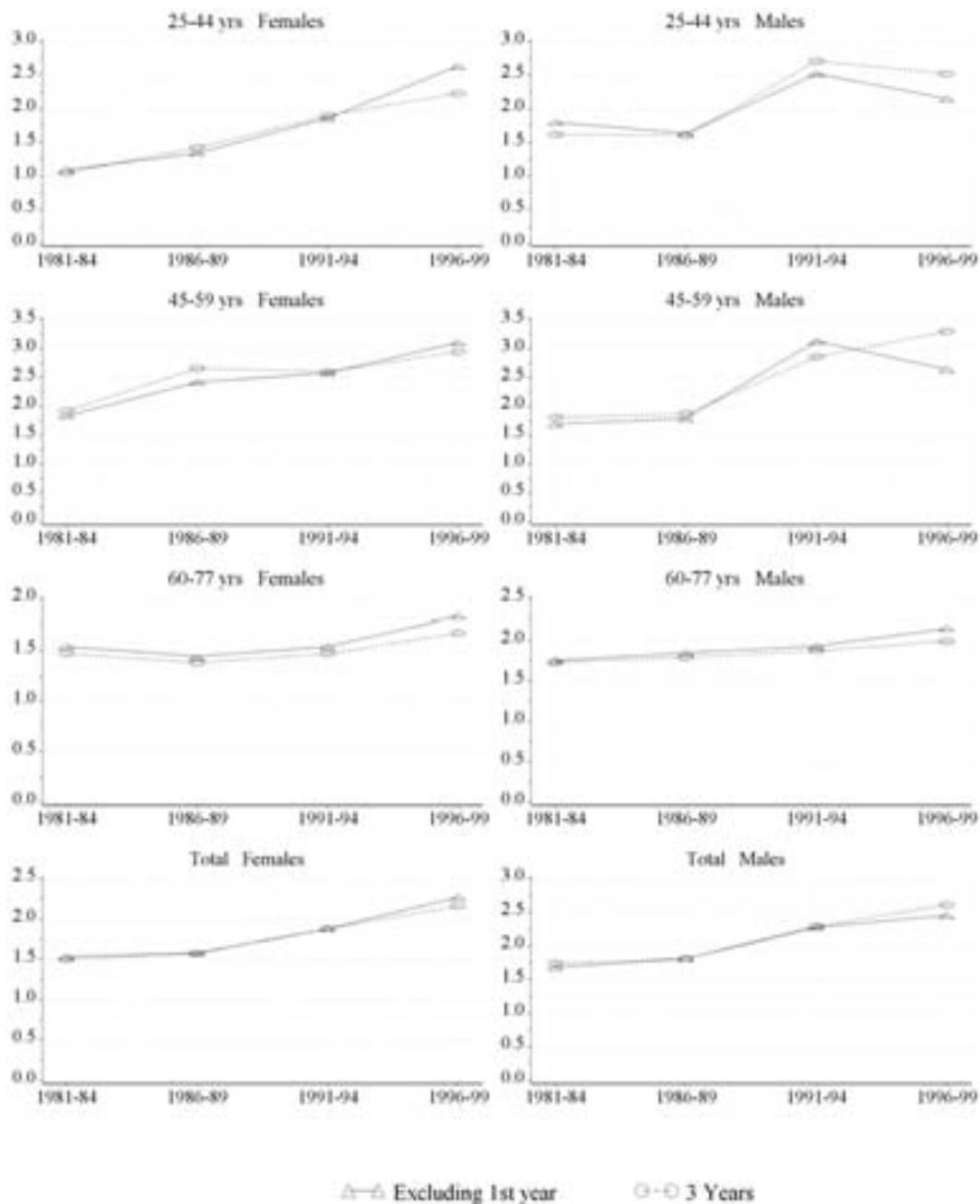
Illness prior to death is likely to lead to a downward drift in personal and household income level prior to death. In the presence of a gradient in mortality by income, a downward income drift could lead to inflation of differentials in mortality associated with income. It is likely that this drift would be greatest for the period soon after each census and for cohort members of working age whose household income is mainly derived from employment. Furthermore the effect would likely be greater for causes of death that are likely to be preceded by long periods of illness or disability and for the working age population. To assess the whether there was any evidence that drift in household income influenced the measures of inequality by income mortality rates, SRR and RII were calculated that excluded the first year of follow-up after the census.

Figure 6-22 shows the RII for all-cause mortality by age for the last two years of follow-up compared to the full 3-years of follow-up. Limiting the analyses to cohort members who died at least 12 months after the census generally had little impact on the RII level, or on trends in the RII. For females, and for men aged 60-77 years, excluding the first year of follow-up, slightly increased the trend towards increased inequality by income. However for younger and middle aged males the RII for the last cohort decreased, disrupting the trend for increasing inequality by income. Given the higher level of labour force participation for males in this age group compared to females or older males, these results are consistent with some degree of downward drift in income prior to illness, but only in 1996-99.

Figure 6-23 shows the RII for all-cause mortality by age for the last two years of follow-up compared to the full 3-years of follow-up for CVD, injury and lung cancer. These results suggest that for CVD in the last cohort, exclusion of the first year of follow-up reduced the inequality measurement in the last cohort. However the confidence intervals for the RII overlapped - 1.94 (95%CI:1.54-2.45) excluding the first 12 months of follow-up compared to 2.13 (95% CI: 1.73-2.62) for the full three years for females and 2.41 (95% CI:2.03-2.86) compared to 2.65 (95%CI:2.28-3.08) for males for the respective follow-up periods. These results appear consistent with the interpretation of some level of downward drift in income prior to death, but only in 1996-99.

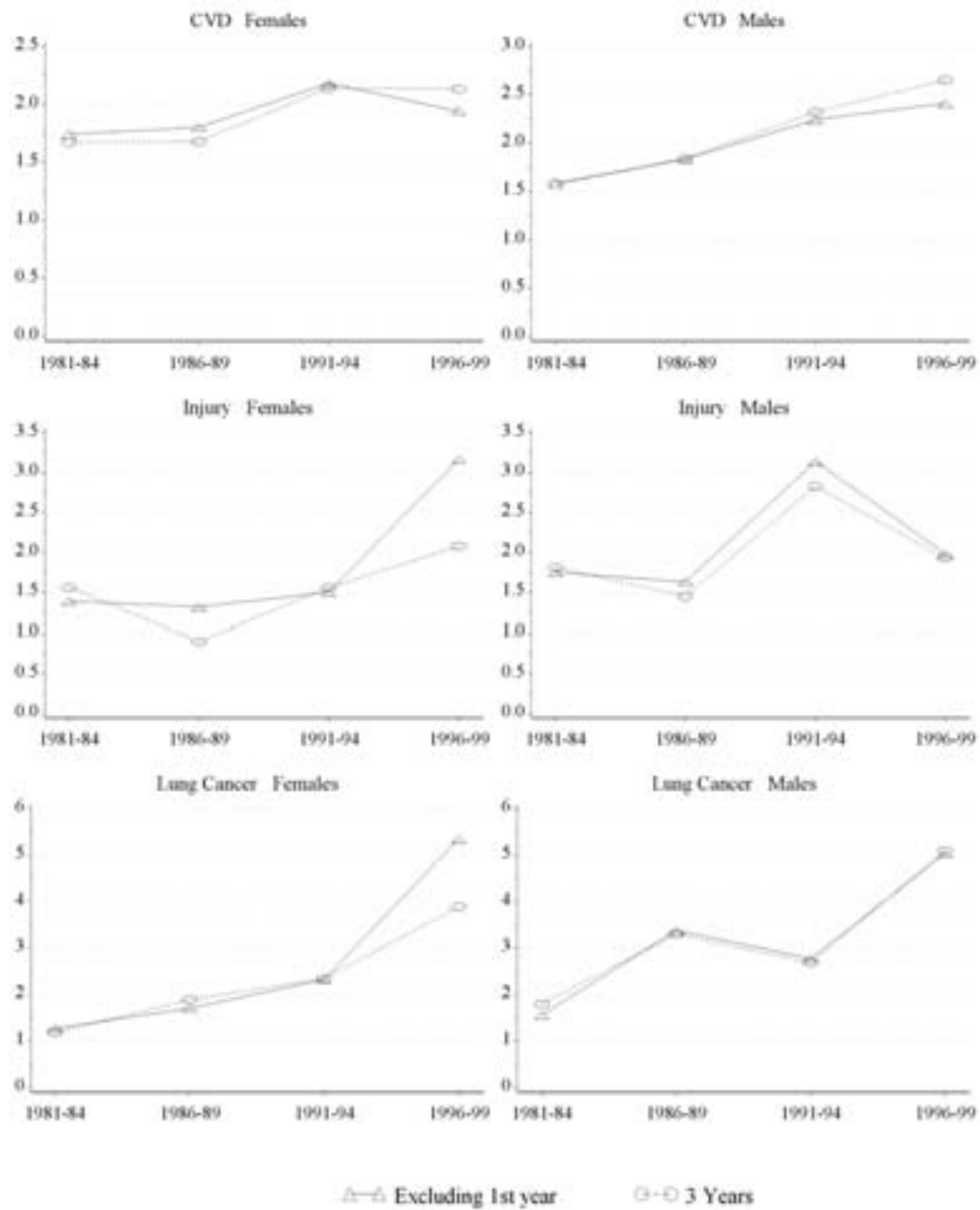
The implication of this finding is that some, but not all, of the trend towards increasing mortality differences by income from 1991-91 to 1996-99 might be attributed to increasing amount of drift health selection. The impact of this bias will be considered further in the discussion.

**Figure 6-22 RII\* for Income by Period after Each Census Cohort, by Sex and Age - All-Cause Mortality**



\*age and ethnicity standardised

**Figure 6-23 RII\* for Income by Period after Each Census Cohort, by Sex and Cause of Death- ages 25-77 years**



\*age and ethnicity standardised

## Chapter 7 Trends in Mortality By Occupational Class

### **Text Box 6. Summary of Trends in Mortality by Occupational Class**

Description and Assessment of Data: Cohort members with missing occupational data accounted for around 40% of all females and 20% of all males aged 25-59 years (Table 7-2). The proportion of females with no occupational code declined over the period of the cohorts for females but increased for males. The class distribution of the cohorts changed over time towards greater proportions in higher classes

#### ***All Cause Mortality:***

For males, there was a consistent monotonic association between lower occupational class and higher mortality rates for each cohort period. For females no consistent association is evident in the first cohort but the relationship emerges over time, so that by the last cohort there is a clear pattern of higher mortality in lower occupational classes.

Trends in Mortality rates: Mortality rates, for both females and males have declined in each occupational class over the four cohorts. However the absolute rate of decline was higher for lower classes while the proportional declines were greater for higher classes.

Trends in Relative Inequality: The RII increased substantially for both females and males. For males the RII increased between 1981-84 and 1996-99, from 1.73 (95%CI: 1.51-1.97) to 2.52 (95%CI: 2.06-3.08); for females the RII increased from 1.35 (95%CI: 1.06-1.72) to 1.73 (95%CI: 1.34-2.24).

Trends in Absolute Inequality: For males there was no particular trend in the SII but for females the SII increased by 29%.

Variation by Age: Whereas all occupational classes show substantial declines in mortality rates for 45-59 year olds, low occupational classes did not show any decline for 25-44 year old males. Relative inequality increased in all age groups, except for 25-44 year old males. The RII was however substantial in this age. Absolute inequality measures remained stable for males of all ages and 25-44 year old females, however for older females the SII between 1981-84 and 1996-99 the SII almost doubled

#### ***CVD Mortality***

For males, there was a consistent monotonic association between lower occupational class and higher mortality rates for each cohort period. For females the relationship is less consistent but becomes increasingly apparent with each subsequent cohort, so that by the last cohort the association is clearly evident.

Trends in Mortality rates: Mortality rates, for both females and males have declined in each occupational class over the four cohorts. However the absolute rate of decline was higher

for lower classes but proportionately declines were greater for higher classes.

Trends in Inequality: Relative inequality increased substantially for both males and females while absolute inequality measures remained stable.

### ***Health Selection Bias***

Health Selection Bias is of concern in these analyses. Adjustment for economically inactive substantially increased the inequality measures especially the SII. Trends in the RII remained largely unchanged but the size of the change in the SII makes interpretation of the trends in absolute inequality more problematic.

## 7.1. Description and Assessment of Data

### 7.1.1 Counts of Deaths and Person-Time

Weighted person-years of follow-up for the occupational class-restricted cohort are given in Table 7-1 and raw and weighted counts of deaths in Table 12-36 (Appendix, page 428). Deaths by sex, age group and broad cause of death categories are given in the appendix (Table 12-37, page 428).

**Table 7-1 Person-years (1000s) by Sex, Age and Cohort for the Occupational Class Restricted Cohorts aged 25-59 years.**

Sex	Age	Cohort			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	650	829	863	995
	45-59 yrs	380	446	501	646
	25-59 yrs	1,030	1,274	1,364	1,641
Males	25-44 yrs	1,078	1,216	1,138	1,179
	45-59 yrs	661	694	663	763
	25-59 yrs	1,740	1,910	1,801	1,942

### 7.1.2 Cohort Restriction

The analyses were restricted to cohort members with non-missing occupational class information. Cohort members with missing data accounted for around 40% of all females and 20% of all males aged 25-59 years (Table 7-2). The proportion of females with no occupational code declined over the period of the cohorts for females but increased for males.

The analyses were restricted to cohort members aged 25-59 years because the age of qualification for national superannuation was 60 years until 1992. After retirement the proportion of census respondents reporting a current occupation decreases sharply.

Possible biases arising from differential exclusion from the analyses due to lack of current occupational class are explored further in section 7.3.2, page 252. However, due to the relatively high proportion of cohort members with missing data, all occupational class analyses for females should be treated with caution. To a lesser extent this is true for males in the late 1990s.

**Table 7-2 Proportion of Cohort Population with Missing or Non-Codable Occupational Class Information by Sex, Age and Cohort Period.**

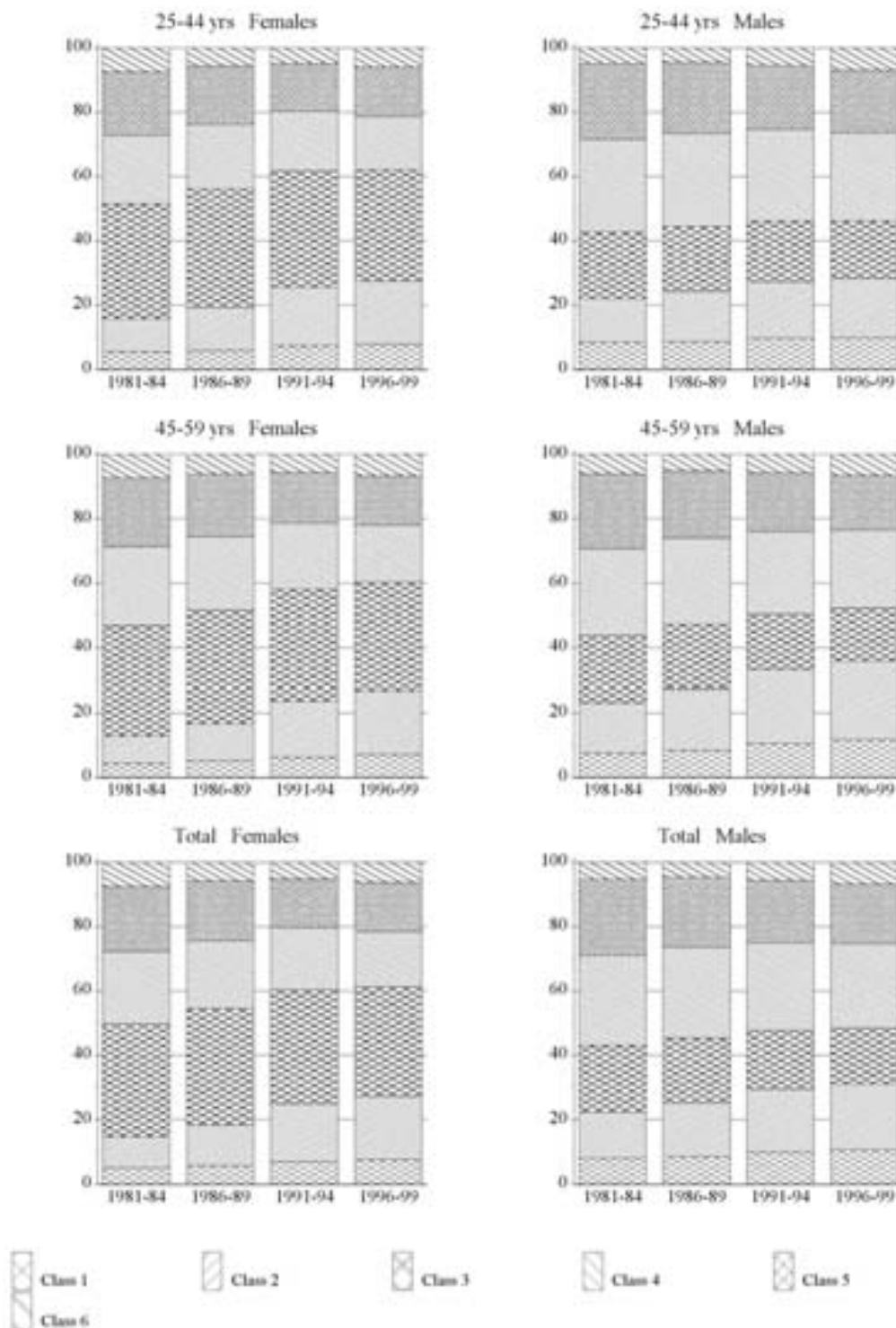
Sex	Age	Cohort Period			
		1981-84	1986-89	1991-94	1996-99
Females	25-44 yrs	45	38	41	37
	45-59 yrs	48	41	39	35
	Total	46	39	40	36
Males	25-44 yrs	8	8	19	22
	45-59 yrs	11	10	20	22
	Total	9	9	20	22

### 7.1.3 Occupational Class Distribution

Figure 7-1 shows the percentage of the cohort in each Elley-Irving Class by age, sex and cohort. The occupational class distribution of the cohort varied by sex. Approximately one third of females were in class three and around seven percent were in classes one (highest) and six (lowest). For males about one quarter of cohortees were in class four, ten percent were in class one and around seven percent were in class six.

There were substantial changes in the cohort distributions by occupational class over the four cohorts. For both males and females, the proportion of the cohort in the lower classes decreased across the four cohorts and the proportion in the higher classes increased.

**Figure 7-1 Distribution of Person-Years in Each Occupational Class, by Sex, Age and Cohort**



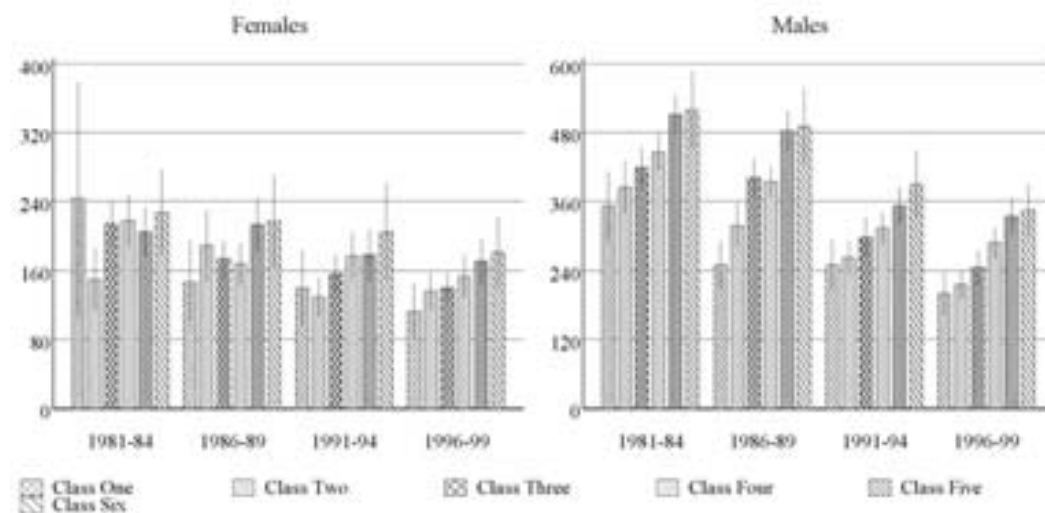


## 7.2. Mortality Trends by Occupational Class

### 7.2.1 All-Cause Mortality

Figure 7-1, below, shows all-cause mortality rates by occupational class for 25-59 year old cohortes by sex and cohort. Table 7-3 and Table 7-4 give the number of deaths, age standardised and age and ethnicity standardised rates for each occupational class level. Table 7-5 and Figure 7-3 shows the RII and SII for mortality by occupational class by sex and cohort.

**Figure 7-2 Mortality Rate by Occupational Class, Cohort Period and Sex – 25-59 years**



\*age and ethnicity standardised per 100,000 person-years

For males, there was a consistent monotonic association between lower occupational class and higher mortality rates for each cohort period. For females the relationship is less consistent but becomes increasingly apparent with each subsequent cohort, so that by the last cohort the association is clearly evident. In the early cohorts the confidence intervals for the class one and two mortality rates are very wide for females.

The mortality rate of farmers is generally similar to the rates for occupational class groups two and three.

Mortality rates, for both females and males have declined in each occupational class over the four cohorts.

For males, The absolute rate of decline was higher for lower classes; mortality rates declined by 152, 169, 173, 159, 178 and 175 per 100,000 person-years for classes one (high) through to six (low). Proportionately however mortality declines were greater for higher classes; 43%, 44%, 41%, 36%, 35%, and 34% respectively for classes one to six.

For females the trends in mortality for higher classes is difficult to assess because the confidence intervals are wide. However considering only classes two through to six the mortality rates declined by 14 (9%), 74 (35%), 65 (30%), 34 (17%), 47 (21%) per 100,000 person-years; thus both absolute and relative declines in mortality were greatest for classes three and four. If classes one and two are combined the mortality rate for classes one and two declines by 45 per 100,000 person-years (26%) from 174 to 130 per 100,000 person-years.

*Trends in Relative Inequality:* For males, despite the pattern of differential rates of mortality decline for males the SRR show no particular trend towards increase or decline. The RII increased, from 1.73 (95%CI: 1.51-1.97) in 1981-84 to 2.52 (95%CI: 2.06-3.08) in 1996-99. Although the trend was not consistent, the confidence intervals for the first and last period do not overlap, suggesting a real increase in relative inequality.

For females, a similar pattern is seen with no discernible pattern to the SRR over time but a consistent increase in the RII from 1.35 (95%CI: 1.06-1.72) in 1981-84 to 1.73 (95%CI: 1.34-2.24) in 1996-99. The test for trend was significant (p-value=0.01). Relative inequalities were smaller for females than for males at each period.

*Trends in Absolute Inequality:* Wide confidence intervals limit the interpretation of trends in the SRD for either males or females. For males the SII was higher for the 1980s cohorts than the 1990s cohorts but the decline was not consistent and confidence intervals overlapped. For females there was a consistent decrease in the SII and, despite overlapping confidence intervals, the test for trend was significant (p-value=0.01).

*Confounding by Ethnicity.* Table 7-3 and Table 7-4 and show the impact of ethnicity standardisation on occupational class mortality rates. The distribution by occupational class varies by ethnicity and ethnicity is independently associated with mortality; and so, ethnicity is a confounder in the association of occupational class with mortality rates. For example for males in 1996-99 ethnicity standardisation increases the mortality rate of occupational class

one by three percent and decreases the mortality rates of the lowest occupational class by eighteen percent. This shift reflects the distribution of Māori and Pacific cohortes towards the lower occupational classes compared to the general population. Throughout this chapter age and ethnicity standardised rates are presented, and are the basis of all RII and SII calculation

**Table 7-3 All Cause Mortality Rates (per 100,000 person-years ), SRR and SRD by Occupational Class and Cohort–Females, ages 25-59 years**

Cohort	Occupational Class	Deaths (n)	Crude Rate	Std Rate	Ethnicity Std Rate	SRR (95% CI)			SRD (95% CI)		
1981-84	Class One	81	167.7	187.4	243.0	1.12	(0.63-	1.99)	25.6	-113.8-	165.0)
	Class Two	132	146.9	148.7	149.8	0.69	(0.52-	0.91)	-67.6	-115.0-	-20.2)
	Class Three	579	173.9	205.4	213.9	0.98	(0.82-	1.19)	-3.5	(-44.2-	37.2)
	Class Four	441	206.6	210.5	217.4	1.00	-		0.0	-	
	Class Five	405	209.5	214.6	204.2	0.94	(0.77-	1.15)	-13.2	(-55.5-	29.1)
	Class Six	177	252.5	246.3	227.3	1.05	(0.81-	1.35)	9.9	(-48.1-	67.9)
	Farmers	114	138.8	161.8	162.0	0.75	(0.55-	1.01)	-55.4	-109.2-	-1.6)
1986-89	Class One	84	125.8	152.4	146.3	0.88	(0.61-	1.26)	-20.9	(-75.0-	33.2)
	Class Two	210	140.9	186.6	188.5	1.13	(0.87-	1.46)	21.3	(-25.6-	68.2)
	Class Three	603	142.7	168.5	173.2	1.04	(0.86-	1.25)	6.0	(-25.5-	37.5)
	Class Four	396	161.2	167.1	167.2	1.00	-		0.0	-	
	Class Five	417	191.5	222.5	212.8	1.27	(1.04-	1.56)	45.6	(6.5-	84.7)
	Class Six	159	233.7	238.5	216.6	1.30	(0.97-	1.72)	49.4	(-9.0-	107.8)
	Farmers	153	140.4	157.3	157.2	0.94	(0.71-	1.25)	-10.0	(-55.6-	35.6)
1991-94	Class One	105	121.5	145.8	139.8	0.79	(0.56-	1.12)	-36.4	(-87.6-	14.8)
	Class Two	261	115.3	131.5	129.2	0.73	(0.58-	0.93)	-47.0	(-82.3-	-11.7)
	Class Three	564	125.3	154.5	155.9	0.88	(0.72-	1.09)	-20.3	(-54.7-	14.1)
	Class Four	372	151.3	170.7	176.2	1.00	-		0.0	-	
	Class Five	315	162.6	187.8	177.4	1.01	(0.80-	1.26)	1.2	(-39.1-	41.5)
	Class Six	135	205.4	216.4	204.4	1.16	(0.84-	1.59)	28.2	(-34.8-	91.2)
	Farmers	126	129.5	130.9	140.0	0.79	(0.58-	1.08)	-36.2	(-82.5-	10.1)
1996-99	Class One	108	92.4	105.4	112.8	0.74	(0.53-	1.03)	-40.1	(-81.3-	1.1)
	Class Two	360	119.7	133.8	136.1	0.89	(0.71-	1.11)	-16.8	(-49.4-	15.8)
	Class Three	633	121.2	136.2	140.1	0.92	(0.75-	1.12)	-12.8	(-42.5-	16.9)
	Class Four	336	128.5	151.9	152.9	1.00	-		0.0	-	
	Class Five	390	166.7	181.0	170.5	1.12	(0.89-	1.39)	17.6	(-17.9-	53.1)
	Class Six	180	186.0	203.4	180.7	1.18	(0.89-	1.56)	27.8	(-20.1-	75.7)
	Farmers	138	126.5	114.8	115.3	0.75	(0.57-	0.99)	-37.6	(-73.1-	-2.1)

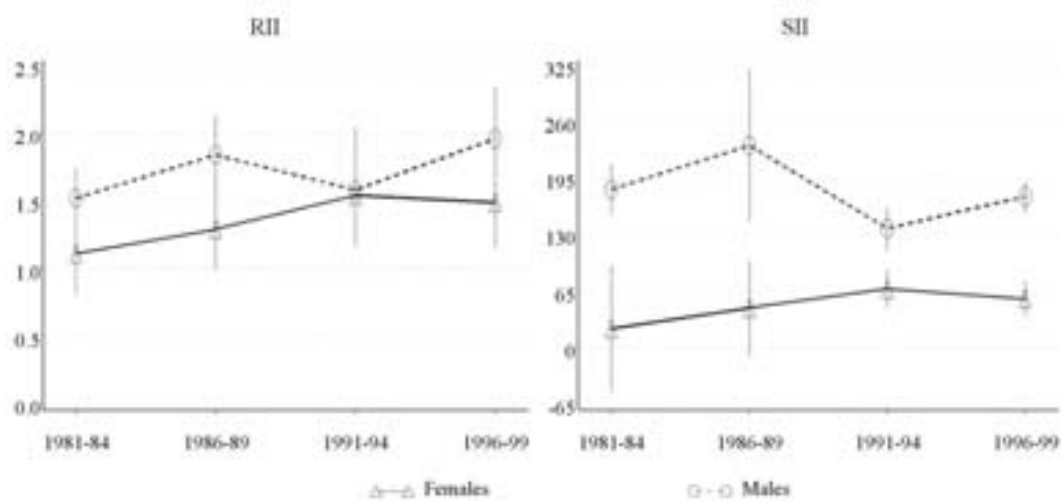
**Table 7-4 All Cause Mortality Rates (per 100,000 person-years ), SRR and SRD by Occupational Class and Cohort –Males, ages 25-59 years**

Cohort	Occupational Class	Deaths (n)	Crude Rate	Std Rate	Ethnicity Std Rate	SRR (95% CI)			SRD (95% CI)		
1981-84	Class One	363	290.0	341.6	352.1	0.79	(0.66-	0.95)	-94.3	-161.6-	-27.0)
	Class Two	732	332.3	358.5	384.6	0.86	(0.75-	0.99)	-61.8	-117.8-	-5.8)
	Class Three	1,188	373.6	405.9	418.4	0.94	(0.84-	1.05)	-28.0	(-75.8-	19.8)
	Class Four	1,680	385.8	434.9	446.4	1.00	-		0.0	-	
	Class Five	1,773	489.7	533.8	511.3	1.15	(1.04-	1.26)	64.9	(18.6-	111.2)
	Class Six	450	543.0	539.2	518.9	1.16	(1.00-	1.35)	72.5	(-1.9-	146.9)
	Farmers	633	323.3	350.7	357.8	0.80	(0.70-	0.92)	-88.6	-140.0-	-37.2)
1986-89	Class One	294	204.8	249.4	248.9	0.63	(0.53-	0.75)	-145.4	-194.5-	-96.3)
	Class Two	756	264.6	299.1	317.6	0.81	(0.70-	0.93)	-76.7	-123.9-	-29.5)
	Class Three	1,131	332.0	392.7	401.3	1.02	(0.91-	1.13)	7.0	(-35.7-	49.7)
	Class Four	1,608	333.7	385.3	394.3	1.00	-		0.0	-	
	Class Five	1,605	435.0	508.0	483.0	1.22	(1.11-	1.35)	88.7	(45.2-	132.2)
	Class Six	423	524.6	540.6	490.5	1.24	(1.07-	1.45)	96.2	(24.2-	168.2)
	Farmers	612	295.7	311.6	331.2	0.84	(0.73-	0.97)	-63.1	-113.6-	-12.6)
1991-94	Class One	327	202.5	235.5	249.0	0.79	(0.65-	0.97)	-64.5	-116.1-	-12.9)
	Class Two	726	230.9	247.6	261.1	0.83	(0.72-	0.96)	-52.4	(-92.2-	-12.6)
	Class Three	684	230.3	280.5	296.8	0.95	(0.82-	1.09)	-16.7	(-60.2-	26.8)
	Class Four	1,125	252.9	305.1	313.5	1.00	-		0.0	-	
	Class Five	1,005	320.7	372.8	352.4	1.12	(0.99-	1.27)	38.9	(-2.4-	80.2)
	Class Six	336	370.8	422.2	389.6	1.24	(1.05-	1.48)	76.1	(11.5-	140.7)
	Farmers	474	259.6	291.3	298.9	0.95	(0.81-	1.12)	-14.6	(-62.2-	33.0)
1996-99	Class One	309	165.7	193.8	200.0	0.70	(0.57-	0.85)	-87.7	-132.1-	-43.3)
	Class Two	714	196.2	207.1	215.6	0.75	(0.65-	0.87)	-72.1	-107.6-	-36.6)
	Class Three	594	195.7	240.5	245.0	0.85	(0.73-	0.99)	-42.7	(-81.9-	-3.5)
	Class Four	1,044	225.8	283.5	287.7	1.00	-		0.0	-	
	Class Five	999	305.6	365.9	333.8	1.16	(1.02-	1.32)	46.1	(5.3-	86.9)
	Class Six	480	405.5	418.4	344.1	1.20	(1.02-	1.41)	56.4	(3.6-	109.2)
	Farmers	408	224.8	231.4	239.6	0.83	(0.70-	1.00)	-48.1	(-93.4-	-2.8)

**Table 7-5 All Cause Mortality by Occupational Class – RII and SII by Sex and Cohort – ages 25-59 years**

Age	Period	RII (95% CI)	P (Trend)	SII (95% CI)	P (Trend)
Females	1981-84	1.35 (1.06- 1.72)	.	61 (14- 109)	.
	1986-89	1.42 (1.10- 1.83)	.	63 (-2- 128)	.
	1991-94	1.59 (1.20- 2.09)	.	73 (47- 99)	.
	1996-99	1.73 (1.34- 2.24)	0.01	79 (45- 113)	0.01
Males	1981-84	1.73 (1.51- 1.97)	.	234 (182- 286)	.
	1986-89	2.12 (1.83- 2.45)	.	283 (187- 380)	.
	1991-94	1.87 (1.57- 2.23)	.	184 (136- 231)	.
	1996-99	2.52 (2.06- 3.08)	0.22	238 (181- 295)	0.75

**Figure 7-3 All Cause Mortality by Occupational Class – RII and SII by Sex and Cohort – ages 25-59 years**

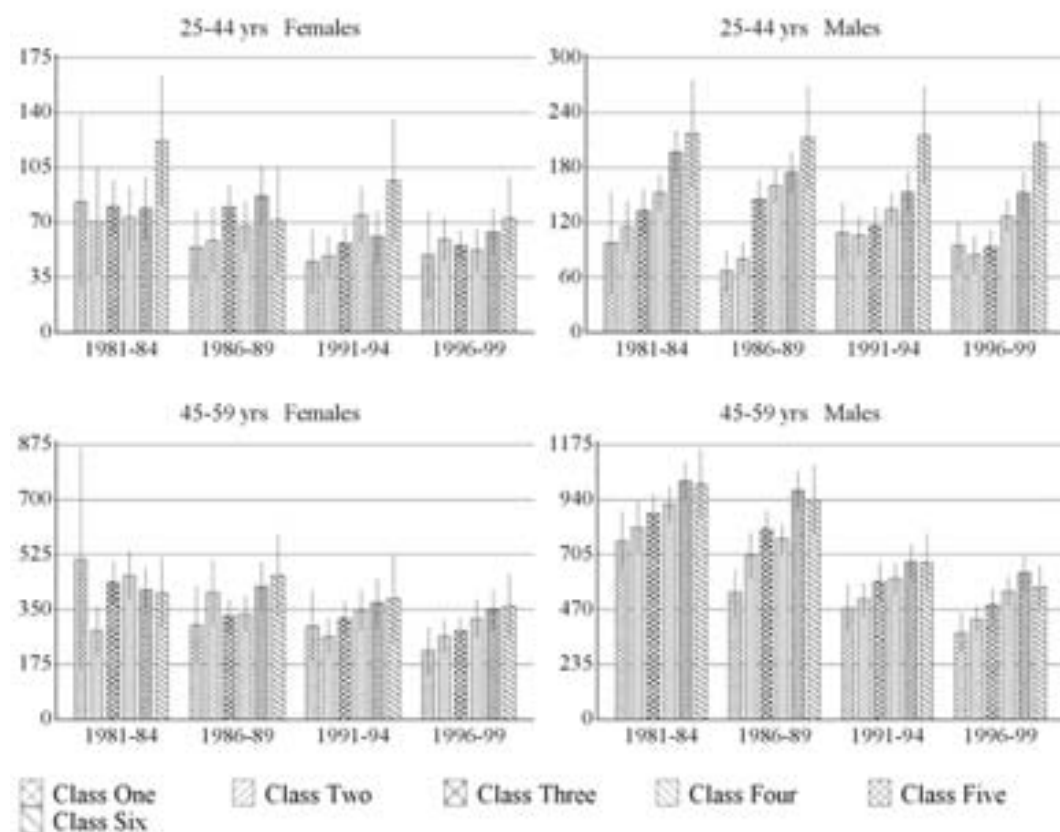


\*age and ethnicity standardised

### 7.2.1.1 Variations by Age in Trends in All-Cause Mortality by Occupational Class

Figure 7-4, below, shows mortality rates by occupational class for 25-44 and 45-59 year age groups. RII and SII measures are given in Table 7-5. These results show a relatively consistent association between occupational class and mortality for all age, sex and cohort periods, except females in 1981-84. The association is stronger for males, which is reflected in higher measures of relative inequality.

**Figure 7-4 All Cause Mortality Rates\* by Occupational Class, Cohort Period, Sex and Age**



\*age and ethnicity standardised per 100,000 person-years

Mortality rates and 95% CIs are given in the appendices, Table 12-25 and Table 12-26, page 405.

*Females:* For females, wide confidence intervals in the earlier cohort make trends in the occupational classes mortality rates difficult to interpret. However the RII and SII measures suggest that there was no change in either absolute or relative inequality among 25-44 year olds. In contrast, for 45-59 year olds, the RII increased from 1.23 to 1.79 and the SII from